Original Article

Institution of MECHANICAL ENGINEERS
Journal of PROCESS MECHANICAL ENGINEERING

Experimental thermodynamic performance analysis of semi-transparent photovoltaic-thermal hybrid collectors using nanofluids

Proc IMechE Part E:
J Process Mechanical Engineering
0(0) 1–13

DOI: 10.1177/09544089211013663
journals.sagepub.com/home/pie
SAGE

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Abstract

In this article, the experimental thermodynamic performance analysis of a semi-transparent photovoltaic-thermal hybrid collector (SPV-THC) using CuO, Al_2O_3, TiO_2 based nanofluids and water is investigated and compared with conventional opaque photovoltaic panels. The SPV-THC consists of a polycrystalline silicon cell photovoltaic module with a serpentine tube configuration heat sink. The influence of nanoparticle concentration, mass flow rate of nanofluids, ambient factors such as solar irradiation and ambient temperature on thermodynamic performance of SPV-THC have been experimentally studied under the weather conditions in Coimbatore, India. The concentration of nanoparticles and mass flow rate of nanofluids were optimized to 0.2% (by volume) and 0.016 kg/s, respectively based on experimental trials. The experimental result shows that the electrical efficiency of SPV-THC using CuO, TiO_2, Al_2O_3 based nanofluids and water has been improved by 11.2%, 9.1%, 7.3% and 5.9% respectively than the conventional opaque photovoltaic modules. Also, the thermal efficiencies of SPV-THC using CuO, TiO_2 and Al_2O_3 nanofluids improved by 42.6%, 34.8% and 19.7% respectively than water.

Keywords

Semi-transparent photovoltaic-thermal hybrid collectors, nanofluids, thermodynamic performance

Date received: 22 February 2021; accepted: 5 April 2021

Introduction

The energy requirement in India is increasing rapidly because of increased industrial developments and the human population. More than 80% of energy demand has been fulfilled by conventional fossil fuels imported from foreign countries. The availability of conventional fossil fuels is depleting rapidly and the environmental concerns caused during its combustion have inspired the researchers to use renewable energy resources to produce electricity and heat. Solar energy is the prime dual-energy resource (light and heat) receiving more attention during recent years. The electricity generation using photovoltaic panels is widely used. Photovoltaic modules have low electrical efficiency between 10 and 15% due to increased cell temperature.[1] About 80% of thermal energy absorbed by the photovoltaic panel is lost to the surroundings. Kern and Russell[2] proposed a novel hybrid technology to integrate the photovoltaic panel and heat sink to provide electricity and heat outputs simultaneously. The photovoltaic cells in photovoltaic-thermal hybrid collectors (PV-THC) convert solar illumination into electricity. Heat sink recovers the thermal energy by circulating the fluids through it. The PV-THC improved the electrical efficiency by maintaining low cell temperature.[3] Cooling systems and power converters have the greatest influence on power generation of the PV module. The modeling of power converters has a critical role in electric power conversions.[4] Several research studies were reported on PV-THC using air, water, nanofluids and refrigerants.[5] The summary of selected research studies on PV-THC is presented in this section.

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European Journal of Pharmacology 886 (2020) 173551

Contents lists available at ScienceDirect

European Journal of Pharmacology

journal homepage: www.elsevier.com/locate/ejphar

Full length article

Curcumin, a traditional spice component, can hold the promise against COVID-19?

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ARTICLE INFO

Keywords:
COVID-19
Curcumin
Cytokine storm
Inflammation
Molecular targets

ABSTRACT

The severity of the recent pandemic and the absence of any specific medication impelled the identification of existing drugs with potential in the treatment of Coronavirus disease-2019 (COVID-19), caused by severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2). Curcumin, known for its pharmacological abilities especially as an anti-inflammatory agent, can be hypothesized as a potential candidate in the therapeutic regimen. COVID-19 has an assorted range of pathophysiological consequences, including pulmonary damage, elevated inflammatory response, coagulopathy, and multi-organ damage. This review summarizes the several evidences for the pharmacological benefits of curcumin in COVID-19-associated clinical manifestations. Curcumin can be appraised to hinder cellular entry, replication of SARS-CoV-2, and to prevent and repair COVID-19-associated damage of pneumocytes, renal cells, cardiomyocytes, hematopoietic stem cells, etc. The modulation and protective effect of curcumin on cytokine storm-related disorders are also discussed. Collectively, this review provides grounds for its clinical evaluation in the therapeutic management of SARS-CoV-2 infection.

1. Introduction

An outburst of Severe Acute Respiratory Syndrome-Coronavirus-2 (SARS-CoV-2) infection causes COVID-19 pandemic; with millions of cases and approximately 540 thousands of deaths (WHO, 2020). Prophylactic and therapeutic measures are not yet available against COVID-19 (Scavone et al., 2020). Prompted responses throughout the world have been initiated to identify the therapeutic molecule against SARS-CoV-2; large number of drugs have been suggested for repurposing against COVID-19 (Wu et al., 2020). Several reviews have suggested a potential role of phytochemicals in the fight against SARS-CoV-2 infection and the onset of COVID-19 (Mani et al., 2020; McKee et al., 2020). Phytochemicals have been proven effective against previous episodes of virus outbreaks in the last two decades (Barnard and Kumaki, 2011; Kunnumakkara et al., 2017; Xu and Liu, 2017). Bioactive ingredients may offer potential candidates for the prevention and treatment of COVID-19. Turmeric is one of such plant products that provide benefits in a variety of medical ailments including respiratory infections (Barnard and Kumaki, 2011; Buhrmann et al., 2020; Kunnumakkara et al., 2019; Soni et al., 2020; Vishvakarma, 2014; Xu and Liu, 2017). A major bioactive component of turmeric, curcumin has been shown to confer curative and preventive effects in the diverse forms of pathology and disorders, infections, and malignancies (Barnard and Kumaki, 2011; Kunnumakkara et al., 2019; Soni et al., 2020; Vishvakarma, 2014; Xu and Liu, 2017).

Various demographic factors, including dietary habits, have been linked with low COVID-19 case fatality rate observed in South-East Asia and East-Mediterranean (WHO, 2020). Turmeric is an integral part of

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https://doi.org/10.1016/j.ejphar.2020.173551
Received 10 July 2020; Received in revised form 17 August 2020; Accepted 10 September 2020
Available online 12 September 2020

Cytokine xxx (xxxx) xxxx

Contents lists available at ScienceDirect

Cytokine

journal homepage: www.elsevier.com/locate/cytokine

Dendritic cell engineered cTXN as new vaccine prospect against *L. donovani*

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ARTICLE INFO

Keywords:
Visceral leishmaniasis
cTXN
Dendritic cells
Macrophages
IL-10
IFN-γ
GM-CSF
NFκβ
Vaccine

ABSTRACT

Dendritic cells (DCs), as antigen-presenting cells, can reportedly be infected with *Leishmania* parasites and hence provide a better option to trigger T-cell primary immune responses and immunological memory. We consistently primed DCs during culture with purified recombinant cytosolic tryparedoxin (rcTXN) and then evaluated the vaccine prospect of presentation of rcTXN against VL in BALB/c mice. We reported earlier the immunogenic properties of cTXN antigen derived from *L. donovani* when anti-cTXN antibody was detected in the sera of kala-azar patients. It was observed that cTXN antigen, when used as an immunogen with murine DCs acting as a vehicle, was able to induce complete protection against VL in an infected group of immunized mice. This vaccination triggered splenic macrophages to produce more IL-12 and GM-CSF, and restricted IL-10 release to a minimum in an immunized group of infected animals. Concomitant changes in T-cell responses against cTXN antigen were also noticed, which increased the release of protective cytokine-like IFN-γ under the influence of NF-κβ in the indicated vaccinated group of animals. All cTXN-DCs-vaccinated BALB/c mice survived during the experimental period of 120 days. The results obtained in our study suggest that DCs primed with cTXN can be used as a vaccine prospect for the control of visceral leishmaniasis.

1. Introduction

The Indian sub-continent accounts for approximately 90% of the disease incidence of visceral leishmaniasis (VL) caused by the protozoan species of the genus *Leishmania*. VL is otherwise endemic in 88 countries, affecting approximately 350 million people worldwide [1–4]. The disease spreads to humans through the bites of *phlebotomine* sand flies, during which the parasite gains silent entry into a macrophage (Mφ) during uptake of neutrophils or endothelial cells infected with - *Leishmania donovani* (*L. donovani*) [5]. The *Leishmania* parasite has been shown to develop a well-stratified evasion mechanism resulting in suppression of pro-inflammatory cytokines such as interleukin-12 (IL-12) by the activation of immune-suppressive elements such as prostaglandin E2. Transforming growth factor-beta (TGF-β) and platelet-activating factor (PAF), which in tandem lead to the degradation of ATP into ADA, ensure parasite survival by weakening the Mφ defence against the parasite [6,7]. These parasite-provoked evasion strategies further induce abrupt expression of MHC molecules (class I & II) on the surface of the Mφ. The expression of such molecules (B7.1 and B7.2) is the pre-requisite for the upregulation of host protective Th1 and Th17 types [8–10]. Such impairments in Mφs lead to the development of clinical symptoms in patients, such as hepatosplenomegaly, pancytopenia, anaemia, etc., and patients become immune suppressed [11,12]. Current drugs to treat VL patients are miltefosine, paromomycine, etc. The safety and efficacy of anti-leishmanial drugs remain a dilemma due to continued concern based on available reports on frequent gene amplification in the *Leishmania* parasite that leads to resistance to cytotoxic drugs [13]. The disease still awaits a suitable, cost-effective, desirable vaccine for clinical human trials. Previous attempts to develop a vaccine involving leishmanial targets such as *lipophosphoglycan* (LPG), glycoprotein (Gp63), LACK (*Leishmania*-activated kinase), gp46, A2 (amastigote-specific protein), P4, P8, crude soluble antigen (CSA), kinetoplastid membrane protein (KMP-11), Hbr or the sandfly salivary protein LJM 19, *protein disulfide isomerase* (PDI), ornithine decarboxylase (ODC), and *Leishmania* eukaryotic initiation factor (LeIF-2) could not could not progress beyond animal pre-clinical trials [14–18].

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https://doi.org/10.1016/j.cyto.2020.155208
Received 14 January 2020; Received in revised form 6 July 2020; Accepted 11 July 2020

Molecular Therapy
Nucleic Acids
Original Article

Theranostic Application of a Novel G-Quadruplex-Forming DNA Aptamer Targeting Malate Synthase of Mycobacterium tuberculosis

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The successful management of tuberculosis (TB) requires efficient diagnosis and treatment. Further, the increasing prevalence of drug-resistant TB highlights the urgent need to develop novel inhibitors against both drug-susceptible and drug-resistant forms of disease. Malate synthase (MS), an enzyme of the glyoxylate pathway, plays a vital role in mycobacterial persistence, and therefore it is considered as an attractive target for novel anti-TB drug development. Recent studies have also ascribed an adhesin function to MS and established it as a potent diagnostic biomarker. In this study, a panel of *Mycobacterium tuberculosis* (Mtb) MS-specific single-stranded DNA aptamers was identified by Systematic Evolution of Ligands by EXponential enrichment (SELEX). The best-performing G-quadruplex-forming 44-mer aptamer, MS10, was optimized post-SELEX to generate an 11-mer aptamer, MS10-Trunc. This aptamer was characterized by various biochemical, biophysical, and *in silico* techniques. Its theranostic activity toward Mtb was established using enzyme inhibition, host cell binding, and invasion assays. MS10-Trunc aptamer exhibited high affinity for MS (equilibrium dissociation constant [K_D] ~19 pM) and displayed robust inhibition of MS enzyme activity with IC_{50} of 251.1 nM and inhibitor constant (K_i) of 230 nM. This aptamer blocked mycobacterial entry into host cells by binding to surface-associated MS. In addition, we have also demonstrated its application in the detection of tuberculous meningitis (TBM) in patients with sensitivity and specificity each of >97%.

INTRODUCTION

Active tuberculosis (TB) affected more than 10.4 million people in 2017, whereas an estimated 1.7 billion individuals (about a quarter of the world's population) are estimated to harbor a latent/persistent infection with *Mycobacterium tuberculosis* (Mtb).[1] The current treatment for TB is prolonged, and drug-resistant cases are increasing,[2] which together pose a significant threat to TB control in the community.[3,4] Therefore, there is an urgent need to develop new inhibitory compounds or molecules that have the potential to work against both the drug-susceptible and resistant TB.

Metabolic pathways of central metabolism have attracted attention in recent times as a source of new targets for novel TB drug development. The glyoxylate shunt pathway in particular is considered as a prominent target pathway owing to its role in mycobacterial survival and persistence, as demonstrated in cell and animal models of Mtb infection.[5,6] This two-enzyme pathway enables bypass of the decarboxylation steps in the tricarboxylic acid cycle and conserves carbon for subsequent gluconeogenesis. Isocitratelyase, the first enzyme of this pathway, generates glyoxylate and succinate from isocitrate, and malate synthase (MS), the second enzyme, catalyzes the formation of malate using glyoxylate and acetyl-CoA (coenzyme A).[5] Notably, these enzymes appear to be absent in mammals,[5] a feature that enhances its relevance as an anti-TB drug target. In addition to its enzymatic activity, MS was shown to be expressed on the cell wall of Mtb and impart host-adhering function to bacteria, thus establishing an additional role for it as an adhesin.[7] Furthermore, MS is reported as a potential biomarker for TB infections because it is expressed in the early stage of infection and independent of HIV

Received 9 July 2019; accepted 27 September 2019;
https://doi.org/10.1016/j.omtn.2019.09.026.

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CERTIFICATE
OF PUBLICATION
E-ISSN : 2320-3358
P-ISSN : 0972-5547
Journal of Natural Remedies
This is to certify that Dr.Archana Yadav Manuscript Title INVISIBLE DISABILITY: A HIDDEN PROBLEM IN SOCIETY-CHALLENGES AND IT'S IMPACT has Published in Volume 21, Issue 4, August 2020 with
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UGC-CARE SCOPUS SOURCE LIST GROUP-II JOURNAL
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Journal of
Modern Thamizh Research
(A Quarterly International Multilateral Thamizh Journal)

தொகுதி-9 எண் 1
Vol. 9 No. 1

மார்கழி 2051 - பங்குனி 2052
January - March 2021

ISSN : 2321 - 984X

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Sl.No. 237 250
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Tiruchirappalli - 620 023, Tamil Nadu, India.
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தொகுதி-9 எண்1
Vol. 9 No. 1

மார்கழி 2051 - பங்குனி 2052
January - March 2021

ISSN : 2321-984X

நவீனத் தமிழாய்வு

(பன்னாட்டுப் பன்முகத் தமிழ் காலாண்டு ஆய்விதழ்)

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EFFECT OF COVID-19 ON THE MENTAL HEALTH OF CHILDREN IN INDIA

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Abstract

Coronavirus disease has a psychological impact on children in India. Quarantine and isolation can create a psychological burden, which has a greater impact than physical suffering caused by this virus. Children's usual lifestyle is disrupted by lack of outdoor activities, school closure, sleeping habits, and aberrant diet. Various problems are increased due to this situation such as distress, monotony, annoyance, impatience, and neuropsychiatric manifestation. This paper explains the impact of this pandemic situation on normal activities and lifestyles of children. Adultered online contents, domestic violence, and child abuse are increased during a lockdown, which is included in this paper. On the other hand, children of frontline workers and migrant workers faced various kinds of problems. However, the government needs to maintain the psychological illness of children during the Covid-19 outbreak with the involvement of various strategies.

Keywords – Coronavirus, Psychological, Quarantine, Isolation, Physical, Suffering

Introduction

Coronavirus disease has a psychological impact on children in India. Quarantine and isolation can create a psychological burden, which has a greater impact than physical suffering caused by this virus. Children's usual lifestyle is disrupted by lack of outdoor activities, school closure, sleeping habits, and aberrant diet. Various problems are increased due to this situation such as distress, monotony, annoyance, impatience, and neuropsychiatric manifestation. This paper explains the impact of this pandemic situation on normal activities and lifestyles of children. Adultered online contents, domestic violence, and child abuse are increased during a lockdown, which is included in this paper. On the other hand, children of frontline workers and migrant workers faced various kinds of problems. However, the government needs to maintain the psychological illness of children during the Covid-19 outbreak with the involvement of various strategies.

Impact of Covid-19 on children in India

In India, children are also getting affected severely due to the pandemic of (COVID 19) coronavirus disease. According to Kumar et al. (2020), therefore, there are multifaceted effects on children which can be resembled in the perspective of cultural, mental, psychological, mental, and physical. India's population is about 41% of the age group of fewer than 18 years who don't know how to deal with their mental health issues. Thus, being the Indian citizen we possess the responsibility not to neglect their mental health problems which they face during the pandemic session and post-pandemic session. Posted by the national committee of (UNICEF, 2020a), such impacts on children due to COVID 19 bring out several issues related to children which are not at all limited to health but also reflect in their well-being. Thus, other extensions are also there which can also be surveyed on many dimensions related to the lives of children including safety, education, and poverty.

Many of the children become sad during this lockdown because they have had no idea to enjoy during this pandemic while on the way out to enjoy with their schoolmates, peers, relatives, and friends neither can they enjoy physical accessibility for so many months. Therefore, not at all scope of the limited options for enjoying an outdoor game and less socialization makes some of the children get bored easily where they sometimes become impulsive and some adverse situations make them frustrated also. Even though, some children are seen to be active virtually and to be busy with mobile phones. Therefore, in this manner, high probability can be raised that few of them will be engrossed with online entertainment within a social media platform (Kumar and Nayar 2020). The overuse of digital phones is signified to be reported in its Indian lifestyles where the media plays a vital source.

Apart from it, such issues can be depicted such as to have functioned all across every house of children mentioned by. Digital connections are also raised and as an outcome they need to face 'emotional contagion' where they can't be out of distress and they are scared of being severely affected while communicating with other people as such diseases can be disseminated on air. Children are also suspected to be the victim of a novel coronavirus in a general perception (Mukherjee 2020). Though, it is already mentioned in the reports that those children who are below12 years of age, in India, are also getting infected. Somehow, in comparison to other age groups very few get to be infected by COVID 19 mentioned in (The New Indian Express, 2020). In children, some of the agencies also served their concern by speaking about them that problems related to the children can be raised as heightened anxiety where that could be because of the distress to be seen among their family members because of COVID-19. Thus, it may become an exacerbation of children's mental health issues.

Overview of Mental health impact on children

The lifestyle of many people is disrupted due to the outbreak of Covid-19 across the world. The sense of uncertainty and anxiety is increased during the Coronavirus pandemic. Saurabh and Ranjan (2020) stated that, along with this, the whole world is unable to predict and prepare for this critical situation. Stress level is increased among children and adolescents, which directly has an impact on their mental health. Due to the closure of the school, many children were detached from the study. Children of poor families and migrant workers are mainly impacted by this problem. The school was only one medium of study for these children, as the parents of these children were unable to help them during the study. With the help of this information, it is easy to understand that the education system is badly disrupted by the Covid-19 outbreak and lockdown. Various undesirable adverse effects are increased in children due to stress, these effects are depression, panic attack, mood disorder, development of anxiety, and other mental disorders (Sahoo and Biswal 2020).

Few children are affected by observing critically ill family members or passing of close relatives due to Covid-19. This factor can increase the psychological illness of children. Along with this fear about the virus has a detrimental impact on the mental health of children. Covid-19 outbreak and lockdown can leave an effective impact on the healthy daily routine of children. Hiremath et al. (2020) stated that mental wellbeing can face significant threats by this pandemic situation. With the help of a survey, it is observed that children are faced with problems regarding additional stress and sleeping difficulties. Uncertainties about future ambition, personal relationships, and academics are nursed during this pandemic situation. The risk of drug abuse is also

increased widely in India during the lockdown. The mental health of children is effectively impacted by Covid-19, as well as few effective factors are increased by Copvid-19 such as post-traumatic stress order and a higher rate of depression. However, few effective strategies and processes are used to maintain the mental health of children (Singh and Adhikari 2020).

Impact of COVID-19 on children's emotion in India

Because of the pandemic, children who have lost their parents which can be variably different situations for them are to be forced to be that distressed. In some cases, some kind of bereavement reactions is also experienced by children where they find complicated factors to deal with or connect an ill relative who is before handed passed away. This happens because of peculiar quarantine restrictions. According to Dubey et al. (2020), fear about loved ones' health and financial security can take an emotional toll on children. So, the children may face trouble dealing with numeric ranges of psychological problems associated with loss of appetite, anxiety, insomnia, and low mood. (Jacob et al., 2020) stated that traumatic bereavement, isolation, and Quarantine may lead to post traumatic distress disorders in children (Unni 2020).

Three categories are also presented in representing adversities which affect children may be divided into the segments mentioned below:

(a) Isolation did to the COVID positive patients and are considered under the same;

(b) COVID positive parents' children and those who either lost their both parents or one of them because of the infection;

(c) Because of general lockdown, some of the children who are shielded for quarantine, thus become isolated. So, different children with numerous concerns can be categorized to face variable mental health problems.

Effect of school closure

Covid-19 outbreak directly has an impact on the education infrastructure of India. To maintain the practice of social distancing all schools, colleges, and universities are closed. Balasubramanian et al. (2020) stated that school can provide an effective free space for children along with education. Along with this window of freedom and scope of interaction is provided by the school towards children. Various psychological factors of children are maintained by schools. Along with this personal hygiene, healthy food, physical activity, and body habits, related information is provided by schools. However, schools are closed to maintain social distancing that can control the spreading of COVID-19 in India. Due to this problem children are unable to interact with their friends and others, which directly has an impact on their mental state. The environment of the school is missed by children (Patel 2020).

The sense of normalcy is shattered in this situation, as well as the physical and mental health of children is disrupted due to lack of social interaction. Long-term physical inactivity, irregular sleeping patterns, and improper diet plan can increase various problems such as childhood obesity and cardio-respiratory problems (Murthy 2020). Due to lockdown and school closure, the use of smartphones and television has increased rapidly, which is not useful for children. Closure of school can increase various problems for children such as fear of infection, frustration, lack of;-person contact with peers and teachers, and insufficient information. The psychological state of children is affected mostly by these problems.

Children can learn about financial problems in the family, which directly has an impact on their

mental state. This factor can increase the stress level for children. Along with this lack of personal space in this house can increase various problems for children. Education and educational inequalities are impacted by this pandemic situation. However, various schools are trying to conduct education via virtual platforms with the help of smart phones, laptops, PC, and other related devices. Roy et al. (2020) stated that this homeschooling process is conducted with the involvement of good internet connection and audio-visual systems. Children of poor manly and migrant workers are unable to grab this facility due to lack of proper medium. Due to this problem drop out of formal education is observed in India.

Child abuse, domestic violence, and teenage promiscuity: increasing threats of lockdown.

During lockdown health finance and partial activity, related anxieties are increased rapidly. In this period all industrial fields, educational fields, and others are closed, as well as to maintain the outbreak of Covid-19 all people are staying at home (Ramteke 2020). Due to this problem domestic violence is increasing in India, which directly has an impact on the mental state of children. Children are faced with physical punishment, psychological aggression, and abuse by caregivers. This factor can be left a permanent wound on children's minds. Due to these problems, multiple substance cases of abuse, improper development of the brain, higher rates of psychosomatic and neuropsychiatric disorders, tendency of suicide, and addiction to the drug are increased. On the other hand, it is also observed that financial deadlock, lack of affection, and care from parents, and school discontinuation can increase the psychological illness of children.

John et al. (2020) stated that, during the Covid-19 epidemic, teenage pregnancy, sexual exploitation, and child marriage related problems are increased in India. To maintain food, water, and shelter child marriage is observed between the poor part of India. As the schools are closed online platforms are used widely by children. Online platforms are used by children with excessive and uncensored time to maintain their loneliness. Harmful and abusive contents are provided by various online sites and platforms, which directly has an impact on the mental state of children. Rates of cyber-crime have increased during Covid-19 outbreaks; excessive use of online platforms is beneficial for cyber-attacker. Various kinds of Child-abuse materials are provided by various online platforms. Cyber cells need to control psychosexual aberrancy (Kanojia 2020).

Impact of Covid-19 on children whose parents are frontline workers and migrant workers.

Lockdown can provide effective opportunities for employees of various fields to maintain their children properly and helps to provide time for their children. However, whose parents are in health services and defense services they are unable to grab this opportunity (Jena 2020). These frontline workers are involved in tireless and hard-pressed work, they are unable to find time for their families and children. Along with this, fear and guilt of contamination of the Coronavirus are observed in these workers. During this period children are missing their parents too much. However, they are trying to maintain the basic requirements of children such as breastfeeding, if the mother is a frontline worker. However, children feel proud of the contribution of their parents. Kumar et al. (2020) stated that long-term physiological impacts such as anger generalize disgraced and aggression for the society is observed in children during this situation.

On the other hand, migrant workers are faced with economic problems, which directly has an impact on her children. Children's growth of bran

is prevented by this situation. Due to the lack of financial support risk of roping out is increased during this pandemic situation. With the help of a few effective reports, it is noticed that a 12-year-old child died after walking 100 kilometers. Verma and Prakash (2020) stated that food and shelter were critical problems for children, whose parents are migrant workers. Along with this, it is observed that children are living in an unhygienic and hazardous condition that can have an impact on their physical and mental health. With the help of this information, it is observed that the Covid-19 outbreak has a long-lasting impact on children's mental and physical health. The educational structure of children diminishes properly during this pandemic situation.

How to control the impact of Covid-19 on Children

Such kind of scenario can be alarming to work out with the mental health deterioration which can be handled by the service providers analyzed by the immediate caregivers or the parents. In distress, some of the service providers' major responsibility becomes to guide children who are distressed due to COVID 19. Some of the parents, at home, should know to form a sense of normalcy while planning it as a holiday package. According to Ghosh et al. (2020), it should be composed of playing games, interacting with family members while making them busy in academic activities which may include some kind of creative writing, doing video calls to their friends by socializing through mobile phone and communicating with the relatives. Reassurance can be gained by 'The Indian Association for Child and Adolescent Mental Health' for the children that they need to be aware of the fact that this pandemic session will pass soon.

Thus, it becomes vital for the caregivers as well as parents that they need to be proactive and calm and allow the child to express their emotions while checking them what they are going through and listening to their thoughts and deeds. (UNICEF, 2020b) passed that monitoring their (parents) own views can reflect in their children's behavior. Therefore, it is suggested along with that the child's mental health care should be stable and relaxed. Though, essentiality can be seen to improvise in developing public health interventions in the case of children. In India, reflected stigma can be related to mental health issues which can be shown to be strong. It might leave such an impression within the children's vulnerability under long term distress (Banerjee and Rao 2020). So, the government is ready to take appropriate steps for mitigating the mental health impact in children. So, being the Indian citizen we do carry some responsibilities towards children without avoiding their mental health problems during the pandemic session.

Conclusion

Based on this paper it is concluded that the outbreak of COVID-19 has an effective impact on children. However, it is important to maintain this impact, as well as this situation can decrease the mental state of children. A healthy diet and other routine lifestyles of children are impacted properly by the Covid-19 outbreak and lockdown. Based on this paper it is concluded that to maintain the impact of Covid-19 on children's lifestyle it is important to understand the emotional needs. After the announcement on lockdown all schools are closed, due to this problem children are unable to conduct social-interaction. During the lockdown, children are attracted excessively to the internet, smart phones, and television, which is concluded in this paper. Child abuse and domestic violence are increasing widely in this period.

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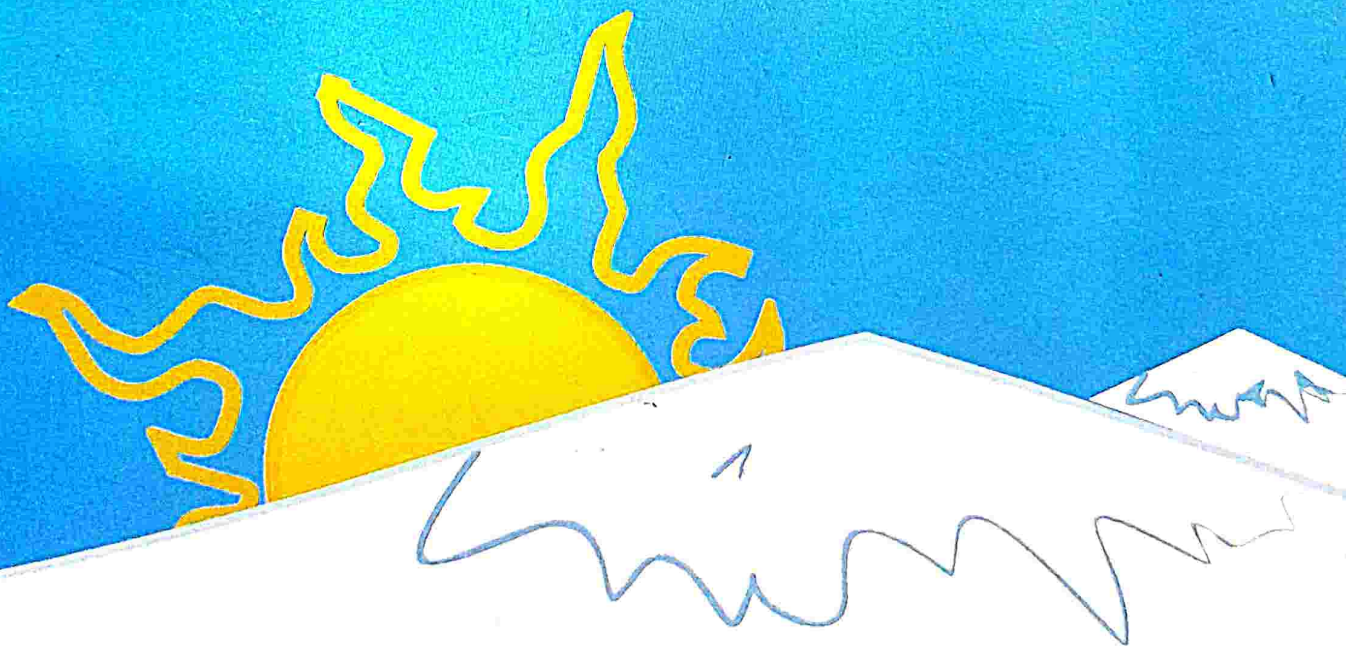
ISSN 2319-2976

ADMINISTRATIVE DEVELOPMENT

A Journal of HIPA, Shimla



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YOUTH DEVELOPMENT: SITUATING CIVIL SOCIETY ORGANISATIONS IN DEVELOPMENTAL PARADIGM

Vikram Singh*

Abstract

Youth development is possible if their participation is ensured in social, civic and political processes which are increasingly recognized as an important developmental objective. However, evidence shows that the extent to which youth participate in such processes and the factors that facilitate it remain inadequate in most developing countries including India. Hence civil society organisations came into continuation to catalyse the youth development. Civil society in contemporary times has led a wider impact in the society in the form of social and political mobilization. It has impacted people's participation in the democratic sphere of raising their voice for the rights which are often not fulfilled by the state. The role of civil society has influenced the youth and institutions to come together and bring social change in the form of advocating for their rights, demanding justice and execution of rights from the state and influencing public policies. The paper seeks to study the role of civil society in youth development vis-à-vis in the formation of vibrant society, which is proactive for their rights. It also attempts to analyse the perception of youth towards civil society. Besides, it examines the pro-active role of civil society in bringing social change and how civil society channelizes youth to participate in processes of social change & developmental process, as well as agents of mobilization among them in reducing disparity and access to justice.

Keywords: *Youth Development, Civil Society Organisations, Developmental Paradigm*

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LITERARY STUDIES

Volume 32 March 2019

LITERARY ASSOCIATION OF NEPAL

The Mystique Mountain: Nanda Devi in the Eyes of Bill Aitken, Hugh Thomson and Stephen Alter

Asis De and Maitrayee Misra

In literature, mountains usually stand for the supra-mundane. Its vastness, its altitude, the difficulty associated with the art of mountaineering — all contribute to the stature of the mountain as something beyond the ordinary. In English literature, the trend of using mountains as literary metaphors of strength, vastness, height and challenge is a common practice. In ancient Indian (Sanskrit *Kavya* poetry) and Chinese literature (*shan-shui* poetry), mountains and mountainscapes represent mostly religio-philosophical knowledge, spiritual truth and issues transcendental amid the wilderness of nature. It is usually observed that the western treatment of mountains in literary productions chiefly rely on the spatiality of the mountainscapes whereas the oriental attitude rests on the spirituality associated with the mountains and a subtle temporality in a tangent relationship with the consciousness of the transcendental. In European/ western literary productions, the crucial truth about the treatment of mountains—whether it was the depiction of Alps or the Andes, was not at all a positive one till the 17th century! Though Marjorie Hope Nicolson, in her book *Mountain Gloom and Mountain Glory: The Development of the Aesthetics of the Infinite* (1959), observes that human "response to mountains has been influenced by inherited conventions of literature and theology" (3), there is no denying that early European literatures— written both in the Classical periods and in the Christian era, had no relation with the depiction of mountains in them. In her book, Nicolson finds the Christian era till 17th century as the period of 'Mountain Gloom', when mountains had negative depiction in literary or theological texts:

"During the first seventeen centuries of the Christian era, 'Mountain Gloom' so clouded human eyes that never for a moment did poets see mountains in the full radiance to which our eyes have become accustomed. Within a century…all this was changed. The 'Mountain Glory' dawned, then shone full splendour. Why? It was not merely a matter of literary language and conventions….The change in human attitudes about mountains involved a reversal of many basic attitudes." (3)

As Nicolson admits here, there was a certain "change in human attitudes about mountains" in the Eurocentric world of literature and academia after the seventeenth century due to "a reversal of many basic attitudes". Nicolson also cites a reference to a poem of Alexander Pope, where the poet talks about the heights of Alps and wishes climbing up:

"So pleased at first the tow'ring Alps we try,
Mount o'er the vales, and seem to tread the sky." (qtd. in Nicolson 4)

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Drishti : the Sight

ISSN 2319-8281

Volume IX, Issue II, (November, 2020 - April, 2021)

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Transnationality and Intergenerational Transformation of Indian Middle-Class Family in Jhumpa Lahiri's *The Lowland*

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tract:

ilial ties, in the context of the Indian middle-s, are continually being re-shaped with snational movement in search of better material ortunity. The conventional practice of living parents and siblings inside the domestic space e Indian family along with kith and kins around neighbourhood is fast fading away, and the ective mutual support of the community is also ting lost. Rapid intergenerational sformation of the traditional models of Indian dle-class family and kinship often results in the olution of traditional values. It paves way for nd of negotiation withnew cultural practices. bring home the point,I have selected Jhumpa iri's novel The Lowland *as a case study.The novel is the saga of four generations of the Mitra ily of Calcutta. The portrayal of the elderly ntal generation represents the iconic traditional an family whereas the dislocated nuclear family ubhash and Gauri (who settle in the US) shows transformation of the traditional ethnic middle-s Indian family. Their daughter Bela—the third eration Indian who is born and brought up in American cultural space, believes in single herhood and represents a further sformation. This articleprimarily investigates the conventional notions of 'family' and ship transform through time and space; how issues like transnational movement and the New Economy contribute to the change of values in the questions of family and kinship.*

Keywords: *New Economy, Transnational dislocation, nuclear family, single motherhood, intergenerational transformation*

In the nucleus of this research article, are the typical Indian middle-class family and its transformation by two important vectors—New Economy and the resultant transnational movement. Before the discussion of those vectors, it is necessary to clarify the oft-asked question—what do we mean by the Indian middle class? Is it any group within the society representing any specific economic condition or a specific lifestyle and values? It is a general tendency to place the middle class between the rich and the poor, though over time this oversimplification is questionable. The Indian middle class has now become iconic of the 'common person or every man', the "aspirational, proud, and acquisitive citizen" (Jodhka and Prakashix). Since the 1970s, "in the post-colonial context… the middle class has been historically linked to the question of development" (Lobo and Shah 1). In recent times, the concept of the middle class in India refers precisely to a population—urban, educated, affluent, multilingual, ambitious men and women, "seeking white collar jobs" (Lobo and Shah 1); "a society with the chance of upward mobility and achievement beyond subsistence"

ISSN 0975 - 6302

TERESIAN JOURNAL OF ENGLISH STUDIES

April - June
2021
Volume XIII
Issue II

Double-blind
Peer Reviewed
International
Quarterly

Listed in:

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ST. TERESA'S COLLEGE (AUTONOMOUS), INDIA

Searching for 'Essence' in the Metafictional World of Gita Mehta: A Phenomenological Reading of *A River Sutra*

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Abstract

Gita Mehta in her *A River Sutra* focuses on the rich heritage of Indian culture and other related aspects with outmost care and sincerity. Mehta shows the current cultural and religious practices which are contrary to the Indian sensibility. She does not advocate any particular religion but rather gives more attention to spirituality and humanity. Like a postmodern writer, she fuses the grand narratives into one single narrative and gives a carnivalesque presentation of life. Here all the characters come to the bank of Narmada. River Narmada plays a great role in the novel to make the lives of the characters more meaningful. Most importantly the novel mixes tradition with contemporary, life and death, love and hate, region and spirituality.

Keywords: *Tradition, Culture, and Postmodernism.*

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UGC - CARE listed vide Sl. No. 168, Gr. D
March & June 2020 Vol. XXIV No. I & II

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Neither being Object nor being Subject: a Backward Movement from Lacanian Symbolic Stage to Pre-oedipal Stage in Han Kang's Novella *The Vegetarian*

Prasenjit Panda

> *I am much more open about categories of gender, and my feminism has been about women's safety from violence, increased literacy, decreased poverty and more equality. I was never against the category of men.*— (Judith Butler "As a Jew, I was taught it was ethically imperative to speak up" in Haaretz. February 24, 2010)

Gender, sex and sexuality have become hot cake for any debate concerning feminism or gender studies. Female body has been seen as a metaphor of weakness and feminine quality by the world of dominating masculine patriarchy. This suppressive phalogocentrism becomes one of the major ideologies by which female body is constructed, evaluated and measured ever since the human eats the fruit of knowledge. The very essence of a female body is wiped out by rational patriarchy as it is believed that female bodies are defective male bodies, marked by lack, the lack which forms the necessity and negative opposite to the plentitude of masculinity and stamped with imaginary associations in which female bodies are experienced chaotic, formless and threatening. Hence female body is termed as Achilles heel for the women world until and unless the advent of postmodern feminists starts seeing the body as no longer a weakness for them rather as a strong weapon to resist, to revolt and to retaliate against the stereotypes presentation of female body in any narratives constructed by the patriarchy. Post modern feminists like Elaine Showalter, Helene Cixous, Luce Irigaray and others have tried to demystify the myth of the patriarchy and its episteme by relating female body with creativity and power. Though not powerful like *Laugh of the Medusa* or not as radical like *Mad woman in the Attic*, Han Kang's The vegetarian, a novella which is translated into English by Deborah Smith is the true portrayal of a journey from objectification of body to subjectification of body. The novel echoed a lot about how women were treated at that time after the colonial period, and that is the reason why this novel had a really good local impact at first. The writing encounters a system of severe principles of Korean culture, which demands devotion to the family and conformism. Kang belongs to a

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Easterine Kire's *Son of the Thundercloud*: A Mythical Discourse between Man and Nature.

Prasenjit Panda

> "For our children's children and for those people out there whose voices have been drowned out by the politics of greed. I thank you all for this amazing award tonight. Let us not take this planet for granted. I do not take tonight for granted." (Leonardo DiCaprio)

We are living in the dystopian world of ignorance and hypocrisy. After the great speech of Leonardo DiCaprio in the Oscar winning ceremony for his *The Revenant*, people started to take the environmental crisis as real. Easterine Kire's *Son of the Thundercloud* is a combination of myth and reality which enables her to focus on the dystopian world we live in. The novella allegorically presents her concerns for the degrading world caused by the endless greed of human. Kire combines lyrical storytelling with the magic and wisdom of Naga legends to produce an unforgettable, life- affirming fable only to establish an ageold relationship between man and nature which is somewhere lost in the progressive worldview.

Keywords: Dystopia, environmental crisis, nature

Climate change is the biggest challenge that is faced by the mankind today. But surprisingly enough, we are not paying any heed to the upcoming peril. There are large amount of pages have been written by the environmentalists and the ecocritics to make us aware of the disaster which is looming large in our life. Easterine Kire expresses the urgent concern of climate and ecological change which has brought about famine and annihilated complete tribes in the North-East, especially in Nagaland. These are complex natural phenomena which are beyond rational truth and beyond the comprehension of common people. So to aware the people about the environmental crisis, Kire takes help from the Naga folktales and myth. Hence, Kire's*Son of the Thundercloud* better be seen as an allegory of hope and resurrection which is narrated through primitive myth and dialogues. The tale of hope amidst a dystopian world takes us into a timeless place of the myth of the son of the

Materials Chemistry and Physics 251 (2020) 123098

Contents lists available at ScienceDirect

Materials Chemistry and Physics

journal homepage: www.elsevier.com/locate/matchemphys

Magnetic reversal in Fe substituted $NdCrO_3$ perovskite nanoparticles

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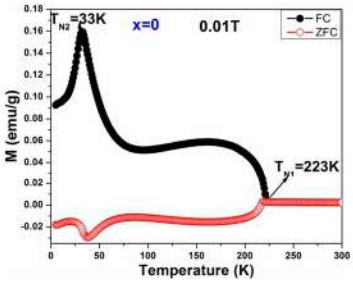
HIGHLIGHTS

- Crystalline size found to be in the order of 30–50 nm.
- x = 0 to x = 0.3 at 0.01T showed magnetic reversal behavior for T ≤ TN1.
- All samples except x = 1 at 300 K showed weak ferromagnetic behavior.
- Magnetization increased with rise in Fe content at 0.01T, 0.5T fields.
- Frustration for x = 1 is more 2.8, 2.4 at 0.01T, 0.5T fields respectively.

GRAPHICAL ABSTRACT



ARTICLE INFO

Keywords:
Perovskite ceramics
Sol-gel auto-combustion method
Diamagnetism
Weak ferromagnetism
FC
ZFC

ABSTRACT

The polycrystalline $NdCr_{1-x}Fe_xO_3$ (x = 0, 0.3, 0.5, 0.7, 1) perovskite ceramic compounds were made by sol-gel auto-combustion technique and characterized by using XRD and SEM spectroscopic techniques. X-ray studies of all samples noticed no trace of impurity and are single phase orthorhombic structure with Pbnm space group. Average crystallite size is in the order of 30–50 nm. Temperature and field dependent magnetic data were performed in the temperature range up to 300 K at 0.01T, 0.5T applied field, field range ±5T at 5 K, 300 K temperature respectively. M-T curve of x = 0, 0.3 samples at 0.01T field exhibited novel magnetic (diamagnetic like) behavior, with further increase in Fe content reversal magnetism disappeared. M-H hysteresis of all samples under ±5T (except x = 1 at 300 K) at 5 K and 300 K showed weak ferromagnetic behavior, and x = 1 sample at 300 K exhibited ferromagnetic nature. The antiferromagnetic ordering is observed at T_{N1} = 223 K, 190 K, 232 K, 192 K and 157 K for x = 0, 0.3, 0.5, 0.7 and 1 respectively. All samples (except x = 0.5, 0.7 at 0.01T and x = 0.7 at 0.5T) have shown negative paramagnetic Curie temperature (θ_P) nature, due to antiferromagnetic exchange interactions.

1. Introduction

ABO_3 perovskite oxides play a dynamic role in industrial applications. In recent years perovskite material exposed exciting physical properties including, ferroelectric, semiconducting, colossal magneto resistance, high temperature (T_c) super conducting, magnetic and multi ferocity [1]. ABO_3 material attracting more attention to study the magnetic super exchange interactions between A^{3+}-A^{3+}, A^{3+}-B^{3+}, B^{3+}-B^{3+} and for their applications such as spintronics and magnetic data storage devices. The super exchange phenomenon explains interesting

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https://doi.org/10.1016/j.matchemphys.2020.123098
Received 25 November 2019; Received in revised form 19 March 2020; Accepted 16 April 2020
Available online 21 April 2020

Journal of Alloys and Compounds 841 (2020) 155730

Contents lists available at ScienceDirect

Journal of Alloys and Compounds

journal homepage: http://www.elsevier.com/locate/jalcom

Impact of Fe substitution on electrical properties of $ErCrO_3$ semiconductor perovskite ceramic nanoparticles

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ARTICLE INFO

Article history:
Received 14 April 2020
Received in revised form
18 May 2020
Accepted 19 May 2020
Available online 27 May 2020

Keywords:
Impedance
Modulus
Dielectric loss
Ac conductivity
Semiconductor

ABSTRACT

$ErCr_{1-x}Fe_xO_3$ ($0 \leq x \leq 1$) (ECFO) perovskite compounds are synthesized by sol-gel auto-combustion processes. The impedance measurements were performed at up to 600 °C temperature, 1 Hz- 1 MHz frequency range. Z' vs Z''/f plots of x = 0, 1 compounds have shown one relaxation peak corresponds to grain boundary relaxation, whereas x = 0.2, 0.4, 0.6, 0.8 compounds have shown two relaxation peaks up to 300 °C which may be corresponds to the grain and grain boundary relaxations at higher and lower frequencies respectively. The $f\varepsilon'$ value increased with increase in Fe content up to x = 0.6 and thereafter gradually decreased with rise in Fe content, this could be the reason of hopping of charge carriers are very high between Cr^{3+}-Fe^{3+} in x = 0.6 sample. The grain and grain boundary resistance increases due to increase in B-cite cation radii with increase in Fe^{3+} substitution in place of Cr^{3+}. The complex modulus plots are also noticed that grain and grain boundary resistance is decreased with increase in temperature, which suggests that the samples are having semiconducting nature. Where x = 1.0 sample have very less conductivity in the order of 10^{-7}(S/m), 8×10^{-5}(S/m) at 1 Hz, 1 MHz respectively and whereas x = 0.4 sample have high conductivity in the order of 2×10^{-3}(S/m), 10^{-2}(S/m) at 1 Hz, 1 MHz respectively. E_a of grain is 0.14eV and 0.08eV for x = 0.2 and x = 0.8 respectively, whereas E_a of grain boundary is 0.24eV and 0.07eV for x = 0 and x = 1.0 respectively. Based on these results and as per the earlier reports these materials are more suggestible for giant capacitor, solid oxide fuel cell applications.

1. Introduction

The perovskite compounds exist in ABO_3 structure, (where A is rare earth cation and B is transition metal cation) it has interesting properties include magnetic, semi-conductivity, ferroelectric, and multiferroic properties [1–5]. From the last decade on words more research is going on these multiferroic materials because of their wide range of potential applications in various fields like, electronic devices, multilayer capacitors, resonators, and memories [6–9]. In recent studies, it is noticed that most of the ABO_3 oxides exhibit multiferroic behavior [10–12]. In ABO_3 structure, the zero occupancy of d-block electrons in the B cation is favor for ferro-electricity, whereas availability of d-block electrons in the B cation is necessary for ferromagnetism [13–15]. These ferromagnetism and ferro-electricity are interrelated properties of perovskite oxides. Hence, perovskite materials are encouraged in many theoretical and practical applications due to the inadequacy of ferromagnetic and ferroelectric materials [16,17].

In the few months ago, R. Mguedla et al. was synthesized $PrCrO_3$ via sol-gel process. The dielectric and conductivity properties performed at 160 K–440 K temperature, 1 Hz-10MHz frequency range. The magnitude of $\varepsilon'$is in the order of ~2×10^4 at 280 K, 1 KHz and ac conductivity is estimated in the order of 10^{-3} S/cm at 440 K, 5×10^2 Hz. The activation energies of grain and grain boundary have been estimated from Arrhenius plot of relaxation time and found to be Eag = 0.215eV and Eagb = 0.231eV [18].

Perovskite oxide materials have noticed that ferroelectricity and magnetic transition at higher and lower temperatures respectively. $BiCrO_3$ [19], $BiFeo_3$ [20], and $YMnO_3$ [21,22] are examples of ferroelectric and also anti ferromagnetic [AFM] perovskite compounds. Heavy rare earth manganite materials exhibit multiferroic properties like canted antiferromagnetic and

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https://doi.org/10.1016/j.jallcom.2020.155730
0925-8388/

Materials Chemistry and Physics 251 (2020) 123081

Contents lists available at ScienceDirect

Materials Chemistry and Physics

journal homepage: www.elsevier.com/locate/matchemphys

Effect of Mg-substitution in Co–Ni-Ferrites: Cation distribution and magnetic properties

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HIGHLIGHTS

- Nanocrystalline Mg-doped Co–Ni-ferrite samples were prepared by sol-gel auto-combustion method.
- Mg and Ni occupy the tetrahedral (T_d) and octahedral (O_h) sites of the spinel structure, respectively.
- Co occupies both the T_d and O_h sites of the spinel structure in the ratio 2:3; Fe adjusts its occupation as required.
- By Mg substitution for Ni, the coercivity remains constant but saturation magnetization decreases slightly.

ARTICLE INFO

Keywords:
Mg-doped Co–Ni ferrite
Sol-gel autocombustion
Cation distribution
Rietveld refinement
Mössbauer spectroscopy

ABSTRACT

We report the changes in structural and magnetic properties of spinel ferrites by doping magnesium, a cation that occupies the tetrahedral site, in place of nickel that occupies the octahedral site in Co–Ni ferrite ($Co_{0.5}Ni_{0.5}Fe_2O_4$) ceramic. We synthesized nano-crystalline $Co_{0.5}Mg_xNi_{0.5-x}Fe_2O_4$ (x = 0, 0.1, 0.2, 0.3, 0.4) ceramic powder samples by sol-gel autocombustion method followed by calcination at 600 °C in air for 2 h. X-ray diffraction (XRD) patterns of the synthesized samples confirm crystalline single-phase spinel structure with cubic symmetry (*Fd-3m* space group). Refined structural parameters were calculated through Rietveld refinement of the XRD patterns. The crystallite sizes for all the samples were found to be in the range of 30–38 nm. Porous morphology of the samples was clearly observed from the scanning electron micrographs. The FTIR spectra confirm the formation of the spinel phase through the observed vibrational bands assigned to the tetrahedral (T_d) and octahedral (O_h) interstitial complexes in the spinel structure. Magnetic measurements indicate a decrease of saturation magnetization (M_s) with increase in concentration of Mg. Room temperature ^{57}Fe-Mössbauer spectroscopy in association with XRD results confirmed the ferrimagnetic nature of the samples with Mg occupying the T_d site, Ni occupying the O_h site and Co occupying both the T_d and O_h sites in the ratio of 2:3. Using the cation occupancies, Néel's two sublattice model could explain the observed magnetic properties in our Mg doped Co–Ni ferrite samples.

1. Introduction

Nanocrystalline spinel ferrites show remarkable structural and magnetic properties with good chemical and thermal stability which make them potential candidates for wide varieties of applications [1–7]. The AB_2O_4 type spinel structure consists of a cubic close-packed array of oxygen atoms containing metal cations in tetrahedral (T_d) and octahedral (O_h) interstitial positions. The lattice sites occupied by metal ions are the interstitial sites of two types: tetrahedral (A) site and octahedral (B) site formed by the systematic arrangement of nearest oxygen neighbors. The complete unit cell contains eight molecules (formula units) with twenty-four metal cations distributed among sixteen B (O_h)

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https://doi.org/10.1016/j.matchemphys.2020.123081
Received 22 December 2019; Received in revised form 23 March 2020; Accepted 12 April 2020
Available online 17 April 2020

Magnetolattice coupling, magnetic frustration, and magnetoelectric effect in the Cr-doped $FeVO_4$ multiferroic material and their correlation with structural phase transitions

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(Received 16 April 2019; revised manuscript received 4 July 2019; published 29 July 2019)

A detailed account of magnetolattice coupling, magnetic frustration, and magnetoelectric effects in $Fe_{1-x}Cr_xVO_4$ ($x = 0 - 1.0$) studied by temperature-dependent synchrotron x ray diffraction (SXRD), temperature- and magnetic-field-dependent dielectric permittivity ε, and magnetization measurements are presented in this paper where progressive Cr doping leads to structural transitions from triclinic (T)—monoclinic (M)—orthorhombic (O) symmetries. SXRD data shows an intricate relationship between magnetic, ferroelectric, and lattice degrees of freedom in these systems. $FeVO_4$ reaches a magnetically ordered state with two successive antiferromagnetic orderings at T_{N1} (21.85 K) and T_{N2} (15.65 K), having collinear and noncollinear natures, respectively, as evidenced in DC magnetization measurements. Progressive Cr^{3+} incorporation at the Fe^{3+} site in $Fe_{1-x}Cr_xVO_4$ shifts these transitions to higher temperatures in T phase ($x = 0.0$ and 0.10). At $x = 0.175$ [in (T + M) phase], these transitions become closer to each other. Beyond this concentration, a single broad antriferromagnetic transition is observed in M ($x = 0.20 - 0.30$) and O ($x = 0.90 - 1.0$) phases. A nonlinear behavior in isotherm M-H curves below T_{N2} indicates field-induced spin-reorientation transitions at higher magnetic field. In dielectric permittivity ε a sharp peak at T_{N2} in T and near M regions with a minimal suppression because of applied magnetic field is found and no such peak is observed in far M phase. A discontinuity evidenced in electromagnetic susceptibility indicates magnetoelectric effect at the polar to nonpolar transition regions. The structural incongruence in progressive transformation from T to M to O symmetries plays a vital role in controlling the nature of magnetic interactions. Our results indicate a strong correlation between structural transitions, magnetolattice coupling, magnetic frustrations, and magnetoelectric effect in $Fe_{1-x}Cr_xVO_4$.

DOI: 10.1103/PhysRevB.100.014436

I. INTRODUCTION

Multiferroic materials exhibiting more than one ferroic order such as (anti)ferromagnetism and ferroelectricity (FE) hold great potential for applications due to magnetoelectric (ME) coupling, allowing switching of improper ferroelectricity associated with magnetic field and vice versa. The contradicting requirements for mutiferroicity are the presence of *d* electrons for magnetism, where ferroelectric distortion is suppressed by the presence of *d* electrons and FE needs the crystallization in a noncentrosymetric space group, producing an acentric frustrated magnetic structure that breaks the inversion symmetry of the lattice [1–5]. Several multiferroic materials have been studied wherein the FE arises due to various reasons [5–11]. Amongst available multiferroics, type-II multiferroics exhibit ferroelectric nature induced by a magnetically ordered phase where the cross coupling between two ferroic orders may lead to the ME effect, such as polarization switching in the materials due to spiral spin order with external magnetic fields [10–12]. The magnetically induced FE in type-II multiferroics has several different microscopic mechanisms in different types of materials. One of the most common origins is the breaking of space inversion symmetry having a noncollinear spiral spin order where the FE is driven by inverse Dzyaloshinskii-Moriya (IDM) interaction associated with relativistic spin-orbit exchange interactions. This type of polarization is formulated as $P \sim e_{ij} \times (S_i \times S_j)$, where e_{ij} is the unit vector connecting two neighboring spins, S_i and S_j, which can be arising from spin currents, ionic displacement, or induced polar lattice distortions [11–14]. Some well-studied examples having this type of origin are $DyMnO_3$ [15], $TbMnO_3$ [16], $Ni_3V_2O_8$ [17], YMn_2O_5 [18], and $MnWO_4$ [19,20], where the polarization switching is driven by an external magnetic field, leading to a ME effect [21]. Another common origin of improper FE in type-II multiferroics having collinear magnetic spin structure is exchange striction or magnetostriction without spin-orbit interaction, where the FE polarizations can be expressed as $P \sim S_i.S_j$ [11–14,22,23]. This type of mechanism occurs either in the presence of different transition metal (TM) ions or in the same TM ions with different charge states, as can be seen in $Ca_3Co_{1-x}Mn_xO_6$ or Ca_3CoMnO_6 [9,24] RMO_3 (R = Gd, Ho, Sm and M = Fe, Mn) [25–28]. The spin-dependent *p-d* hybridization also causes a small electrical polarization as evidenced in multiferroic $Ba_2CoGe_2O_7$ material [29] in which the polarization is given

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Journal of Alloys and Compounds 842 (2020) 155746

Contents lists available at ScienceDirect

Journal of Alloys and Compounds

journal homepage: http://www.elsevier.com/locate/jalcom

Rapid photodegradation of methylene blue dye by rGO- V_2O_5 nano composite

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ARTICLE INFO

Article history:
Received 3 September 2019
Received in revised form
2 April 2020
Accepted 19 May 2020
Available online 29 May 2020

Keywords:
Photo catalysis
Reduced graphene oxide
Orthovanadates

ABSTRACT

Here we present rapid photo degradation of Methylene Blue (MB) dye using novel rGO-V_2O_5 nanocomposite synthesized through simple and fast methods. In the present work, rGO, V_2O_5 nanoparticles (NP's) and rGO- V_2O_5 nanocomposite were synthesized through modified Hummer's method, sol-gel method and sonochemical methods, respectively. The nano composite and other compounds were studied through X-ray diffraction, Raman spectroscopy and Scanning Electron Microscopy (SEM) to understand structural and morphological information. XRD studies confirm the formation of compounds in single phase where Raman spectroscopic results corroborate the XRD results. Micrographs of SEM show excellent distribution of V_2O_5 nanoparticle on rGO flakes. The photocatalytic activity of rGO-V_2O_5 nanocomposite was tested by photocatalytic degradation of methylene blue (MB) dye in visible light irradiation. A rapid degradation of the MB was observed where 71% degradation of MB happens in just 20 min duration. A concentration varying effect on the degradation is also being studied where 30 wt% solution of photocatalyst shows highest rate constant, 1.84×10^{-2} min^{-1} and rapid degradation of MB.

1. Introduction

Environmental pollution has become a vital problem in the present world causing a global damage to the life on the earth. Water pollution, one of the aspects of this issue due to the dumping of wastes from industries and chemical factories into the water bodies consisting organic and carcinogenic pollutants is one of the major concerns of the world today. Water contamination by organic pollutants leads to soil pollution, which directly and indirectly affects the day to day living [1–3]. To date, many treatment technologies, such as adsorption, coagulation, photocatalysis, biodegradation etc. Have been applied in removal of these pollutants [4]. Among these approaches, photocatalysis is an important method for purification of water due to its ability to transform the toxic organic compounds into non-toxic inorganic compounds. Photocatalytic degradation is an important process for waste water management as it yields no secondary pollutants. The method is very economic and the catalysts are reusable [5]. Photocatalytic activity of a photocatalysts depends on its ability of forming free radicals generated with a participation of electrons and holes [6]. Efficient photocatalyst fulfills various requirements like well-tuned band gap, photo and chemical stability and high affinity to light [7]. Nano sized metal oxides have been proven as good photocatalytic materials with larger surface area and efficient recyclability, some reported catalysts are α-Fe_2O_3 [8], Bi_2WO_6 [9], CuO and Cu_2O [10], ZnO [11], WO_3 [12], TiO_2 [13],Cr_2O_3 [14] and V_2O_5 NP's [15]. V_2O_5, a transition metal oxide, is n-type semiconductor material used in photocatalytic degradation applications due to its narrow band gap (~2.4–2.8 eV), non-toxicity, good chemical, electrical and photo stability, low cost, ease in synthesis, large abundancy and high visible light absorption [16]. But V_2O_5 has some limitations such as volumetric expansion, low electronic conductivity, low strength and slow kinetic diffusion rate [17]. To enhance photocatalytic performance of V_2O_5 two major approaches are devised. 1) reducing the size of V_2O_5 material to nanoscale and modifying it's morphology because nano material possesses larger surface area to volume ratio and 2) introduction of optically and electrically active material into V_2O_5 [18]. V_2O_5 in

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https://doi.org/10.1016/j.jallcom.2020.155746
0925-8388/

Journal of Molecular Structure 1220 (2020) 128660

Contents lists available at ScienceDirect

Journal of Molecular Structure

journal homepage: http://www.elsevier.com/locate/molstruc

Synthesis of $Sr_{1-x}Ba_xBi_2B_2O_7$ glass ceramics: A study for structure and characterization using experimental techniques and DFT method

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ARTICLE INFO

Article history:
Received 20 March 2020
Received in revised form
8 June 2020
Accepted 8 June 2020
Available online 12 June 2020

Keywords:
Glass ceramics
NLO effect
HOMO-LUMO
FTIR and Raman spectra
DFT

ABSTRACT

In this investigation, the synthesis of glass ceramics of $Sr_{1-x}Ba_xBi_2B_2O_7$ (for $0 \leq x \leq 1.0$) and its structural, morphological and vibrational properties are presented. $Sr_{1-x}Ba_xBi_2B_2O_7$ glass ceramics are fabricated through standard melt-quenching method followed by annealing at temperatures below its glass transition temperature. The fabricated glass ceramic compounds are studied through X-ray diffraction technique for the structural characterization where the glass like nature with an indication of crystalline peak is observed. There is a shift in the observed peak with the increase in the barium concentration indicating the changing local crystal lattice parameters. The samples were studied through Scanning Electron Microscopic imaging to visualize its morphology, where it is evident that large grain are grown indicating mixed glassy and crystalline nature. The structure of synthesized glass ceramics was determined using quantum chemical calculations carried out by density functional theory (DFT) employing B3LYP functional in conjunction with SDD basis set. FTIR and Raman spectra were recorded and vibrational analysis of these materials was made using potential energy distribution (PED) obtained in DFT computations. NLO behaviour and HOMO-LUMO energies of these glass ceramics were also evaluated.

1. Introduction

Glasses play a vital role in designing solid state electronic and ionic devices, such as wave guides, lasers, magneto-optic couplers, fast ion-conductors, optical switches, etc. They are supercooled liquids which are transparent and amorphous in nature. They are formed by fusion without any crystallization. The important difference between glass and crystal is the existence of long-range order in the crystal structure [1]. The characterization of glasses as a function of composition and other properties needs a comprehensive knowledge on their microscopic structure. For the past few decades, glasses have been focussed to explore the different materials suitable for prominent applications as electrochemical, electronic, electro-optic and magneto-optic devices. Borates, a class of such glasses, are great resources for functional materials, mainly for non-linear optical (NLO) application devices. They are easily quenched for a wide range of composition with alkali content, and continuation variations of their structure and properties [2]. Borate glasses containing alkaline earth oxides along with ZnO, PbO, TeO_2, Bi_2O_3, MgO, CaO, SrO and BaO as glass modifiers are appropriate materials for being designed to meet the applications in the areas of optical communications, laser hosts, optical filters, X- and γ-ray absorbers, photonic devices, etc. [3–9]. Tellurate-borate glasses have been paid much attention due to their ability to host the rare earth elements for the development of fibres and lasers for telecommunication applications [10] and promising materials suitable for optical switching devices [11]. Glasses, containing Bi_2O_3, have been paid attention due to their enormous applications in glass ceramic field as layers for optical and opto-electronic devices, thermal and mechanical sensors, reflecting windows, etc. [12,13]. They are extensively used as lead-free sealing for sensors, solar cells and opto-electronics [14–16]. Bismuthate

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https://doi.org/10.1016/j.molstruc.2020.128660
0022-2860/

IOP Publishing
Journal of Physics D: Applied Physics
J. Phys. D: Appl. Phys. 53 (2020) 484003 (6pp)
https://doi.org/10.1088/1361-6463/aba982

Spin splitted topological surface states in $PbBi_4Te_7$

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Received 25 April 2020, revised 25 July 2020
Accepted for publication 7 August 2020
Published 9 September 2020

Abstract

The most important feature in topological insulators is the conducting surface states that support back scattered prohibited transport of charge carriers. We report weak antilocalization (WAL) effect in mm size thick $PbBi_4Te_7$ single crystal, the transport evidence of the absence of back scattering of the charge carriers. Temperature dependency of phase coherence length is determined from modified Hikami–Larkin–Nagaoka (HLN) fitting of the WAL curves at different temperatures by considering electron–electron and electron–phonon interactions and the fitting parameters reveal two dimensional (2D) origin of the WAL effect, i.e. the presence of the topological surface states. Extracted Hikami pre-factor, α at different temperatures from the modified HLN fitting signifies that the top and bottom surface states in $PbBi_4Te_7$ are connected by bulk diffusive region. Shubnikov–de Haas (SdH) oscillations corroborate the presence of two Fermi surfaces DC1 and DC2 (deep buried one inside other) and non-trivial nature of which are confirmed from the observed $\frac{1}{2}$-shift in Landau-levels fan diagram based on the SdH oscillations. Mobility (μ_{SdH}) values are determined from the Dingle analysis and are quite above the bulk mobility (μ) estimated from the low field Hall data, ascertaining the surface origin of the SdH oscillations. Surface Landé g-factors are determined from the observed peak splitting in SdH oscillations, attributed to the Zeeman effect and are 4.412 and 3.26 for DC1 and DC2, respectively, and are the consequence of strong spin–orbit coupling of the surface Dirac Fermions.

Keywords: topological insulators, Hall effect, Shubnikov-de Haas oscillations, double Dirac cones, spin splitting, surface Landé g-factor

(Some figures may appear in colour only in the online journal)

1. Introduction

Topological insulators (TIs) are novel state of matter having band inversion at the bulk energy gap. Strong spin–orbit coupling (SOC) of the constituent heavy elements in TIs lifts the spin degeneracy of the surface band and makes the surface spin polarized. The unique feature of such spin helical surface states makes them robust against back scattering of charge carriers [1–4]. Many fundamental features, like linear Dirac dispersion [5, 6], spin polarization and quantization of Landau levels [7] of the topological surface states (TSS) are revealed in angel-resolved photoemission spectroscopy (ARPES) measurements, scanning tunneling microscopy (STM) measurements and electronic transport measurements, respectively. $PbBi_4Te_7$ is predicted theoretically [8] and demonstrated experimentally to be a three dimensional (3D)

Contents lists available at ScienceDirect

Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy

journal homepage: www.elsevier.com/locate/saa

Vibrational spectra and optical properties of $Fe_{1-x}Cr_xVO_4$ solid solutions: With a group theory analysis

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ARTICLE INFO

Article history:
Received 20 June 2019
Received in revised form
10 October 2019
Accepted 15 October 2019
Available online 21 October 2019

Keywords:
Vibrational spectroscopy
UV–Visible spectroscopy
D–d transitions
Band gap absorption edges

ABSTRACT

The present manuscript reports vibrational spectra and optical studies of polycrystalline $Fe_{1-x}Cr_xVO_4$ solid solutions through FT–IR spectroscopy augmented with a group theory (G.T.) analysis and UV –Visible DRS spectroscopy. Full set of IR and Raman modes are determined by G. T. for various crystal symmetries in $FeVO_4$–$CrVO_4$ solid solutions where Triclinic, Monoclinic and Orthorhombic structures evolve with increasing Cr concentration. Experimentally obtained vibrational modes support the structural phase transitions and confirm formation of continuous solid solutions in $Fe_{1-x}Cr_xVO_4$. The Diffuse Reflectance Spectra (DRS) of $Fe_{1-x}Cr_xVO_4$ depicts the electronic structure and different optical transitions due to absorption of photon energy. The d–d transitions are manifested for all compounds in terms of crystal field stabilization energy (CFSE) caused by distorted lattice sites. The band gap energy of $Fe_{1-x}Cr_xVO_4$ is calculated using Tauc formula. It shows a red shift initially within triclinic structure then blue shift with the increase of Cr concentration. Urbach energy (E_u) tails in the spectra show the electronic structural disorder in $Fe_{1-x}Cr_xVO_4$ due to impurity energy levels of Cr ions within band gap region. It is observed that E_u decreases with the doping concentration due to the increase in crystal symmetry corresponding to the structural phase transitions in $Fe_{1-x}Cr_xVO_4$.

1. Introduction

Transition metal orthovanadates $M^{3+}VO_4$ (M = Fe, Cr, Bi, Al, In, Ce, Te etc.) have been topic of research for a very long period due to wide ranging physical properties leading to various applications such as gas sensors, catalysts for degradation of organic pollutant, and electrolytes for lithium ion batteries [1–10]. Among these, $FeVO_4$ attracted much attention as a visible light driven photocatalyst due to its narrow band gap energy (E_g) ranging from 2.0 to 2.72 eV, treated as a direct band gap n-type semiconductor [11–16]. $FeVO_4$ shows two antiferromagnetic transitions at T_{N1} 22 K and at T_{N2} 15 K with collinear incommensurate and non-collinear incommensurate or spiral magnetic ordering respectively. Some studies were done in this system to understand the effect of lattice position on magnetic properties through electron spin resonance (ESR) and Mössbauer spectroscopy [17–19]. $FeVO_4$ exhibits large spin-charge-lattice coupling displaying multiferroicity driven by spiral magnetic ordering at low temperature [20]. $CrVO_4$ and $FeVO_4$ posses interesting energy band diagram with band gap in visible range leading to excellent photocatalytic and electrochemical applications [21,22]. $FeVO_4$ and $CrVO_4$ exhibit exciting structural phase diagram by chemical doping and external pressure [23–29]. Interestingly, $FeVO_4$ and $CrVO_4$ having two different crystal structures including triclinic (P-1) and orthorhombic (Cmcm) symmetry respectively [3,30] form a solid solution which adopts a new crystal symmetry, isomorphs with α - $MnMoO_4$ like structure (C2/m) [31].

The $Fe_{1-x}Cr_xVO_4$ solid solutions were studied due to structural phase transition from triclinic to monoclinic to orthorhombic structure with the increase in Cr concentration at Fe site. The IR spectra and magnetic ordering including magnetic frustration have been studied in these solid solutions many years before [32–34] and the recent results on magnetic interactions, magnetic frustration and magneto-electric effect in these solid solutions correlated lattice degrees of freedom were investigated elsewhere [35]. Recently, pure and doped $FeVO_4$ compounds are studied as potentially promising n-type multimetal oxide semiconductor due to external pressure dependent structural phase transitions [8,23] and photoelectrochemical water splitting applications with favorable optical band gap in the visible region. It is interesting that new structural phase and the phase boundaries observed in this solid

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https://doi.org/10.1016/j.saa.2019.117668
1386-1425/

Journal of Applied Physics ARTICLE scitation.org/journal/jap

Observation of 2D transport in Sn- and In-doped $Bi_{2-x}Sb_xTe_{3-y}Se_y$ topological insulator

Cite as: J. Appl. Phys. 129, 095702 (2021); doi: 10.1063/5.0035692
Submitted: 30 October 2020 · Accepted: 4 February 2021 ·
Published Online: 2 March 2021

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Note: This paper is part of the Special Topic on Topological Materials and Devices.
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ABSTRACT

Here we report magnetotransport properties of $Bi_{2-x}Sb_xTe_{3-y}Se_y$ (BSTS), In- and Sn-doped BSTS single crystals, grown through modified Bridgeman technique. In- and Sn-doped BSTS single crystals show bulk insulation in temperature dependency resistivity measurements and are confirmed from the observed impurity band mediated three dimensional variable-range hopping behavior at low temperatures over virgin BSTS with metallic bulk. Magnetotransport measurements for BSTS and Sn-doped BSTS reveal a zero field sharp positive cusp and is identified as two dimensional (2D) weak antilocalization (WAL) effect, which is the consequence of π Berry phase of the carriers. For In-doped BSTS single crystals, crossover is identified from WAL to weak localization with field variation at low temperatures and also with an increase in temperature from 2 K. For all the single crystals, phase coherence lengths (l_ϕ) are determined by fitting low field magnetotransport data with Hikami–Larkin–Nagaoka equation. Temperature dependency of phase coherence lengths is described with 2D electron–electron (e–e) and 2D electron–phonon (e–p) interactions for virgin and In-doped BSTS single crystals while for Sn-doped BSTS specimen $l_\phi(T)$ follows $T^{-0.53}$ power law.

I. INTRODUCTION

The quantum phases of matter that breaks the traditional way of classifying different phases of matter depending on the Landau symmetry breaking theory and are characterized by time reversal symmetry protected conducting boundaries having insulating bulk are known as topological insulators (TIs). After the theoretical prediction and experimental observation of TI phases in HgTe quantum well,[1,2] this field expands its limit rapidly with time and TI phases observed in different binary,[3–6] ternary compounds[7–13] and very recently magnetic topological insulators in $MnBi_2Te_4$.[14–16] However, most of the TIs suffer from a common problem of showing metallic bulk signature in transport studies because of the presence of vacancies and/or antisite defects that shifts the Fermi level toward bulk bands. For example, the Fermi level in prototype Bi_2Se_3 shifts toward the conduction band due to Se vacancies,[17,18] while Bi_{Te}, Te antisite defects shift the Fermi level in Bi_2Te_3 toward the valence band.[19] Thus, intermixing of these prototype materials with optimum stoichiometry may result in positioning of the Fermi level within the bulk gap and lead material researcher to design tetrademyte material Bi_2Te_2Se that proved to be a 3D TI[7] and shows insulating bulk behavior.[20] Further improvement to the bulk insulation was made by partial substitution of Bi with Sb that results in quarternary chalcogenides $Bi_{2-x}Sb_xTe_{3-y}Se_y$ (BSTS). Ren *et al.*[21] studied a series of BSTS single crystals for varying stoichiometric ratio through electronic transport and reported insulating bulk nature for a series of optimized compositions. Kushwaha *et al.* compensated the native defects in Bi_2Te_2Se[22] and $Bi_{1.1}Sb_{0.9}Te_2S$[23] by doping with Sn of very small percentage in Bi and Sb sites, respectively, and resulting in observations of insulating bulk. Sn acts like resonant level

J Mater Sci: Mater Electron

Comparative fermiology study of $PbBi_2Te_4$ and $SnBi_2Te_4$ 3D topological insulators

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Received: 2 April 2021
Accepted: 7 June 2021

ABSTRACT

A comparative study of electronic transport and Hall measurements of $PbBi_2Te_4$ and $SnBi_2Te_4$ single crystals are presented here. The phase coherence lengths at different temperatures are determined by fitting observed low-field weak antilocalization (WAL) effect with modified Hikami-Larkin-Nagaoka equation. Temperature dependence of phase coherence lengths are described in conjugation with electron–electron (*e–e*) and electron–phonon (*e–p*) interactions. The fitting parameters reveal *e–e*, *e–p* interactions that follow T^{-1}, $T^{-2.68}$ power law, respectively, for $PbBi_2Te_4$ single crystal, while for $SnBi_2Te_4$ single crystal *e-e* and *e-p* interactions obey T^{-1} and $T^{-2.8}$ power law, respectively. These indicate the two-dimensional conducting channels are participating in WAL effect. Analysis of the high-field beat-like Shubnikov-de Haas (SdH) oscillations reveals the presence of topological surface states and an elongated band outside the surface states, the non-trivial nature of which is confirmed from the observed $\frac{1}{2}$-shift in Landau levels fan diagram. Estimated lower effective mass from Lifshitz-Kosevich (LK) fit and higher mobility values determined from Dingle analysis confirm the surface origin of the SdH oscillations. Comparison of the effective mass, quantum scattering time, mean free path, mobility, and metallicity parameters for the carriers at the topological surface states determined from the SdH oscillations for both the compounds reflect the topological surface states in $PbBi_2Te_4$ are of superior quality over the topological surface states in $SnBi_2Te_4$. This is indeed the case as Pb with higher atomic weight is replaced for Sn in $SnBi_2Te_4$, which provides more spin-orbit coupling in the system.

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https://doi.org/10.1007/s10854-021-06350-2
Published online: 02 July 2021

J Mater Sci: Mater Electron

Structural, magnetic, dielectric and ^{57}Fe Mössbauer spectroscopic studies on $Fe_{1-x}Ce_xVO_4$: a type-II multiferroic material

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Received: 16 October 2020
Accepted: 2 February 2021

ABSTRACT

Here, we report detailed studies on magnetic phase transitions and magneto-electric (ME) coupling in $Fe_{1-x}Ce_xVO_4$. X-ray diffraction (XRD) and Raman spectroscopic measurements confirm triclinic crystal structure (P-1) with small variation in lattice parameters and Ce incorporation into the $FeVO_4$ lattice up to 10% of Ce. The presence of local lattice distortions and electronic inductive effect in $FeVO_4$ between Fe^{3+} and V^{5+} ions were found in X-ray absorption near edge structure (XANES) studies due to the presence of Fe^{3+}–O–V^{5+} linkages. Two antiferromagnetic (AFM) transitions similar to $FeVO_4$ appear at 21.86 K and 16.03 K, and Ce doping has little effect on the magnetic transitions. ^{57}Fe Mössbauer spectroscopic results show the invariance of Fe valance. Low temperature high magnetic field Mössbauer data depicts the presence of spiral AFM order in all the samples. A sharp peak at 16.0 K in dielectric permittivity with minimal suppression due to applied magnetic field is observed indicating the presence of ferroelectricity and magneto-dielectric coupling. Magnetic and ME transitions are almost robust against Ce doping.

1 Introduction

Multiferroic materials having multiple ferroic orders are studied extensively due to their potential in magnetic storage media and spintronics applications [1–3]. Type-II multiferroicity in large number of systems where the origin of multiferroicity is not clear has been an active area of research throughout the world [4–10]. The commonly found microscopic interactions in different types of type-II multiferroic materials are (i) symmetric spin exchange interaction

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https://doi.org/10.1007/s10854-021-05453-0
Published online: 22 February 2021

Physica E 130 (2021) 114672

Contents lists available at ScienceDirect

Physica E: Low-dimensional Systems and Nanostructures

journal homepage: http://www.elsevier.com/locate/physe

Transport evidence of linear Dirac dispersion of non-trivial surface states in Fe-substituted $PbBi_2Te_4$ 3D topological insulator

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ARTICLE INFO

Keywords:
Topological insulators
Fermi level tuning
Weak antilocalization
Shubnikov-de Haas oscillations
Linear Dirac dispersion
Hall effect

ABSTRACT

We report here the experimental realization of Dirac Fermions in electronic transport measurements through observation of Shubnikov-de Haas (SdH) oscillations with π-Berry phase in $PbBi_{2-x}Fe_xTe_4$ 3D topological insulators. Substitution of magnetic impurity Fe^{2+} for Bi^{3+} ions have tuned the Fermi level towards the Dirac point, evident from the Hall measurements as well as from the SdH oscillations. SdH oscillations of all the single crystals reveal the existence of non-trivial topological surface states along with an elongated band for $x = 0$ outside the surface states, associated with the π-Berry phase of the carriers, and is absent for doped specimens. The massless nature of the carriers having Fermi velocity $\sim 10^5$ ms^{-1}depicts their relativistic nature. The carrier's effective mass are successfully tuned with successive Fe substitution, showing linear dependency on the Fermi wave vector, indicating the linear Dirac dispersion of topological surface states. The observed weak antilocalization fitted with modified Hikami-Larkin-Nagaoka (HLN) equation corroborates the 2D surface states in which the pseudo spin of the carriers move round the Dirac point acquires π-Berry phase and is consistent with the SdH oscillations.

1. Introduction

New Quantum phase of matter that breaks the traditional way of classifying different phases depending on Landau spontaneous symmetry breaking theory and possesses back scattered prohibited conducting boundaries with insulating bulk, has been classified as topological insulators (TIs). Strong spin-orbit coupling of the constituent heavy elements of TIs plays the main trick and shifts the surface energy band giving rise to band inversion at the finite energy gap in the bulk [1–5]. The point of inversion within the bulk band gap is known as Dirac point (DP). Surface carriers become mass less ($m^* \rightarrow 0$) as the Fermi level moves towards the DP. For such mass less Fermions the solution of relativistic Dirac equation, $E = \pm c\sqrt{p^2 + m^{*2}c^2}$ reduces to $E = \pm pc$ i.e., energy eigenvalue (E) varies linearly with momentum ($p = \hbar k$, $\hbar$ corresponds to reduced Planck's constant and k is Fermi wave vector) where c is the velocity of light [6]. The surface states of TIs thus obey linear Dirac dispersion [7,8], unlike parabolic nature of bulk bands. This exotic nature of the surface states can experimentally be verified through angle resolved photo emission spectroscopy (ARPES) [7,8] and scanning tunneling microscopy (STM) [9,10] measurements. Though, experimental realization of topological insulators via electronic transport studies is central for their practical applications as well as to understand the fundamental physics, yet it is quite challenging to probe the surface states in transport measurements as unlike other techniques (e.g., ARPES, STM) this required physical contacts with the sample. The essence of surface states in electronic transport measurements can be obtained from the observation of Shubnikov-de Haas (SdH) oscillations with π-Berry phase [11,12] together with the higher mobility value of the carriers [12,13]. There are very few reports where the evidence of linear Dirac dispersion of surface states in electronic transport measurements is given [11,14–16]. The main strategy to reveal linear Dirac dispersion of surface states in electronic transport is to tune the Fermi

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https://doi.org/10.1016/j.physe.2021.114672
Received 31 October 2020; Received in revised form 6 January 2021; Accepted 3 February 2021
Available online 23 February 2021

ACS OMEGA

http://pubs.acs.org/journal/acsodf

Article

Direct Oxidative Azo Coupling of Anilines Using a Self-Assembled Flower-like $CuCo_2O_4$ Material as a Catalyst under Aerobic Conditions

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Cite This: *ACS Omega* 2020, 5, 30416−30424

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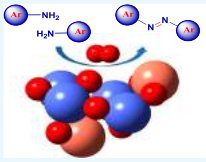
ABSTRACT: Herein, we report the synthesis of a self-assembled flower-like $CuCo_2O_4$ material by the oxalate decomposition method. The crystalline structure and morphology of the material have been analyzed by powder X-ray diffraction, Raman spectroscopy, field-emission scanning electron microscopy, transmission electron microscopy, and energy-dispersive X-ray measurement techniques. The self-assembled flower-like $CuCo_2O_4$ material showed remarkable catalytic activity in the direct aerobic oxidative azo coupling of anilines under oxidant and other additive-free reaction conditions. The mechanistic insight of $CuCo_2O_4$ in the oxidative azo coupling reaction has been established by density functional theory calculations, which disclosed that the absorption and dissociation of areal oxygen preferentially take place at the Cu site and dissociation of aniline takes place at the Co site. Thus, the Cu and Co sites of $CuCo_2O_4$ exert a cooperative effect on the direct oxidative azo coupling reactions through the selective activation of anilines and aerobic oxygen. The $CuCo_2O_4$ material was recovered from the reaction mixture and reused for at least eight runs without appreciable loss of catalytic activity.



- Robust and economic spinel $CuCo_2O_4$ as reusable catalyst
- Additive-free aerobic oxidation
- DFT calculation
- Synergic effect of Cu & Co
- Sustainable approach

INTRODUCTION

Recently, spinel structures (AB_2O_4) having binary and ternary mixtures of metal oxides have been established as promising redox catalysts.[1−6] The presence of two mixed valence metal cations offers an opportunity for transporting electrons very easily between multiple transition-metal cations with relatively low energy of activation. Among the spinel structure, spinel cobaltites (MCo_2O_4), particularly $CuCo_2O_4$, are fascinating due to their low cost, nontoxicity, higher stability, higher electronic conductivity, and electrochemical properties. To date, $CuCo_2O_4$ has been widely used in the fabrication of supercapacitors,[1] Li-ion batteries,[2] electrodes for oxygen evolution reaction,[3] electrochemical sensors for glucose[4]/acylcholin,[5] and catalytic oxidation of isopropanol.[6] However, the catalytic activities of spinel type MCo_2O_4 in useful organic transformations have not been investigated. Here, we speculated that the spinel cobaltite will be very effective as a catalyst for oxidation reactions, and we have taken the initiative to explore the catalytic activity of $CuCo_2O_4$ in the direct oxidation of anilines to aromatic azos.

Synthesis of aromatic azo compounds is essential as these moieties have found wide industrial applications for the preparation of dyes, pigments, indicators, radical initiators, and additives for food. Azos have also been used as therapeutic, diagnostic, and pro-drug agents as well as building blocks of various polymers and natural products.[7] These molecules have also been frequently applied in electronics and optics.[8] Several strategies have been reported in the literature for the manufacture of azo compounds due their abovementioned widespread applications. The conventional methods include diazotization of anilines,[9] reduction of azoxybenzenes,[7a] reductive coupling of nitroaromatics, etc.[10] Besides these methods, direct oxidative coupling of anilines using stoichiometric oxidants, such as HgO,[12a12b]/$Pb(OAc)_4$[12]/Mn-based reagents[13]/^{t}butyl hypoiodite,[15] is also reported. Later, metal-catalyzed azo coupling reactions using O_2 or air as the oxidant have been developed.[15] However, most of these methods have serious drawbacks such as lower yields, longer reaction times (~24 h), use of very toxic oxidants (HgO, $Pb(OAc)_4$, ^{t}butyl hypoiodite)[11−14] and flammable (O_2 gas) or biohazardous reagents (CO gas), and use of metal salts as homogeneous catalysts in combination of nitrogen-containing base, additives, etc. Thus, development of an efficient and sustainable protocol for direct synthesis of azos by oxidative azo coupling of anilines is considerably anticipated.

In continuation of our previous research on developing sustainable organic transformations using heterogeneous nanocatalysts,[16,17] we have previously synthesized Cu_2O−RuO_2[18] and $Cu_{0.9}Fe_{0.1}$@RCAC[18] materials for the oxidative azo coupling of anilines.[17] In this paper, we report the synthesis of self-assembled flower-like $CuCo_2O_4$ and its

Received: July 25, 2020
Accepted: October 6, 2020
Published: November 17, 2020

Materials Letters 283 (2021) 128725

Contents lists available at ScienceDirect

Materials Letters

journal homepage: www.elsevier.com/locate/mlblue

Large area semitransparent inverted organic solar cells with enhanced operational stability using TiO_2 electron transport layer for building integrated photovoltaic devices

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ARTICLE INFO

Article history:
Received 18 August 2020
Accepted 20 September 2020
Available online 24 September 2020

Keywords:
Solar energy materials
TiO_2
Energy storage and conversion
Organic solar cell
Device stability

ABSTRACT

Herein, we have demonstrated the semitransparent organic solar cell (OSC) devices in inverted architecture with TiO_2 as an electron transport layer (ETL). A comparative study is performed with widely used ZnO ETL based devices. The devices with TiO_2 ETL exhibits better device efficiency (2.44%) in comparison to ZnO counterparts (1.94%). The transfer matrix calculations finding indeed validate the experimental results. Furthermore, the large area OSC devices of size 1 cm^2 have been fabricated. The device stability is investigated under operational conditions by measuring time dependent device performance in biased condition at maximum power point. Our findings suggest that the devices fabricated using TiO_2 ETL is much more durable as compare to ZnO based devices.

1. Introduction

In the last few decades, organic solar cell (OSC) technology has witnessed a significant breakthrough in the field of photovoltaics by achieving the power conversion efficiency (PCE) of ~17.3% in tandem solar cell architecture. Note that this value (PCE ~17.3%) in OSCs is very close to commercially available photovoltaic devices. Not only the efficiency, the OSCs have many other technological advantages such as mechanical flexibility, large-area fabrication, ease in processing which makes OSCs superior contender as compared to existing Si-based photovoltaic technology. Many reports are available on solution-processed high performance OSC devices. However, the large-area device integration is the current global demand. In order to realize the large-area devices, several device architectures are proposed. *Hong et* al. has demonstrated large-area modules with PCE ~7.5% using slot die coating technique [1]. Moreover, the issues related to the operational device stability in the ambient atmosphere needs yet to be solved along with a clear understanding of degradation is the utmost necessary for the development of commercial grade OSC devices. It is a well-accepted fact that device stability and efficiency is significantly dependent on the electron and hole transport layer. The quest for an alternative of electron transport layer for inverted device architecture leads to the application of a large number of metal oxides such as Zinc Oxide (ZnO), Titanium Oxide (TiOx), Tungsten Oxide (WOx), Nickel Oxide (NiOx), Molybdenum Oxide (MoOx) and Vanadium Pentoxide (V_2O_5), etc [2].

Among all these metal oxides, ZnO attracted a lot of attention due to its suitable optoelectronic properties. Despite interesting properties, ZnO shows some issues due to the chemisorbed oxygen (O_2) which strongly affects the electrical properties of the material. Furthermore, in the case of semitransparent OSCs, light coupling near the ZnO interface is comparatively low which limits the photon absorption within the photoactive layer. In order to overcome these issues, many-electron and hole transport layers with different types of transparent electrodes have been explored. Cho *et* al. have reported ~2.35% PCE in solar cells fabricated in inverted the architecture of indium tin oxide (ITO)/cesium carbonate (Cs_2CO_3)/P3HT: PCBM/transparent multilayer (MoO_3/Ag/MoO_3) [3]. Huang *et* al. fabricated a semi-transparent plastic solar cell by a lamination process using a Cs_2CO_3 buffer layer and achieved the PCE of ~3.2% [4]. Schmidt *et al.* demonstrated efficient semitransparent inverted organic solar cells with ITO as a top electrode, TiO_2 as

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https://doi.org/10.1016/j.matlet.2020.128725
0167-577X/

Journal of Applied Physics ARTICLE scitation.org/journal/jap

Influence of fractal and multifractal morphology on the wettability and reflectivity of crystalline-Si thin film surfaces as photon absorber layers for solar cell

Cite as: J. Appl. Phys. **129**, 045301 (2021); doi: 10.1063/5.0023474
Submitted: 30 July 2020 · Accepted: 3 January 2021 ·
Published Online: 22 January 2021

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ABSTRACT

Crystalline Si films incorporated with Al are important for applications in microelectronics and solar cells. In this paper, we report on the morphology of crystalline Si surfaces in Al/amorphous-Si bilayer thin films under ion beam irradiation at 100 °C. Micro-Raman and transmission electron microscopy studies show that best crystallization is achieved at a fluence of 1×10^{12} ions cm^{-2}. The contact angle of Si surfaces (after chemically etched unreacted Al), referred to as absorber surfaces, decreases with increasing ion fluence. These surfaces are hydrophobic in nature and the hydrophobicity decreases with increasing ion fluence. Fractal and multifractal analysis of atomic force microscopy images, along with system energy/unit cell and Laplace pressure calculations, supports our observations. Moreover, the calculated multiple scattering cross sections of light, along with reflectivity measurements, indicate that absorber surfaces of best crystalline films have the lowest reflectivity. The present results suggest that such surfaces having low optical reflectance and a hydrophobic nature can be used as photon absorber layers for advanced solar cell devices.

I. INTRODUCTION

Crystalline-silicon (*c*-Si) films and their alloys with some metals have been the focus of extensive research due to their applications in photovoltaic devices as absorber layers and in microelectronics.[1–14] Al incorporated Si layers fabricated by the process of aluminum induced crystallization (AIC)[15–25] have been successfully utilized for the fabrication of solar cells with efficiencies ranging from 3% to 11%.[26–31] In the AIC process, amorphous-Si (*a*-Si) is normally crystallized by thermal annealing at around 200 °C.[15–31] Recently, ion beam irradiation has been demonstrated as an effective tool to synthesize such layers at slightly above room temperature due to its highly precise spatial and local controls.[32,33] However, for the effective use of *c*-Si layers as absorbers in solar cells, it is essential that *c*-Si films possess

Thin Solid Films 733 (2021) 138826

Contents lists available at ScienceDirect

Thin Solid Films

journal homepage: www.elsevier.com/locate/tsf

Growth of low resistive nickel mono-silicide phase under low energy Si ion irradiation at room temperature

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ARTICLE INFO

Keywords:
Nickel mono-silicide
Thermal evaporation
Low energy ion irradiation
Rutherford backscattering spectrometry
X-ray diffraction
Transmission electron microscopy

ABSTRACT

Nickel mono-silicide (NiSi) is considered as a promising material for developing low resistance contacts in complementary metal-oxide-semiconductor technology. In the present work, we report the effect of Ni film thickness on orientation control of low resistive Nickel mono-silicide (NiSi) phase formation using low energy ion irradiation at room temperature. In order to study the effect of Ni film thickness on NiSi phase formation, the Ni films of thicknesses 30 nm and 60 nm were deposited on Si (111) substrate using thermal evaporation technique in a high vacuum chamber. The as prepared Ni/Si samples were then irradiated via 120 keV Si ions with different fluences of 7×10^{14}, 1×10^{15}, 3×10^{15} and 7×10^{15} ions-cm^{-2} at room temperature. The x-ray diffraction and transmission electron microscopy measurements clearly confirm the formation of mono-silicide phase. The composition of the NiSi phase is determined by Rutherford backscattering spectrometry measurements. The crystallinity of NiSi phase has been observed to be better for 60 nm Ni film as compared to the 30 nm Ni film on Si substrate. Most of the NiSi crystallites are found to be oriented in (103) lattice plane. The resistivity and sheet resistance of the NiSi/Si films are found to be very low. The role of composition of Ni and Si in NiSi phase on resistivity and sheet resistance of the films has been investigated carefully. The detailed mechanisms behind the above observations have been discussed in the paper.

Introduction

The application of metal silicides as materials for source, drain and gate resistances in submicron-level metal-oxide-semiconductor (MOS) devices triggered a tremendous research activity aiming to understand the Nickel-Silicide (Ni-Si) system and develop efficient ways to synthesize it [1-3]. Since several years, $TiSi_2$ and $CoSi_2$ have been extensively used to reduce the source, drain and contact resistance in semiconductor devices, including complementary-metal-oxide-semiconductor (CMOS) devices [4-6]. However, as the device dimensions decrease, the resistance has been found to increase disproportionately due to several material-specific reasons. For instance, when the dimension are reduced below 350 nm, the low nucleation density of the desired C54 $TiSi_2$ phase was found to be responsible for the increase in the resistivity in $TiSi_2$. The use of transition elements to increase the nucleation density was found insufficient for low contact resistance below 200 nm. The use of $CoSi_2$ somehow helped the manufacturers to develop gates with low contact resistances for dimensions to 100 nm, but as the dimensions went further down, the contact resistance was found to again increase dramatically [5]. Nickel mono-Silicide (NiSi) has been found to be a promising substitute for developing low resistance contacts beyond 100 nm because of several factors. However, there are several challenges that must be addressed to realize the full potential of NiSi: for example, avoiding the formation of high resistance phases such as $NiSi_2$ and ensuring the stability of NiSi phase over the operational regime of the device.

The conventional schemes to fabricate NiSi may be categorized into either thermal annealing or ion implantation schemes. Thermal annealing has been most popular [7-14], in which a thin film of Ni is deposited on a Si substrate by various methods such as electronic-beam evaporation [7-9, 11], high vacuum evaporation [10], sputtering [12], and chemical vapor deposition [13-14]. The Ni film on Si substrate is

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https://doi.org/10.1016/j.tsf.2021.138826
Received 9 June 2020; Received in revised form 5 July 2021; Accepted 5 July 2021
Available online 10 July 2021

Synthesis and Characterization of CeO_2 Nano Particles

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Abstract. In this paper, we have synthesized the Cerium oxide Nanoparticles (Ceria NPs) by Co precipitation (CPT) method using Cerium tri -nitrate hexahydrate and also potassium carbonate solutions. Then synthesized precipitate was heated at 70℃ for 20 hour. Slow grinding of the precipitate and calcined for 3 hours at different temperatures viz. 700° C, 850° C to form fine Cerium oxide powder- Ceria NPs. The characterization of Ceria NPs calcined at temperatures viz 700° C, 850° C have been done through X-ray diffraction and Raman Analysis. EDS, Scanning Electron Microscopy (SEM), The X-Ray diffraction pattern shows the nature of the Ceria NPs crystal ,with a cubic structure and lattice parameters 5.392 Å for samples calcined at temperature of 700° C and 5.357 Å at 850° C which shows decreasing trend in lattice parameter with calcination temperature. The intensity of Raman peaks is shifted upwards with a rise in temperature. This intensity difference could be because of the rise in vibrational amplitudes of the closest neighboring bonds because of the increase in particle size 11.3 ± 1.0 to 15.6 ± 1.0 nm calcination temperatures at 700° C and 850° C and therefore the Raman peak of peak I, 461 cm^{-1}& peak II, 463 cm^{-1} respectively. Other peaks were not observed in this Raman pattern. The EDS analysis confirms the presence of the Ce and O atoms in the synthesized samples. The morphology and microstructures were studied using SEM analysis. Spherical shapes and homogeneously distributed Ceria NPs and a rather tendency for agglomeration were confirmed.

INTRODUCTION

Ceria (CeO_2) Nano Particles is an oxide, used in the sector of Catalysis, Electro chemistry, Photo-chemistry, and Materials science, Biomedical, Luminescent etc.[1-5]. ,extremely prompt ultraviolet (UV) absorbent ,an oxidation agent and electrochemical devices counter electrode and LPG sensor ,Solid fuel cells electrolyte materials [6-11] .Ceria NPs part Cerium -Ce ,which may be a rare earth element, Lanthanide group(La group) element , whose electronic configuration $4f^1 5d^1 6s^2$, can exist both free or within the oxide form [12-14],excellent semiconductor material that has two valence states of Ce^{3+} (Ce_2O_3) and Ce^{4+} (CeO_2) and also the space group is (Fm3m), fluorite and important quality to modify very easily and reversibly between these oxidation states, and forming, filling, and moving oxygen vacancies within samples [15–17], these two characteristic forms, Ceria NPs are considered because the most stabilize with a fluorite cubic structure, which contains centers of eight coordinate Cerium enclosed by a cube of eight oxide ions . Ce^{4+} ion which contain oxygen vacancies and distortion of the local symmetry [18]. Ceria NPs may be either intrinsic or extrinsic defects. Intrinsic defects are due to thermal disorder in the crystal and between the solid and surrounding atmosphere, whereas the extrinsic defects are due to an impurity or appearance of a foreign dopant Point defects consist of vacant lattice sites, several properties (e.g. conductivity, luminescence and diffusion) in this Ceria NPs are often enhanced or reduced by the existence of those defects .One of important characteristic within the case of intrinsic defects, the CN of Ce^{4+} to O^{2-} to reduce at temperatures (>650ºC). This in turn to reduce the Ce^{4+} to the Ce^{3+} ions as two electrons from an oxygen atom, a vacancy site is created. So this paper is especially focused on temperature of 700° C, 850° C of this ample Ceria NPs.The synthesis of Ceria NPs, surface morphology, and dominated size are significant interest in Materials Science [1-5]. Most Ceria NPs materials were produced at high temperatures (>300ºC), over long periods (24h), because of the necessity to get reliability and nanoparticles with the physical and chemical properties.It is difficult to synthesize very small Ceria NPs and have a narrow distribution sizes. For the little

Advanced Materials and Radiation Physics (AMRP-2020)
AIP Conf. Proc. 2352, 040028-1–040028-5; https://doi.org/10.1063/5.0052427
Published by AIP Publishing. 978-0-7354-4105-7/$30.00

Synthesis and Characterization of Cerium Substituted Cobalt Ferrite

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Abstract. Effect of Cerium doping on cobalt-ferrites has been synthesized by the solid state reaction method. The sintered samples of $CoCe_xFe_{2-x}O_4$ (x = 0.05 and 0.10) were characterized by X-ray diffraction (XRD) and vibrating sample magnetometer. The XRD spectra shows the cubic spinal structure (space group *Fd3m*). The lattice parameter decreased with increasing Ce concentration. Increasing amount of Cerium causes little change in the magnetic parameters namely saturation magnetization, coercivity and remanence.

1. INTRODUCTION

Recently metal-oxide has been the subject of much interest because of their unusual optical, electronic and magnetic properties. Cobalt ferrite ($CoFe_2O_4$) is a well-known hard magnetic material with high coercivity and moderate magnetization. It has a high coercivity of 5000 Oe, a moderate saturation magnetization of about 80 emu/g, a high Curie temperature (T_C) of 520 °C, and a high anisotropy constant of 2.65×10^6 to 5.1×10^6 erg/cm^3 [1-2]. Moreover, cobalt ferrite exhibits good insulation, and excellent chemical stability and physical hardness [1–5]. Hard magnetic cobalt ferrite has been widely used as a high-density magnetic recording medium in magnetic recording [6]. The properties of CoFe2O4 can be altered by substitution of different divalent and trivalent metal ions. Due to this much more work has been conducted on $CoFe_2O_4$ doped with metals and rare earth (RE) metals [7]. Anu et al observed significant effect of Zn substitution on Magnetic and electrical conductivity of $CoFe_2O_4$ nanofluids [8]. Xavier et al. indicates that saturation magnetization decreased with an increase in Sm contents in $CoFe_2O_4$ nanoparticles [9]. Melikhov et al. have investigated the temperature variation of magnetic anisotropy and coercive field of magnetoelastic Mn substituted cobalt ferrites ($CoMn_xFe_{2-x}O_4$ with $0 \leq x \leq 0.6$) [10]. Wu et al. have reported infrared radiation properties of $CoFe_{2-x}Ce_xO_4$ (x = 0, 0.01, 0.05, 0.1 and 0.15) via the sol-gel autocombustion method [11]. In this paper, we report X-ray diffraction and magnetization measurements on two samples with substitution of 5 atomic% and 10 atomic% of cerium for Fe in $CoFe_2O_4$, viz., $CoCe_{0.05}Fe_{1.95}O_4$ and $CoCe_{0.10}Fe_{1.95}O_4$.

2. SAMPLE SYNTHESIS AND CHARACTERIZATION

Cerium substituted cobalt ferrite, $CoCe_xFe_{2-x}O_4$ (x = 0.05 and 0.10), powders were prepared by a solid state reaction. Accurately weighed powders of Fe_2O_3, Co_3O_4 and CeO_2 were mixed together and then milled for 2 hour using mortar. The milled powder was sintered at 850˚C for 8 hrs. All sintering processes are carried in open air. The X-ray powder diffraction patterns of the samples were collected on Rigaku Smart Lab powder diffractometer using Cu K-Alpha radiation. Vibrating sample magnetometer (VSM) is used for the magnetic measurement.

Advanced Materials and Radiation Physics (AMRP-2020)
AIP Conf. Proc. 2352, 020058-1–020058-4; https://doi.org/10.1063/5.0052392
Published by AIP Publishing. 978-0-7354-4105-7/$30.00

Materials Today: Proceedings 46 (2021) 2183–2188

Contents lists available at ScienceDirect

Materials Today: Proceedings

journal homepage: www.elsevier.com/locate/matpr

Comparative study between microwave and infrared assisted peeling of ginger

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ARTICLE INFO

Article history:
Received 18 January 2021
Received in revised form 24 February 2021
Accepted 2 March 2021
Available online 30 March 2021

Keywords:
Peeling
Microwave processing
Infrared observation

ABSTRACT

Gingers are improper in shape, so the peeling process is very time consuming. Gingers of equal weight (approximate) were taken and washed in tap water and then were drained to remove the excess water and done for the primary trials. We have studied the impact of infrared heating and microwave heating parameters on physical and peeling properties of ginger and done the comparative study of infrared and microwave assisted ginger peeling. ANOVA represents that both MW power and MW time had a important ($p < 0.01$) effect on moisture loss, peel loss and peelability. The moisture loss, peel loss and peelability increased with the increased in MW power but at high power peel loss and peelability decreased. The peel loss and moisture loss increased with the increase in MW time. Peelability decreased at high MW time. In infrared assisted peeling ANOVA represents that distance had a important (peelabilty is <0.01), effect on moisture loss, peel loss and peelability. The peel loss showed no important ($p > 0.05$) changes with change in treatment time. Peel loss and peelability were significantly ($p < 0.05$) affected by treatment time. The moisture loss, peel loss and peelability decreased with increase in distance between heating source and sample. The moisture loss increased with increase in treatment time but peelability decreased with the same. Microwave heating showed the minimum (0.46%) moisture loss, and minimum (0.46%) peel loss whereas infrared heating gave the (35.5%) maximum peelability.

Selection and peer-review under responsibility of the scientific committee of the International Conference on Multifunctional Nanomaterials.

1. Introduction

Gingers, important spicery cash crop of the world, obtained from the rhizomes of Zingiber officinale. Tropical family group, derived from the Sanskrit word Singabera i.e. shaped as Ginger and its products have varied applications in different fields. Dried ginger is used both as a spice and medicine and comprises an essential oil, which imparts an aroma, an oleoresin responsible for the pungent smell, many important nutrients .Ginger can be grown both under rain fed and irrigated conditions. India accounted for 30% of the world overall production, followed by other countries. Ginger has staring potential for treating a number of ailments. It also has anti-inflammatory and anti-oxidative properties. The bioactive molecules of ginger like gingerols have shown antioxidant activity in various modules [1,2]. The major component in ginger rhizomes are carbohydrates, lipids (3–8%), terpenes, and phenolic compounds [3]. Besides these, amino acids, raw fiber, ash, protein, phytosterols, vitamins and minerals are also present [4]. Ginger plays an important role in different diseases. Ginger consumption before exercise might reduce naturally occurring quadriceps muscle pain [5].

Peeling is an important step in the processing of fruits, vegetables and spices. Infrared radiation (IR) energy is in the electromagnetic wave form and can be used for thermal processing of foodstuff Enzymatic peeling, ohmic peeling, and ultrasonic peeling have been studied..Microwave heating is generally performed by locating the sample within a container, can show absorb or transmit microwaves based on the dielectric properties. Keeping in view the above facts, the following objectives were undertaken in this paper.

- To study the impact of infrared heating and microwave heating parameters on physical and peeling properties of ginger.
- Comparative study of infrared and microwave assisted ginger peeling.

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https://doi.org/10.1016/j.matpr.2021.03.033
2214-7853/
Selection and peer-review under responsibility of the scientific committee of the International Conference on Multifunctional Nanomaterials.

Applied Surface Science 536 (2021) 147830

Contents lists available at ScienceDirect

Applied Surface Science

journal homepage: www.elsevier.com/locate/apsusc

Structural and optical properties of multilayered un-doped and cobalt doped TiO_2 thin films

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ARTICLE INFO

Keywords:
Spin coating
X-ray diffraction
Spectroscopic ellipsometry
Transmittance
Refractive index

ABSTRACT

The present investigation reports the effect of multilayers (1, 3 and 7 layers) and cobalt (Co) doping on structural and optical properties like transmittance, refractive index, extinction coefficient, etc. of TiO_2 thin films prepared by a sol–gel spin coating technique. X-ray diffraction (XRD) and Raman spectroscopy were used to investigate the phase and structure of the prepared films which confirm the formation of single phase anatase TiO_2 structure of the films. Morphology study by SEM indicate development of cracks with increase in number of layers at large scale but in the small (nano) scale the films are compact and smooth. Thickness study by cross sectional SEM shows increase in thickness with increase in number of layers. Energy Dispersive X-ray spectra were used to study the presence of cobalt in doped films. UV–Visible spectroscopy was used to study the transmittance of the films and spectroscopic ellipsometry was used to study the optical constants like refractive index and extinction coefficient which indicate the highest refractive index and the lowest extinction coefficient for single layered cobalt doped TiO_2 thin films while 7 layered films show the lowest refractive index and the highest transmittance. Spectroscopic ellipsometry studies indicate increase in packing density of coated layers in Co-doped TiO_2 films due to which refractive index as well as transmittance of these films are significantly more in comparison to undoped films. Photoluminescence spectra show increase in oxygen vacancies in Co-doped multilayered TiO_2 films indicating increase in blue emission. Thus, the enhanced values of refractive index as well as transmittance and blue emission in Co-doped TiO_2 multilayers films are promising for optical device applications.

1. Introduction

Titanium dioxide (TiO_2), popularly known as titania is a wide band gap semiconductor, has been given large importance due to its non toxicity, cost effectiveness, biocompatibility, good chemical stability, high refractive index, high transmittance in the visible region, strong catalytic activity, good antibacterial properties etc. [1–6]. Due to these excellent properties it finds potential applications in cosmetics, paints, self-cleaning surfaces, water purification, light assisted water splitting and photocatalytic reaction [7–10]. The large interest in this material arises due to its tunable optical and electronic properties. In thin film form, TiO_2 finds various applications in antireflection coatings, multilayer optical coatings, gas sensors, solar cells, LEDS, spintronics, energy storage, photocatalysis etc. [11–17]. However due to its wide band gap (3.0–3.2 eV) it finds limited applications as small region of solar energy can be used for practical purposes. Generally, TiO_2 has been found in three different polymorphs i.e anatase, rutile and brookite. Among these, anatase and rutile phases have significant applications in optoelectronics and photovoltaics due to its good photo stability, chemical stability, transmittance in the visible region, high refractive index etc. As a bulk material, rutile is the most stable form at higher temperatures (700 to 900 °C), however, at lower temperatures (from 400 to 600 °C) solution phase preparation method is generally preferred for anatase phase formation [18–22]. Various thin film

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https://doi.org/10.1016/j.apsusc.2020.147830
Received 16 February 2020; Received in revised form 4 August 2020; Accepted 5 September 2020
Available online 11 September 2020
0169-4332/

Journal of Luminescence 233 (2021) 117737

Contents lists available at ScienceDirect

Journal of Luminescence

journal homepage: http://www.elsevier.com/locate/jlumin

Near-infrared light-mediated Er^{3+} and Yb^{3+} co-doped $CaTi_4O_9$ for optical temperature sensing behavior

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ARTICLE INFO

Keywords:
Up-conversion
Fluorescence intensity ratio
Calcium titanate
Temperature sensing

ABSTRACT

In present report, $CaTi_4O_9$: 1 at% Er^{3+}, 1 at% Yb^{3+} phosphors have been synthesized via sol-gel method and reported herein for its temperature sensing performance. XRD spectra confirms high crystallinity and successful inclusion of rare earth (RE) ions into $CaTi_4O_9$ as the dopant ions do no induce any change in the peak position. The X-ray diffraction analysis indicates that the host calcium titanate exhibits hexagonal crystal structure. The green up-conversion (UC) emission observed using 980 nm diode laser excitation. Since, Er^{3+} ion has ladder type energy levels, thereby it receives energy from Yb^{3+} ion by excited state absorption and energy-transfer up-conversion processes. Furthermore, the Er^{3+} ion has two temperature sensing levels $^4S_{3/2} \rightarrow {}^4I_{15/2}$ (550 nm) and $^2H_{11/2} \rightarrow {}^4I_{15/2}$ (525 nm). Therefore, temperature dependent up-conversion spectra illustrate good temperature sensitivity for present phosphor. The sensitivity of above mentioned phosphor has been evaluated with temperature from 300K to 500K, which shows the suitability of the phosphor for developments in temperature thermometry.

1. Introduction

The field of up-conversion causes immense attraction because of its ability to generate photons of shorter wavelengths as compared to excitation wavelengths on laser stimulation [1]. **The growing interest in up-converting materials, doped with trivalent rare earth (RE^{3+}) ions is because of their applicability to solar cells, color display, bio-label, fiber optic communication, temperature sensors etc** [2–8]. Till the date most of these potential applications are in design phase, and hence further basic research in this field remains a challenge [9]. The infrared to visible UC can be completely attributed to the interplay between host compound and rare earth centers. In photon up-conversion process ion-lattice interaction induces multiple electronic transitions in rare earth ions. In order to maximize radiative emissions, the lattice phonon energy should be minimum since the phonons present in the host cause non-radiative losses [10]. The linear or non-linear light matter interactions, one ion or a pair of ions' collective actions and resonant or photon assisted energy transfer causes photon emission, however the mechanism of up-conversion luminescence in nano-phosphors has become more complicated due to variations in electronic and chemical structures. To the date different up-conversion studies have been made with different nanoscale materials, e.g. halides, oxy-sulphides, oxides, vanadates, garnet etc [11,12]. Halides and oxy-halides have low phonon energy than the oxide hosts but due to poor chemical constancy and low laser penetration these hosts have limited applicability [13]. **Among several oxides, $CaTi_4O_9$ is chosen as host, because of its suitable properties such as low phonon energy, good chemical stability, low cost, lower relative permittivity (ε_r) and larger negative temperature coefficient of resonant frequencies (τ_f). The low phonon energy of host material, reduces the multi-photon relaxation rate and thus helps to achieve efficient UC emission** [14]. **Relative permittivity (ε_r) is an important property of a dielectric material and the dielectric response of the material is characteristic of Debye-like relaxation with a single relaxation time** [15]. **Also temperature coefficient of resonant frequencies (τ_f) is a vital aspect since negative τ_f produces a large resonant**

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Journal of Alloys and Compounds 866 (2021) 158936

Contents lists available at ScienceDirect

Journal of Alloys and Compounds

journal homepage: www.elsevier.com/locate/jalcom

Structural, morphological and thermodynamic parameters investigation of tunable $MAPb_{1-x}Cd_xBr_{3-2x}I_{2x}$ hybrid perovskite

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ARTICLE INFO

Article history:
Received 4 October 2020
Received in revised form 18 January 2021
Accepted 26 January 2021
Available online 2 February 2021

Keywords:
Thermodynamic
Hybrid perovskite
Pin hole
Band tunable

ABSTRACT

Organic-inorganic hybrid perovskites are a leading successor for the next-generation electronic and optoelectronic devices, owing to their unique optical and electrical properties. There has been a concerted effort to understand how different elements can further allow us to tune these properties more favorably for different applications. Herein, we propose to tune these properties further via simultaneous cation-anion co-doping in $CH_3NH_3PbBr_3$ perovskite using CdI_2. We probed how the incorporation of carefully selected anionic and cationic dopants may synergically affect the perovskite properties, including the crystalline phase, thin-film morphology, optical and thermodynamic properties. We supplemented our studies with microscopy, namely SEM coupled with EDAX, to analyze the impact of double dopants on the grain size, pinhole morphology, and elemental composition of the hybrid perovskites. Spectroscopic measurements (UV–Vis–DRS and FTIR) were conducted on the hybrids to see how the interactions with Cd and I with the perovskite might additively modulate the energy band gap and functional group functionality. With the help of the simultaneous application of TGA and DSC, we were able to characterize the thermodynamic behavior (thermal stability and enthalpy change) of co-doped hybrids, which become especially important when operating at scale. This combined spectroscopic and thermodynamic study on the effects of co-doping will help to develop better algorithmic designs to choose multiple dopants which can synergically enhance desired optoelectronic properties at scale.

1. Introduction

The emerging technique based on organic-inorganic perovskite metal halide perovskite (OIMH) has revolutionized as an excellent semiconductor for optoelectronics applications. Within a short period, the power conversion efficiency (PCE) of perovskite solar cells has increased rapidly from 3.8% to 24.15%, and the photoluminescence quantum yield (PLQY) of perovskite quantum dots (PQDs) reached up to 100% [1–3]. This outstanding performance of OIMH perovskite-based device is ascribed to the extraordinary structural and optoelectronic properties, for example, band tunability, high absorption coefficient, low excitation binding energies, long charge carrier life-time, high color purity and defect tolerant features [4,5]. Such kind of high enactment of OIMH perovskite materials poses an outstanding challenge to commercial silicon solar cell and traditional light-emitting diodes (LEDs). Beside this, low material cost, easy solution-processed technique, short reaction time, and high efficiency make OIMH perovskite-based devices promising candidates for optoelectronic applications over dye-sensitized solar cells (DSSCs) and organic solar cell/LEDs (OSC/OLEDs) [6,7].

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https://doi.org/10.1016/j.jallcom.2021.158936
0925-8388/

Emergent Materials
https://doi.org/10.1007/s42247-020-00155-5

REVIEW

A comprehensive tutorial on the pulsed laser deposition technique and developments in the fabrication of low dimensional systems and nanostructures

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Received: 4 October 2020 / Accepted: 19 December 2020

Abstract
Pulsed laser deposition (PLD) is a simple and extremely versatile technique to grow thin films and nanomaterials of a wide variety of materials. PLD allows the deposition of profoundly different materials, including high-temperature superconductors, oxides, nitrides, carbides, semiconductors, metals, and even polymers or fullerenes with high deposition rates. Growing thin films using PLD is now being used around the world for prototyping thin films of many inorganic materials and even in device fabrication protocols. This article covers the detailed development, versatility, and reliability of the ultraviolet (UV) excimer laser. It is envisioned that this review article is of interest for both the materials and chemical scientists engaged in more fundamental aspects of pulsed laser ablation and deposition. The present article highlights the historical developments of PLD technique, complete mechanism of thin film fabrication, optimization of the quality of thin films and the fabrication of thin films of the materials like ZnO, Graphene, MoS_2, and WS_2 which are being explored for various potential applications.

Keywords PLD · Thin films · ZnO · Graphene · MoS_2 · WS_2

1 Introduction to pulsed laser deposition

Since the discovery of lasers by H. Townes, these have played a significant part in the development of science and technology [1]. Lasers nowadays are used in a variety of applications in the field of physics, chemistry, biology, medicine, industries, materials, and various others. Soon after the discovery of ruby laser, the laser radiation first reported to ablate materials from the target in the early 1960s [2]. Some of the advanced applications of lasers in the field of materials processing are laser annealing [3], laser pyrolysis [4], laser-induced etching [5], laser-induced oxidation and nitridation of surfaces [6], laser-induced melting and fragmentation of more massive sized clusters into smaller one [7–9], and photolithography [10]. Pulsed laser deposition (PLD) can be used to vaporize and ablate all type of solids including metals [11–13], semiconductors [14], insulators [15], and for the fabrication of thin films and nanoscale materials [16–20] as it offers the quickest route to create prototypes of any thin-film coating. PLD also has critical applications as an analytical tool for the qualitative and quantitative estimation of composition. By using laser induced plasma spectroscopy (LIPS) [21, 22], the qualitative and quantitative estimation of the materials can be understood and also to study the plasma diagnosis [23–27], molecular spectroscopy [28–31], the evolution of molecular and atomic clusters in a vacuum, gas, and liquid phase. PLD has been recognized as a simple, flexible, and contamination-free technique for the fabrication of thin films and nanoscale materials of a wide variety of materials ranging from metal to insulators

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Published online: 06 January 2021

frontiers in Physics

ORIGINAL RESEARCH
published: 31 August 2020
doi: 10.3389/fphy.2020.00352

Magnetic and Dielectric Properties of La and Ni Co-substituted $BiFeO_3$ Nanoceramics

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The increasing plead for the realization of ultra-fast, miniaturized, compact, and ultra-low power consumption in electronic as well as spintronic devices has propelled the quest for novel multiferroic materials that efficiently enable voltage control of magnetism. The present work reports the phase stability, magnetic and dielectric responses of polycrystalline $Bi_{1-x}La_xFe_{1-y}Ni_yO_3$ ($0 \leq x \geq 0.2$ and $0 \leq y \geq 0.2$) multiferroic ceramics synthesized through a simplistic sol-gel approach. The maneuver substitutions of La at A^- site of $BiFeO_3$ multiferroic eliminate the secondary phases formed owing to impurities. Rietveld refined XRD analysis reveals the structural transformation of the orthorhombic (Pbnm) phase as La substitution increases. However, an additional lattice distortion is induced as a result of the substitutions of Ni atoms at B^- site. A substantial enhancement in magnetic and dielectric responses has been found in the co-doped (Ni and La) sample at both A and B^- sites as a result of the size confinement of nano-crystallites, the exchange interaction between Fe^{3+} and Ni^{2+} ions, and corresponding variation in Fe-O-Fe bond angles. The dielectric constant has increased substantially in the low-frequency region with simultaneous substitutions of La and Ni at the sites of Bi and Fe, respectively. A careful observation of temperature-dependent magnetization curves (FC and ZFC) indicates a spin glass response with entangled ferromagnetic components. The experimental findings infer that the co-substitutions of La and Ni at their respective sites in $Bi_{1-x}La_xFe_{1-y}Ni_yO_3$ ($0 \leq x \geq 0.2$ and $0 \leq y \geq 0.2$) may significantly improve the ferromagnetic and dielectric responses of the studied nanoceramics.

Keywords: multiferroics, BFO, magnetization, dielectric constant and loss, nanoceramics

OPEN ACCESS

Edited by:
Ambuthira Dutta,
Queen's University, Canada

Reviewed by:
Chirag Garg,
IBM Research Almaden, United States
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Specialty section:
This article was submitted to Condensed Matter Physics, a section of the journal Frontiers in Physics

Received: 20 June 2019
Accepted: 20 June 2020
Published: 31 August 2020

Citation:
Srivastava A, Singh AK, Srivastava ON, Tewari HS, Masood KB and Singh J (2020) Magnetic and Dielectric Properties of La and Ni Co-substituted $BiFeO_3$ Nanoceramics. Front. Phys. 8:352. doi: 10.3389/fphy.2020.00352

INTRODUCTION

Multiferroics are among the special class of materials having ferroelectric and ferromagnetic phases simultaneously and being studied extensively in the recent past as they offer some of the most promising applications of technological importance [1–5]. Among various multiferroic materials, $BiFeO_3$ (BFO) has emerged as a potential material offering a wide range of viable applications in next-generation actuators, sensors, non-volatile memory devices (FeRAMs), and photovoltaics as it

Journal of Molecular Liquids 337 (2021) 116557

Contents lists available at ScienceDirect

Journal of Molecular Liquids

journal homepage: www.elsevier.com/locate/molliq

Incorporation of zinc ions towards low toxicity and high stability of organic-inorganic methyl ammonium lead bromide perovskite QDs via ultrasonication route for white-LEDs

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ARTICLE INFO

Article history:
Received 10 February 2021
Revised 12 May 2021
Accepted 20 May 2021
Available online 24 May 2021

Keywords:
Organic-inorganic perovskite
Lead deficient
Stability
Color gamut
LEDs

ABSTRACT

B-site substitution perovskite quantum dots (PQDs) with amended stability and less toxicity have been acquainted in recent years. However, the PQDs comprising various B-site cations display low photoluminescence quantum yields (PLQYs), instability, and require skimpy synthesis procedure. Herein, we have endeavored to introduce ultrasonication synthesis of $MAPb1_{-x}Zn_xBr_3$ PQDs as an auspicious route to stable PQDs with enhanced PLQY. The successful synthesis of PQDs resulted in a high PLQY (>93%), which is supposed to be owing to the decrease in non-radiative recombination centers. Furthermore, we have found that the structure, morphology, and emission properties are secured with the substitution of Zn^{2+}. The PQDs have been integrated as color converting layers coated on blue light emitting diode (LED) chips, which exhibit white light with the wide color gamut of National Television Standards Committee (NTSC) 124%. The present research reveals a new synthesis route to obtain stable and efficient PQDs without negotiating color quality for display application.

1. Introduction

In recent years, organic-inorganic halide perovskites have come to the vanguard of optoelectronic research as well as solar cells, light-emitting diodes, photodetectors, color converters, and lasers owing to their high photoluminescence quantum yield, broadband absorption, and ease of tuning emission wavelength [1,2]. Methylammonium lead halide ($MAPbX_3$) perovskites have garnered much interest and are being used as an essential component in solution-processed photovoltaics with high power conversion efficiencies (~23.3%) during the initial stage and even after aging (~17% after one year) [3]. The colloidal PQDs are auspicious due to their superior electrical conductivity, high chromatogram purity, narrow FWHM of emission, high charge carrier mobilities, tunable absorption, and emission ranges [4]. Nevertheless, the presence of environmentally toxic Pb severely restricts the successful commercialization [5].

Nowadays, the most adopted synthesis method of PQDs is the hot injection, which is meager, and time-consuming. The hot injection method requires high temperatures (>120 °C), expensive instrumentation, complex synthesis environment [6,7]. It is also hard to control the parameters, especially for the potential scale up production. Sun et al. reported a room temperature-based synthesis approach for $CsPbBr_3$ nanocrystals (NCs), which also required pre-synthesis of the Cs precursor under inert conditions at high temperatures [8]. Consequently, it is necessary to develop a reliable and straightforward method for synthesizing high-quality PQDs. The ultrasonication routes have been utilized to prepare several materials with reduced surface defects, controlled and monodispersed morphology at comparatively low temperatures including CdSe, CdS QDs, $BaTiO_3$@rGO nanoparticles, and $ZnTiO_3$ nanoparticles [9,10]. Song and his group have used ultrasound

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https://doi.org/10.1016/j.molliq.2021.116557
0167-7322/

Synthetic Metals 264 (2020) 116389

Contents lists available at ScienceDirect

Synthetic Metals

journal homepage: www.elsevier.com/locate/synmet

Tailoring of electrical properties of TiO_2 decorated CVD grown single-layer graphene by HNO_3 molecular doping

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ARTICLE INFO

Keywords:
CVD graphene
Molecular doping
TiO_2
Raman spectroscopy
Fermi energy

ABSTRACT

Control of carrier density and shifting of Fermi level provides an approach to tune the physical properties of two-dimensional graphene. Here, we report the modulation in electrical properties of chemical vapor deposition (CVD) grown single-layer graphene (SLG) and titanium dioxide (TiO_2) nanoparticles (NPs) decorated SLG by nitric acid (HNO_3) molecules. The Raman spectroscopy and charge transport measurement confirmed HNO_3 treatment leads to p-type doping in both i.e. pristine graphene and TiO_2 coated SLG. The shift and relative intensity ratio of G and 2D peaks are analyzed after HNO_3 treatment. For HNO_3 doped without and with TiO_2 NPs coated CVD grown SLG, a substantial Dirac point shift is observed in transfer characteristic, reveal p-type doping of CVD grown SLG through charge transfer and HNO_3 molecule interaction. The change in carrier density and Fermi level is also calculated after HNO_3 treatment for all the samples. Our results demonstrate chemical modification is an effective approach to modulate the electrical properties CVD grown SLG for diverse applications.

1. Introduction

Graphene, an allotrope of sp^2 bonded carbon forming the basal planes of graphite, has been the subject of investigations and researches due to its unique electronic, physical and chemical properties. Graphene has shown potential in various applications such as electronic/optoelectronic devices, sensors, displays, and energy devices [1–5]. Graphene synthesized by mechanical exfoliation exhibits excellent electronic properties, whereas production efficiency is low for industrial application [6], epitaxial growth on crystal substrate (SiC) and chemical vapor deposition (CVD) on the desired metal substrate has been proposed for graphene production [7–9]. With the help of CVD and wet transfer method, high quality and large-area graphene sheets with low defects have been successfully produced, which offers better transparency, high mechanical strength and relatively low cost [10–12]. A contact electrode with very low resistance is an essential requirement for electronic/optoelectronic devices. Single-layer graphene (SLG) with low contact resistance is often used as source/drain contact for MoS_2 field-effect transistors, which showed better electrical performance than metal electrodes [13]. Due to its excellent transparency (~97 %) in the visible light, high stability and flexibility, graphene used as a transparent conductive electrode (TCE) in photonic and flexible devices [8].

Although graphene shows high carrier mobility and low carrier concentration which is related to its zero bandgap structure. To increase carrier concentration in graphene, there are few approaches such as the substitution of atoms in the lattice [14–16], adsorption of the gas molecules [17,18], bonding of organic molecules [19], as well as surface functionalization [20,21], have already been reported. The electrical behavior of an atomically thin (~0.345 nm) graphene surface is sensitive to molecules or foreign atoms because all the carbon atoms easily exposed by an ambient environment [22]. It has been previously reported that chemical doping is an effective and easy approach to modulate the electronic structure and Fermi level relative to Dirac point [23]. In recent years, chemical doping by various agents including metal chlorides (e.g. $AuCl_3$, $MoCl_3$) and molecular acids $SOCl_2$, HNO_3, and H_2SO_4 has been studied and proven a way to improve the electrical properties of graphene [24–26]. It has already been reported that HNO_3 imposes p-type doping in graphene, which significantly improves the electrical properties as well as charge transfer efficiency of graphene [27]. Kasry et al. reported the effect of HNO_3 doping in graphene at a variable temperature, afterward graphene shows low sheet resistance and high transparency at high temperatures [28]. It is also reported that chemical doping of HNO_3 over graphene does not cause harmful

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https://doi.org/10.1016/j.synthmet.2020.116389
Received 7 February 2020; Received in revised form 21 March 2020; Accepted 6 April 2020

Materials Science & Engineering B 260 (2020) 114622

Contents lists available at ScienceDirect

Materials Science & Engineering B

journal homepage: www.elsevier.com/locate/mseb

Surface driven nano-morphology of poly 3-hexylthiophene film, and their photophysical, spectral and electronic traits

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ARTICLE INFO

Keywords:
P3HT fluorescent semiconducting polymer
Liquid substrate
Aggregation
Nano-morphology
Electronic structure
Charge transport

ABSTRACT

The present paper compiles, the substrate driven nano-morphology of fluorescent semiconducting poly 3-hexylthiophene (P3HT) polymer films and their effects on photophysical, spectral, and electronic behaviour. Surface morphological study reveals regular long sized aggregation and large crystalline structure of polymer thin film in liquid surface grown (LSG) film as compared to hard surface grown (HSG) film. Experimentally observed and computationally simulated Raman spectra show that HJ coupling dominates in LSG film compared to HSG film. LSG film yields the structured electronic absorption and emission spectra with increased radiative decay time, in comparison to HSG film. These indicate a decrease of non-radiative transitions in LSG film and support more crystalline nature of the P3HT film as well as improve intrinsic mobility and device parameters in the sandwiched structure of Schottky diode configuration. The findings show that LSG based electronic/photonic devices have a high potential for enhanced performance at a little cost.

1. Introduction

Controlled and proper selection of the nano-morphology in the conjugated semiconducting fluorescent polymer film is the key factor for enhancing and optimizing their performance of electronic and optoelectronic devices [1–4]. Fluorescent nanomaterials formed by aggregation of highly fluorescent organic molecules or polymers point out dramatically different spectroscopic properties, which are affected by the micro-environmental factors [5–9]. The thermal/solvent annealing or the use of processing additives can be engineered/manipulated to attain selective solubility in a controlled way. Effective controls may favorably attribute the crystallization and orientation of the polymer [10–14]. Meanwhile, the discovery of crystalline semiconducting fluorescent polymer films, specifically P3HT, has created significant interest in this direction with high field-effect mobility of 0.1–0.3 cm^2/Vs [15,16]. The thin film of P3HT formed by the self-assembly/aggregation process offers a fairly broad range of crystalline structures, and the higher degree of crystallinity and less number of boundaries generally result in higher mobility. The broad range crystalline structure of P3HT is due to interchain and intrachain interactions (H- and J-aggregation), which depend on several intrinsic factors such as molecular weight, regioregularity, and solvent processing conditions, etc [17–20]. Spano et al. [21] estimated the order/disorder parameter using intensity ratios of vibronic peaks in either photoluminescence or absorption spectra which lead to H-type aggregate or J-type aggregates.

Further, Niles et al. [19] reported that the J-aggregated chains adopt a high-degree of main-chain planarization, whereas the thiophene units of H-aggregates are non-coplanar. Subsequently, Moulé's group [10] reported the side-chain packing distance in both aggregates either H or J aggregate based on the observation that the [100] reflections of the samples lie at the same angle in the X-ray profiles. Further, Yamagata and Spano [22] proposed the hybrid HJ coupling between polymer chains, which suggests that the charge-transfer (CT) interactions depend on the alignment of adjacent chains within a π-stack due to an increase in dipole–dipole coupling. The charge-transfer interaction is associated with energy shifts of the highest occupied molecular orbital (HOMO) according to the spatial alignment between adjacent chains. It unravels the competitive effects of intra-chain (J-favouring) versus inter-chain (H-favouring) interactions and their impact on the photophysical response. In the HJ model, a pair of co-facial polymer chains was considered with Coulomb interactions between adjacent repeated units on neighboring chains. Thus, the P3HT

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https://doi.org/10.1016/j.mseb.2020.114622
Received 13 March 2020; Received in revised form 25 June 2020; Accepted 6 July 2020

Materials Today: Proceedings
Volume 46, Part 8, 2021, Pages 2919-2924

Tuning of electronic properties of chemical vapor deposition grown graphene via self-assembled monolayer doping

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Available online 17 December 2020.

https://doi.org/10.1016/j.matpr.2020.11.352

Highlights

- Self assemble monolayer (SAM) significantly tailored the electronic properties of the graphene.
- The Raman analysis and electrical measurements confirmed p-type doping of SLG by OTS treatment.
- Electrical measurements demonstrated that the OTS treatment can significantly shift the charge neutrality point.

RSC Advances

PAPER

Cite this: *RSC Adv.*, 2021, **11**, 3096

Investigation of electronic properties of chemical vapor deposition grown single layer graphene *via* doping of thin transparent conductive films†

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Received 28th November 2020
Accepted 6th January 2021

DOI: 10.1039/d0ra10057a

rsc.li/rsc-advances

It is a crucial challenge to obtain the desired electronic properties of two-dimensional materials for various ubiquitous applications and improvements in the existing technology. In this article, we have demonstrated the modulation in electronic features of the chemical vapor deposition (CVD) grown single-layer graphene (SLG) *via* wet doping of poly (3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS). The PEDOT:PSS is well known as conducting polymer and used as transparent conducting electrode in flexible organic electronic devices. The effect of doping on SLG samples were examined by Raman spectroscopy, electrical transport measurement, atomic force microscopy (AFM), and Kelvin probe force microscopy (KPFM). The Raman peaks position of doped samples provided sought evidence of p-type doping of SLG after the deposition of PEDOT:PSS films. The electrical measurement confirmed the p-type doping of SLG and also revealed enhanced carrier density and mobility of SLG after the deposition of PEDOT:PSS films. AFM micrographs revealed the homogeneous loading of PEDOT:PSS particles over the SLGs. Further, KPFM technique was used to estimate the work function modulation of SLG after PEDOT:PSS film deposition. Our investigation will be useful for understanding the device physics as well as improvement of photovoltaic devices based on PEDOT:PSS coated graphene.

Introduction

In the recent past, a surge has been observed in the development of flexible and stretchable electronic devices in various applications including solar cells, touch screen displays, light-emitting diodes, flexible batteries, sensors, and spintronic devices.[1–5] The essential components of such devices are electrodes, which should be thin, lightweight, and highly transparent so that they can be stretched and flexed without compromising their electrical and optical assets. In recent years, indium tin oxide (ITO) has been most frequently used as transparent conducting electrodes (TCEs) in solar-cell application, because it exhibits low sheet resistance and high transparency in visible-light spectrum.[6] Although, it is quite unsuitable for flexible electronics due to their low flexibility, high cost, limited source of indium and inconsistency in the transparency near the ultraviolet region. Among the available alternatives, graphene has attracted significant interest as TCEs for various optoelectronic devices due to its high transparency and flexibility.[1,7] Graphene is a network of sp^2 hybridization of carbon atoms arranged into a hexagonal structure and is semimetal in nature. Recently, graphene has received considerable interest due to its remarkable properties, including atomically thin, high mechanical strength, thermally stable, and highly transparent two-dimensional sheets as well as high carrier mobility along the sheets.[8,9] Single-layer graphene (SLG) shows high optical transparency (~98%), electrical conductivity and flexibility, which makes SLG is highly suitable for the TCEs.[10] Among the various synthesis approaches, chemical vapor deposition (CVD) technique is the most effective synthesis approach for large-scale production of graphene due to its various advantages such as high-quality, large-area, low cost, and easily transfer on the desired substrate.[11,12]

The tuning of charge carrier and doping type of graphene is a potential step for the realization of multifunctional use in current electronic/optoelectronic devices. In addition, shift of the Fermi level (E_F) position of graphene directly depends on charge carrier doping, and moves upwards or downwards with relative to Dirac point. As reported previously, the electrical properties of pristine graphene can be modulated by various techniques.[13–16] In this context, chemical doping easily modulates the doping type, carrier concentration and work function of graphene.[17] According to previous studies, two types of

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† Electronic supplementary information (ESI) available. See DOI: 10.1039/d0ra10057a

ISSN 1070-4272, Russian Journal of Applied Chemistry, 2021, Vol. 94, No. 3, pp. 402–409. © Pleiades Publishing, Ltd., 2021.

VARIOUS TECHNOLOGICAL PROCESSES

Enhanced Optical and Electrical Properties of Graphene Oxide-Silver Nanoparticles Nanocomposite Film by Thermal Annealing in the Air

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Received February 5, 2021; revised March 18, 2021; accepted March 22, 2021

Abstract—Here, we report the enhanced optical and electrical properties of graphene oxide-silver nanoparticles (GO-AgNPs) nanocomposite due to thermal annealing in air at different temperatures (150, 250, and 350°C). Our findings show that the optical properties of the GO-AgNPs film strongly depend on the annealing temperature. With an increase in annealing temperature, the optical absorption band and photoluminescence (PL) band are monotonically shifted towards a longer wavelength with a slight increase in absorbance. Interestingly, annealing of the nanocomposite film at 350°C in the air results in the nitrogen-doping from air into GO lattice. Unlike the PL bands in the near-ultraviolet (UV) range in cases of GO-AgNPs annealed at 150 and 250°C, this film exhibits pronounced multiple PL bands in the visible range, which are attributed to optical transitions associated with the localized nitrogen defects incorporated from air under thermal annealing and charge transfer between AgNPs and carbon. Mechanisms of the observed optical properties are also discussed. Furthermore, thermal annealing of the film also affects its electrical properties. The sheet resistance of the film reduces with the increase of annealing temperature and its lowest value ~ 21 Ω/□ with transmittance ~ 82% at 550 nm is achieved at 350°C.

Keywords: Thermal annealing in air, nitrogen-doped graphene oxide-silver nanoparticles, transparent conductive electrode, photoluminescence

DOI: 10.1134/S1070427221030186

INTRODUCTION

Graphene has been recognized as a promising material that could be utilized in many areas that include electronics, optoelectronics, energy, and biochemistry [1–10]. However, experimentally synthesized pure graphene has some limitations such as lack of band gap in sp^2 hybridized structure, high sheet resistance [1], and less pronounced luminescence [11]. Modification of graphene structure is therefore needed to extend its effective utilization in various application sectors. Chemically synthesized graphene oxide (GO), in this scenario, has been an attractive and basic material. GO consists of sp^2 bonded carbon atoms with a large fraction of sp^3 hybridized carbon atoms bound to oxygen-related functional groups. GO is an insulator and reduction of GO is demanded to make it conductor or semiconductor which are key materials used in electronic and optoelectronic devices. The reduction of GO indicates the increase of sp^2 contents and materials tend to transform from insulating GO to conducting graphene structure [12]. Ag nanoparticles (AgNPs) have been widely used to fab-

ARTICLES

Journal of Semiconductors
(2021) 42, 074102
doi: 10.1088/1674-4926/42/7/074102

Fabrication, characterization, numerical simulation and compact modeling of P3HT based organic thin film transistors

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Abstract: This paper presents the fabrication, characterization and numerical simulation of poly-3-hexylthiophene (P3HT)-based bottom-gate bottom-contact (BGBC) organic thin film transistors (OTFTs). The simulation is based on a drift diffusion charge transport model and density of defect states (DOS) for the traps in the band gap of the P3HT based channel. It combines two mobility models, a hopping mobility model and the Poole–Frenkel mobility model. It also describes the defect density of states (DOS) for both tail and deep states. The model takes into account all the operating regions of the OTFT and includes sub-threshold and above threshold characteristics of OTFTs. The model has been verified by comparing the numerically simulated results with the experimental results. This model is also used to simulate different structure in four configurations of OTFT e.g. bottom-gate bottom-contact (BGBC), bottom-gate top-contact (BGTC), top-gate bottom-contact (TGBC) and top-gate top-contact (TGTC) configurations of the OTFTs. We also present the compact modeling and model parameter extraction of the P3HT-based OTFTs. The extracted compact model has been further applied in a p-channel OTFT-based inverter and three stage ring oscillator circuit simulation.

Citation: S Dadhich, A D D Dwivedi, and A K Singh, Fabrication, characterization, numerical simulation and compact modeling of P3HT based organic thin film transistors[J]. *J. Semicond.*, 2021, 42(7), 074102. http://doi.org/10.1088/1674-4926/42/7/074102

1. Introduction

Organic electronics have received great attention since the initial discovery[1], due to the range of exotic mechanical properties of the organic semiconductor materials and technologies that they offer in contrast to prevalent inorganic semiconductor technologies. For example, plastics can be flexible[2], stretchable and processed from solution-phase over large areas in roll-to-roll newspaper-style printing[3, 4]. Plastics can also be processed at lower temperatures[5], and hence have lower economic costs than silicon. Another benefit of synthetic polymeric materials is that their properties can be tailored via the introduction of different chemical groups that vary overall molecular structures, giving rise to the idea of "Make to Order" (MTO) electronics. Applications for organic thin film transistor (OTFT) include light-emitting devices[6–32], bioelectronics sensing devices and applications[6] that would require low amounts of computing, such as electronic tags or memory devices[7–9]. One of the primary focuses for organic electronics research over the past few decades has been the organic field-effect transistors (OFETs)[10–32]. OTFTs are a key element of organic electronics[1–32]. Whilst solution-processed OTFT[11–13] with desired mobility values have started to enter the realm of industrial application, they can't be utilized unless the other critical parameters are also addressed. For example, TFTs can be used as switches in both voltage-driven and current-driven applications. Voltage-driven applications, such as liquid crystal displays or e-paper, require a controlled voltage to be applied. On the other hand, display technologies used active matrix organic light emitting diode (AMOLED) commercially for smart phones, laptops, tablets, games consoles, smart watches, digital cameras, media players and televisions are current-driven. In the development of TFT, the mathematical model of device represents an important bridge between manufacturing of semiconductor and circuit design. In past years, some mathematical models of OTFT were developed[14]. All these models describe dc current–voltage characteristics. These models are developed by slight modification in classical MOS transistor models. But these are not able to describe complete behaviour and unique features of OTFTs. During the design process to evaluate the circuit performance, compact model is necessary[12, 28–32]. Therefore, technology computer aided design (TCAD) simulation and compact modeling of organic thin film transistors[13–32] become very important. The researchers have put an extensive research effort into OTFT compact modeling for circuit simulation as in Refs. [28–32]. Further research efforts by various researchers are going on in this direction. In current scenario, a physical model based on organic semiconductor is required for analog and digital circuits. The developed model should have these qualities: (i) consistent behaviour, (ii) having parameter variable that can be put easily, (iii) symmetrical to OTFT structure, (iv) easily derivable and simple calculation, (v) reducible and upgradable, (vi) tunable for bad experimental data, and (vii) all the relations can be justified by physics. So in this work, we try to achieve all these qualities. The model based on fundamental semiconductor equations and drift diffusion charge transport model has been utilized for TCAD based numerical simulation. This approach and model has been successfully examined on experimental data and also extracted the performance parameters

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Received 20 JANUARY 2021; Revised 1 MARCH 2021.

IOP Publishing Nanotechnology
Nanotechnology 32 (2021) 385201 (7pp) https://doi.org/10.1088/1361-6528/ac07d2

Unfolding photophysical properties of poly(3-hexylthiophene)-MoS_2 organic–inorganic hybrid materials: an application to self-powered photodetectors

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Received 19 March 2021, revised 22 May 2021
Accepted for publication 3 June 2021
Published 28 June 2021

Abstract

Self-powered photodetectors have grown as inevitable members of the optoelectronic device family. However, it is still challenging to achieve self-powered photodetection with good responsivity in the visible spectrum region. Herein, we report solution-processable poly(3-hexylthiophene) (P3HT)-molybdenum disulfide (MoS_2) organic–inorganic hybrid material, which can be used as the active layer in self-powered photodetectors. The morphological and structural properties of the synthesized P3HT-MoS_2 hybrid material has been discussed using atomic force microscopy and transmission electron microscopy, respectively. The hybrid material loaded with 1 wt% MoS_2 has shown an enhancement in the self-assembly of polymer in the form of fibrillar formation and excellent structural features in terms of π-conjugation. The self-powered photodetectors have been fabricated in indium tin oxide (ITO) coated glass/P3HT-MoS_2/Al configuration. The merit of P3HT-MoS_2 hybrid photodetectors is measured under the illumination of 470, 530, and 627 nm light in ambient conditions. P3HT-MoS_2 photodetectors show significantly higher responsivity and detectivity. The photo responsivity and detectivity in P3HT-MoS_2 devices are found to be 271.2 mA W^{-1} and 4.4×10^{10} jones at zero bias, respectively, for 470 nm light with the optical power density of 74.1 μW cm^{-2}. Furthermore, the photocurrent switching behaviour at periodic illuminations of 1 Hz has also been examined for P3HT-MoS_2 self-powered photodetectors.

Supplementary material for this article is available online

Keywords: photodetectors, organic–inorganic hybrid, P3HT, MoS_2

(Some figures may appear in colour only in the online journal)

1. Introduction

Optical signal conversion to an electrical signal is essential in modern society for numerous applications such as image sensing, safety/security systems, military/intelligence surveillance, chemical/biological detection, and optical communication [1, 2]. Since their origin, photodetectors have gone through the evolution of several generations in the past few decades. Emerging low dimensional materials (e.g. graphene, hBN, CNTs, and dichalcogenides etc) and

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Electrical transport mechanism of aluminum substituted barium hexaferrite magnetic semiconductor

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Received: 18 October 2020
Accepted: 18 December 2020

ABSTRACT

The polycrystalline M-type barium hexaferrite ($BaFe_{12-x}Al_xO_{19}$) with x = 0.0, 1.0, 2.0, and 3.0 have been prepared by the sol–gel Method. The crystal structure of all the samples is found to be in hexagonal symmetry with $P6_3/mmc$ space group. The impedance was studied over a range of frequencies (1 Hz–1 MHz) for all the compositions. Direct current (DC) electrical resistivity measurements of all the samples were carried out in the temperature range of 303–775 K. All the samples exhibit the semiconducting behavior. The resistivity increases with the increase in Al^{3+} substitution. The impedance along with DC resistivity results established the electron hopping conduction mechanism in the Al^{3+} substituted barium hexaferrites. The electrical conductivity has been well explained by the Mott variable-range hopping mechanism of localized polarons. The dielectric dipoles are frozen at low temperature and activated at high temperature as observed two transition temperatures in temperature versus impedance plot. A correlation between ac impedance and DC resistivity has been established in the M-type hexaferrite magnetic semiconductor.

1 Introduction

The M-type hexaferrites, have a huge commercial impact due to its technological applications including microwave devices, high-speed recording media, ferrofluids, catalysis and magnetic refrigeration systems [1–5]. These materials are considered better than other magnetic materials because of low eddy current losses, which is due to their high resistivity [6]. The combination of magnetic and dielectric properties of ferrite materials make them very useful for microwave applications such as; microwave frequency antennas and components for microwave applications. For microwave application, it is desired to have low magnetic loss [7–10]. The resonant frequencies of spinel and garnet based ferrite materials in the range from Hz to hundreds of mega hertz. It is due to the limit of Snoek effect, which can be overcome by using hexaferrite in the microwave frequency range [11, 12]. Therefore, it is expected to use spinel or garnet ferrite for low-frequency applications and hexaferrite for microwave requirements. Barium

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https://doi.org/10.1007/s10854-020-05152-2
Published online: 08 January 2021

AIP Conference Proceedings

No Access
Published Online: 13 September 2021

Characterization $CH_3NH_3PbI_3/TiO_2$ nano-based new generation heterojunction organometallic perovskite solar cell using thin-film technology

AIP Conference Proceedings **2369**, 020006 (2021); https://doi.org/10.1063/5.0061288

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Growth, characterizations, and the structural elucidation of diethyl-2-(3-oxoiso-1,3-dihydrobenzofuran-1-ylidene)malonate crystalline specimen for dielectric and electronic filters, thermal, optical, mechanical, and biomedical applications using conventional experimental and theoretical practices

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Received: 29 June 2021
Accepted: 4 August 2021
Published online: 18 August 2021

ABSTRACT

The single crystals of diethyl-2-(3-oxoiso-1,3-dihydrobenzofuran-1-ylidene) malonate (D23DYM) were grown successfully and efficiently by the standard slow evaporation method. The lattice cell parameters by XRD analysis also confirmed that the crystal system is Triclinic with the space group of Pī. The FTIR spectrum portrays the presence of major and active functional groups in D23DYM. The thermal studies explained the two major weight losses between 107 and 153 °C and 153 and 800 °C for D23DYM have been observed. It is very clear that the hardness profile of D23DYM increases with increase in load which

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https://doi.org/10.1007/s10854-021-06761-1

XRD, CHNSO, fluorescence, filter-influx, NLO, photoconductivity, hardness and helical spring-fabricated device stress analysis of 2′-chloro-4-methoxy-3-nitrobenzil (CMNB) crystal of different scalings for opto-electronic filter and band gap engineering utilities

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Received: 24 January 2021
Accepted: 2 March 2021
Published online: 20 March 2021

ABSTRACT

2′-Chloro-4-methoxy-3-nitrobenzil (CMNB) crystals are grown by solution growth method, and organic crystalline materials are utilized due to their enhanced applications as frequency multipliers, phase matched equipments, etc. CMNB is utilized in electronic and mechanical sectors based on the filter, fluorescence (FL), tribological and also by NLO studies. The single crystal X-ray diffraction (XRD) of CMNB shows the formula as $C_{15}H_{10}ClNO_5$ and the lattice parameters are a = 7.8560 Å, b = 8.1005 Å, c = 12.4964 Å, α = 74.90°, β = 74.81°, γ = 68.59°, crystalline system is triclinic, space group as Pī. Here, the crystals are analyzed with XRD, CHNSO, fluorescence (FL), filter influx, NLO, hardness and photoconductivity nature and also for fabricated device stress analysis methods by surface interaction tool as a mechano utility in instrumental industries.

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https://doi.org/10.1007/s10854-021-05663-6

Growth and XRD, Elemental, Mechanical, Dielectric, Optical and Photoconductivity, and Surface Morphological Characterizations of 2-[4-(Trifluoromethyl) phenyl]-1H-benzimidazole (TFMPHB) Crystals for Electronic, Mechanical Applications

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Received: 28 December 2020 / Accepted: 26 February 2021 / Published online: 29 March 2021

Abstract

Nonlinear optical crystalline material is the fascinating tool for the optoelectronic devices and for phase-matched equipments, frequency matching circuits and etc. Present study portrays the synthesize and utility of macro and nano scaled crystals of 2-[4-(trifluoromethyl) phenyl]-1H-benzimidazole (TFMPHB) by slow evaporation solution growth method and by milling conversion. As-prepared crystals were studied by XRD, CHNSO analysis, dielectric and tribology-mechanical, NLO, and photoconductivity. The orthorhombic phase structure with the average crystalline size of 21 nm was observed. The elemental composition of crystals was analyzed for the presence of elements. Tribological studies of macro and nano TFMPHB crystals were favorable for mechanical applications. Further, the high dielectric constant (363 K) at low frequency was suitable for microelectronic devices; NLO is analyzed with phase matching effect over particle size, and photoconductivity study also reported for the entitled crystalline specimen. The structural parameters by AFM and SEM, absorbance nature by UV spectra, and modeling data by computational methods are also reported.

Keywords NLO · Crystals · Dielectric constant · Tribology · Influx · Electronic material

1 Introduction

Present scenario on the material applications has greater and significant attention in organic nonlinear optical (NLO) crystalline materials with bulky optical nonlinearities in second-order second harmonic generation (SHG) appropriate to their striking prospective usage and applications in frequency convertors, in photonics, in speedy data progression, and in opto electronics [1–3]. Moreover, the figures of merit of NLO organic crystals are of superior one than that of their inorganic matching parts. Due to the above sort of applications, organic NLO materials and crystals are of higher demand. It has become a significant investigation hub to form and incorporate new NLO organic type of crystals and materials with extraordinary implementation. Among them, single crystals are one of the most appealing materials from their huge nonlinearities, high packing density, and superb orientational and photochemical stable and reliable, also with their prevalent optical quality.

Ultimately, an ideal organic material is the one, has an eminent as well as prominent efficiency, an extremely small absorption trivial cut-off (to permit pathway into the

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Letter

Experimental evidence of exact E(5) symmetry in ^{82}Kr

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(Received 13 October 2020; revised 26 July 2021; accepted 24 August 2021; published 7 September 2021)

The low-lying positive-parity structures of ^{82}Kr have been investigated following their population in the ^{76}Ge(^{9}Be, $3n$) reaction at $E_{lab} \approx 31$ MeV and using a large array of Compton suppressed HPGe clovers as the detection setup. Apart from other spectroscopic measurements, level lifetimes of the states have been extracted using the Doppler shift attenuation method. The level energies and the associated transition probabilities exhibit superlative overlap with the calculations in the framework of the interaction boson approximation and the E(5) model. The ^{82}Kr nucleus, thus, exemplifies the critical point of phase (shape) transition from the U(5) (spherical vibrator) to the O(6) (γ-soft rotor) paradigms of nuclear structure.

DOI: 10.1103/PhysRevC.104.L031302

The investigation of the phase-transitional properties of physical systems is known to be of pertinence in natural science. One of the challenges in such pursuits pertains to the rapid change in the order parameter with variation in the control parameter at the point of phase transition that makes it obscure to unambiguously identify the latter. In nuclei, the phase transitions will occur at zero temperature and correspond to the change in the equilibrium deformation or ground-state symmetry of the system with variation in the number of nucleons that acts as the control parameter [1,2].

As far as shapes or deformations of nuclei are concerned, they can principally be a spherical harmonic vibrator [3], an axially symmetric deformed rotor [4], or a γ unstable (axially asymmetric) rotor [5]. These constitute the idealized limits of nuclear shapes that have been encoded in the framework of the interacting boson approximation (IBA) and have been identified to correspond to different dynamical symmetries: The spherical vibrator is associated with U(5), the axially symmetric rotor with SU(3) and the γ-soft rotor with O(6) [6]. Each of these symmetries has characteristic experimental signatures, such as the ratio of the excitation energies of the first 4^+ and 2^+ states $R_{4/2}$, that is 2.0 for U(5), 3.33 for SU(3), and 2.5 for O(6).

Furthermore, the (phase) transition from one of these paradigms into another is characterized by critical point symmetries (CPS) as invoked by Iachello for a simple parameter-free analytical treatment of transitional nuclei [7,8]. The CPS associated with the transition from the spherical vibrator to the axially symmetric rotor is $X(5)$ [7] whereas that with a spherical vibrator to a γ-soft rotor is E(5) [8]. The transitional character is typically quantified through experimental observables, such as the aforementioned ratio of excitation energies as well as the ratio of transition probabilities, eventually elaborated in this paper. Recently, the relativistic mean-field theory has been applied to probe the $X(5)$ symmetry in ^{148,150,152}Sm [9] and E(5) in Ti isotopes [10] whereas, most proximal manifestations of E(5) symmetry has been identified in ^{134}Ba [11], ^{130}Xe [12], ^{104}Ru [13], and ^{102}Pd [14]. These investigations have not reported the levels above the first excited 0^+ state which is crucial for the understanding of the E(5) behavior in nuclei. The position of this excited 0^+ state vary along with the U(5) to O(6) transition [15–17]. For U(5), this state has a two-phonon character with high B(E2) rate to the one phonon 2_1^+ level. In the O(6) limit this level becomes very high in excitation energy and the B(E2) transition strength to the 2_1^+ state is forbidden. In contrast, the second excited 0^+ level preserves its three-phonon character across the entire U(5) to O(6) path [15].

It may be noted that all the above-mentioned findings on E(5) symmetry are for stable nuclei with $A > 100$. The lone exception is the proposition of E(5) symmetry in ^{58}Cr [18]

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The Astronomical Journal, 161:108 (9pp), 2021 March

https://doi.org/10.3847/1538-3881/abd4d8

Are There Transit Timing Variations for the Exoplanet Qatar-1b?

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Received 2020 January 21; revised 2020 December 9; accepted 2020 December 14; published 2021 February 8

Abstract

Motivated by the unsettled conclusion on whether there are any transit timing variations (TTVs) for the exoplanet Qatar-1b, 10 new transit light curves are presented and a TTV analysis with a baseline of 1400 epochs is performed. Because the linear model provides a good fit with a reduced chi-square of $\chi^2_{\rm red} = 2.59$ and the false-alarm probabilities of the possible TTV frequencies are as large as 35%, our results are consistent with a null-TTV model. Nevertheless, a new ephemeris with a reference time of $T_0 = 2455647.63360 \pm 0.00008$ (BJD) and a period of $P = 1.4200236 \pm 0.0000001$ (day) is obtained. In addition, the updated orbital semimajor axis and planetary radius in units of stellar radius are provided, and the lower limit of the modified stellar tidal quality factor is also determined.

Unified Astronomy Thesaurus concepts: Exoplanet astronomy (486); Transit photometry (1709)

Supporting material: machine-readable table

1. Introduction

The increasing focus on the science of extrasolar planets (exoplanets) is one of the most prominent features of astrophysics in the twenty-first century. Thousands of extra-solar planets have been discovered and the main credit goes to the methods of Doppler shift and transits. While the Doppler-shift detection technique played a major role in the initial phase, the transit method has played a more vital role in finding new planetary systems in recent years. The new transit discoveries caused an unprecedented jump in the number of known exoplanets owing to the satellite observations by CoRoT (Baglin et al. 2006), Kepler (Borucki et al. 2010), and the updated version of Kepler, i.e., the K2 mission (Howell et al. 2014). However, the role of ground-based observations has been very crucial as well. Various ground-based surveys such as the Transatlantic Exoplanet Survey (TrES; Alonso et al. 2004), SuperWASP (Pollacco et al. 2006), Kilodegree Extremely Little Telescope (KELT; Pepper et al. 2007), Multi-site All-Sky CAmeRA (MASCARA; Talens et al. 2017), Qatar (Alsubai et al. 2013), etc. have discovered many exoplanets.

Hot Jupiters, the preferred targets for the ground-based transit surveys, are the gas giants found at closer orbital distances with masses larger than $0.25M_J$ and radii about 1 or 2 R_J (Labadie-Bartz et al. 2019). Even though hot Jupiters are rare according to the occurrence rate (Dawson & Johnson 2018), the sensitivity of current observing techniques favors their detection, as they have deep transits (~1%) and short orbital periods (1–10 days) which enable multiple observations at a short interval to confirm their planetary nature (Hellier et al. 2019).

While the total number of known exoplanets has been increasing steadily, the above exciting results have triggered many theoretical investigations and statistical studies. For example, the planet formation has been modeled and addressed in Mordasini et al. (2009). The orbital evolution has been studied in Jiang & Ip (2001), Ji et al. (2002), Jiang et al. (2003), Jiang & Yeh (2004a, 2004b, 2007), and Gayon & Bois (2008). The distributions of exoplanets on the period–mass plane were addressed in Zucker & Mazeh (2002), Tabachnik & Tremaine (2002), and Jiang et al. (2006). Additionally, the coupled period–mass functions were first explored in Jiang et al. (2007, 2009), and then further investigated with proper treatments of the selection effect in Jiang et al. (2010). Moreover, Jiang et al. (2015) studied the period-ratio–mass-ratio correlation of adjacent planet pairs in 166 multiple planetary systems. A moderate correlation between the period ratio and mass ratio was found with a correlation coefficient of 0.5303.

In addition to the above theoretical and statistical studies, the transit observations of known planetary systems has also led to new implications. When the periodicity of the transit timing is not a constant, it is related to the transiting exoplanet orbiting in a non-Keplerian potential which could be caused by the presence of additional planets in the system (Linial et al. 2018). The deviations from a linear ephemeris are called transit timing variations (TTVs). In a known exoplanetary system, there can be some undiscovered planets. The hindrance in their detection is caused by the limitations of detection techniques and the sensitivity of the available instruments. In such cases, the TTVs can play a very crucial role. Thus, in-depth follow-up studies of

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RAA 2021 Vol. 21 No. 4, 97(11pp) doi: 10.1088/1674-4527/21/4/97

http://www.raa-journal.org http://iopscience.iop.org/raa

Research in Astronomy and Astrophysics

Non-sinusoidal transit timing variations for the exoplanet HAT-P-12b

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Received 2020 July 13; accepted 2020 October 26

Abstract Considering the importance of investigating the transit timing variations (TTVs) of transiting exoplanets, we present a follow-up study of HAT-P-12b. We include six new light curves observed between 2011 and 2015 from three different observatories, in association with 25 light curves taken from the published literature. The sample of the data used thus covers a time span of $\sim$ 10.2 years with a large coverage of epochs (1160) for the transiting events of the exoplanet HAT-P-12b. The light curves are utilized to determine the orbital parameters and conduct an investigation of possible TTVs. The new linear ephemeris shows a large value of reduced χ^2, i.e. $\chi^2_{\rm red}(23) = 7.93$, and the sinusoidal fitting using the prominent frequency coming from a periodogram shows a reduced χ^2 around 4. Based on these values and the corresponding $O-C$ diagrams, we suspect the presence of a possible non-sinusoidal TTV in this planetary system. Finally, we find that a scenario with an additional non-transiting exoplanet could explain this TTV with an even smaller reduced χ^2 value of around 2.

Key words: planetary systems: techniques: photometric

1 INTRODUCTION

Many generations of astronomers have been searching for the possible existence of exoplanets before the end of the twentieth century (Briot & Schneider 2018) with the discovery of 51 Peg b (Mayor & Queloz 1995). Since then, exoplanetary science has witnessed a boom that has made it one of the most studied branches of astronomy. Although the initial success in discovering exoplanets came from the results of the Doppler method, the transit method has played the most dominant role in discovering new exoplanets. This is due to space-based surveys like Kepler (Borucki et al. 2010), K2 (Howell et al. 2014), Convection, Rotation and planetary Transits (CoRoT, Baglin et al. 2006) and also, the recently launched Transiting Exoplanet Survey Satellite (TESS, Ricker et al. 2015). However, transit surveys from ground-based observing facilities have also contributed significantly in discovering transiting exoplanets owing to the surveys such as the Hungarian-made Automated Telescope Network (HATNet, Bakos et al. 2004), the Hungarian-made Automated Telescope Network-South (HATSouth, Bakos et al. 2013), Trans-Atlantic Exoplanet Survey (TrES, Alonso et al. 2004), Super Wide Angle Search for Planets (SuperWASP, Pollacco et al. 2006), Kilodegree Extremely Little Telescope (KELT, Pepper et al. 2007),

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J. Astrophys. Astr. (2021)42:38
https://doi.org/10.1007/s12036-020-09688-x

SCIENCE RESULTS

AstroSat observation of 2016 outburst of H 1743-322

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MS received 6 November 2020; accepted 18 December 2020

Abstract. We present the detection of type C quasi-periodic oscillation (QPO) along with upper harmonic at respective frequencies of $\sim$0.6 Hz and $\sim$1.2 Hz in the single AstroSat observation taken during the 2016 outburst of the low-mass black hole X-ray binary H 1743-322. These frequencies are found to be shifted by $\sim$0.4 Hz for the QPO and $\sim$0.8 Hz for the upper harmonic with respect to that found in the simultaneous *XMM-Newton* and *NuSTAR* observation taken five days later than the AstroSat observation, indicating a certain geometrical change in the system. However, the centroid frequency of the QPO and the upper harmonic do not change with energy, indicating the energy-independent nature. The decreasing trend in the fractional rms of the QPO with energy is consistent with the previous results for this source in the low/hard state. The value of the photon index ($\Gamma \sim 1.67$) also indicates that the source was in the low/hard state during this particular observation. In addition, similar to the *XMM-Newton* observations during the same outburst, we find a hard lag of $\sim$21 ms in the frequency range of $\sim$1–5 Hz. The log-linear trend between the averaged time lag and energy indicates the propagation of fluctuations in the mass accretion rate from outer part of the accretion disk to the inner hot regions.

Keyword. Black hole physics—binaries: close—X-rays: binaries—X-rays: individual: H 1743-322.

1. Introduction

A majority of black hole X-ray binaries (BHXRBs) exhibits transient nature and shows occasional outbursts due to sudden change in the mass accretion rate while spending most of the time in quiescence. The source luminosity may increase up to several orders of magnitude during such outbursts (Tanaka & Shibazaki 1996; Shidatsu *et al.* 2014; Plant *et al.* 2015). In the course of a usual outburst, the black hole transients (BHTs) evolve through the low/hard state (LHS) to the high/soft state (HSS) via two intermediate states, viz. the hard and soft intermediate states (HIMS and SIMS; Belloni *et al.* 2005; Belloni 2010). These states are attributed to certain spectral and timing characteristics, which can be distinguished through the hardness intensity diagram (HID; Belloni *et al.* 2005; Homan & Belloni 2005; Gierliński & Newton 2006; Fender *et al.* 2009; Belloni 2010). The X-ray spectrum in the LHS is dominated by the Comptonized emission with a powerlaw index <2 and cutoff energy $\sim$100 keV, and the source is associated with strong variability ($\sim$30%). On the other hand, the thermal emission from the optically thick and geometrically thin accretion disk dominates the HSS, where the photon index can extend up to 2.5 with a few percent of variability.

Low-frequency quasi-periodic oscillations (LFQPOs), ranging from 0.05–30 Hz, are often observed in the BHTs. The exact origin of these LFQPOs are still not clear. However, LFQPOs are categorized into three

This article is part of the Special Issue on "AstroSat: Five Years in Orbit".

Published online: 10 June 2021

Dr. Parijat Thakur

The Astronomical Journal, 160:47 (15pp), 2020 July
https://doi.org/10.3847/1538-3881/ab9818

Probing Transit Timing Variation and Its Possible Origin with 12 New Transits of TrES-3b

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Received 2019 December 26; revised 2020 May 28; accepted 2020 May 29; published 2020 June 29

Abstract

We present 12 new transit light curves of the hot-Jupiter TrES-3b observed during 2012–2018 to probe the transit timing variation (TTV). By combining the midtransit times determined from these 12 transit data with those reestimated through uniform procedure from 71 transit data available in the literature, we derive new linear ephemeris and obtain the timing residuals that suggest the possibility of TTV in the TrES-3 system. However, the frequency analysis shows that the possible TTV is unlikely to be periodic, indicating the absence of an additional body in this system. To explore the other possible origins of TTV, the orbital decay and apsidal precession ephemeris models are fitted to the transit time data. We find the decay rate of TrES-3b to be $\dot{P}_q = -4.1 \pm 3.1$ ms yr^{-1}, and the corresponding estimated modified stellar tidal quality factor of $Q'_* \sim 1.11 \times 10^5$ is consistent with the theoretically predicted values for the stars hosting the hot-Jupiters. The shift in the transit arrival time of TrES-3b after 11 years is expected to be $T_{\rm shift} \sim 69.55$ s, which is consistent with the rms of the timing residuals. Besides, we find that the apsidal precession ephemeris model is statistically less probable than the other considered ephemeris models. It is also discussed that despite the fact that the linear ephemeris model appears to be the most plausible model to represent the transit time data, the possibility of the orbital decay cannot be completely ruled out in the TrES-3 system. To confirm this, further high-precision and high-cadence follow-up observation of transits of TrES-3b would be important.

Unified Astronomy Thesaurus concepts: Exoplanets (498); Hot-Jupiters (753); Tidal interaction (1699); Transit photometry (1709); Transit timing variation method (1710)

1. Introduction

Hot-Jupiters are short period ($P < 10$ days) gas-giant Jupiter-like extra-solar planets, detected in tight orbits ($a < 0.1$ au) to their host stars. Since the discovery of first hot-Jupiter, 51 Pegasi b (Mayor & Queloz 1995), around a Sun-like star, more than 4000 extra-solar planets[11] have been confirmed so far. Of these, 394 extra-solar planets in a wide range of masses (0.36 $M_J \leqslant M_P \leqslant 11.8$ M_J) are referred to as hot-Jupiters, and the majority of them are detected using the transit method. The photometric study of these transiting hot-Jupiters are of vital importance. Because of their short periods and strong transit signals, a long-term photometric follow-up observation of transits of these systems help in improving the estimates of their physical and orbital parameters (e.g., Sozzetti et al. 2009; Montalto et al. 2012; Kundurthy et al. 2013; Maciejewski et al. 2013a; Collins et al. 2017).

The improved estimate of midtransit time from high-precision transit photometry allows for the refinement of the transit ephemeris. The multi-epoch, high-precision transit photometry also provides an opportunity to examine the transit timing variations (hereafter TTVs) of known planets, which could be due to the presence of additional bodies in the planetary system when the TTV signal is periodic (Miralda-Escudé 2002; Agol et al. 2005; Holman & Murray 2005; Heyl & Gladman 2007; Jiang et al. 2013, 2016; Maciejewski et al. 2015, 2016; Mislis et al. 2015; Thakur et al. 2018). The proximity of the massive hot-Jupiters to their host stars makes them an ideal laboratory to test the long-standing theoretical predictions of orbital decay and apsidal precession, induced by the tidal interactions between hot-Jupiters and their host stars (see Levrard et al. 2009; Ragozzine & Wolf 2009; Adams et al. 2010; Matsumura et al. 2010; Maciejewski et al. 2016; Patra et al. 2017; Csizmadia et al. 2019). These two phenomena are the other possible reasons to produce TTVs in the hot-Jupiter systems, which can be examined with the precise transit data if available for a decade or more (Maciejewski et al. 2016; Patra et al. 2017).

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[11] http://exoplanet.eu/catalog/

Dr. Parijat Thakur

The Astrophysical Journal, 893:142 (14pp), 2020 April 20
https://doi.org/10.3847/1538-4357/ab829a

2016 Outburst of H 1743–322: XMM-Newton and NuSTAR View

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Received 2019 November 14; revised 2020 March 18; accepted 2020 March 19; published 2020 April 24

Abstract

We report the detection of a type C quasi-periodic oscillation (QPO) along with an upper harmonic in the commensurate ratio of 1:2 in two observations of the low-mass black hole transient H 1743–322 jointly observed by XMM-Newton and NuSTAR during the 2016 outburst. We find that the QPO and the upper harmonic exhibit shifts in their centroid frequencies in the second observation with respect to the first one. The hardness intensity diagram implies that in contrast to the 2008 and 2014 failed outbursts, the 2016 outburst was a successful one. We also detect the presence of a broad iron $K\alpha$ line at ~6.5 keV and a reflection hump in the energy range 15–30 keV in both of the observations. Along with the shape of the power density spectra, the nature of the characteristic frequencies and the fractional rms amplitude of the timing features imply that the source stayed in the low/hard state during these observations. Moreover, the photon index and other spectral parameters also indicate the low/hard state behavior of the source. Unlike the soft lag detected in this source during the 2008 and 2014 failed outbursts, we observe hard time lags of 0.40 ± 0.15 s and 0.32 ± 0.07 s in the 0.07–0.4 Hz frequency range in the two observations during the 2016 outburst. The correlation between the photon index and the centroid frequency of the QPO is consistent with the previous results. Furthermore, the high value of the Comptonized fraction and the weak thermal component indicate that the QPO is being modulated by the Comptonization process.

Unified Astronomy Thesaurus concepts: High energy astrophysics (739); Low-mass X-ray binary stars (939); Stellar mass black holes (1611)

1. Introduction

Low-mass black hole X-ray binaries consist of a low-mass companion star ($\lesssim 1\ M_{\odot}$) gravitationally bound to a stellar-mass black hole (Steiner et al. 2012). The companion star feeds material to the black hole via Roche lobe overflow, resulting in the formation of an accretion disk. The viscous forces between the different layers of the accretion disk near the black hole raise the temperature up to 10^7 K, and the source primarily emits X-rays (Steiner et al. 2012; Motta et al. 2017). Most of the black hole X-ray binaries (BHXRBs) are known to be transients that stay in quiescence for a long time and show outbursts very sporadically. These outbursts can last from several days to months, during which the luminosity of the source is increased by several orders of magnitude (Tanaka & Shibazaki 1996; Shidatsu et al. 2014; Plant et al. 2015). The BHXRBs can undergo generally four states during an outburst, namely, the low/hard state (LHS), the hard-intermediate state (HIMS), the soft-intermediate state (SIMS), and the high/soft state (HSS; Belloni et al. 2005). The classification of the states relies upon the detailed spectral and timing behavior of the source during an outburst.

The spectrum of the LHS is dominated by a hard power law with photon index <2 and a high-energy cutoff ≈100 keV (Motta et al. 2009; Shidatsu et al. 2014). The power-law component is thought to originate from the Compton up-scattering of the soft X-ray photons from the disk by the hot electrons in corona. The power density spectra (PDS) in the LHS state show strong variability with fractional rms ~30% (McClintock & Remillard 2006; Belloni et al. 2011; Zhou et al. 2013; Shidatsu et al. 2014; Ingram et al. 2017). The transition of the BHXRBs to the HSS occurs via the two intermediate states (HIMS and SIMS). However, the transition from the hard to soft is not a smooth one, and in many outbursts, several excursions to harder and softer states have been observed. As the source moves from the hard state to the soft state, the power-law component starts to steepen (up to $\Gamma \sim 2.5$), and the X-ray continuum becomes increasingly dominated by emission from an optically thick and geometrically thin accretion disk with a few percent of fractional rms variability (Shakura & Sunyaev 1973; Belloni et al. 2011). In the soft state, the accretion disk either reaches closer to the innermost stable circular orbit (ISCO) or extends down to the ISCO (Gierliński & Done 2004; Steiner et al. 2010). It is worth mentioning here that there is an ongoing debate on the nature of extent of the accretion disk in the LHS. However, several workers have found that a hot advection-dominated accretion flow (ADAF), as proposed by Esin et al. (1997), replaces the geometrically thin and optically thick accretion disk, introducing a truncated inner disk (McClintock et al. 1995, 2001, 2003; Narayan & Yi 1995; Narayan et al. 1996; Esin et al. 2001; Plant et al. 2015).

Another salient observational feature of BHXRBs is the X-ray reflection. This appears when the hard Comptonized X-rays from the corona are reflected from the disk, giving rise to a reflection hump in ~10–40 keV and a fluorescent iron line K_{α} line at ~6.4–6.9 keV. The iron line may be distorted by special and general relativistic effects (Fabian et al. 1989; Reynolds & Nowak 2003; Miller 2007; Ingram et al. 2017). Modeling of the broad iron line with relativistic reflection gives an alternative way to measure the inner disk radius. The modeling of the reflection continuum can also play a crucial role in understanding the inner accretion dynamics of the disk, as well as probe key parameters like the black hole spin and the disk inclination. It is worth mentioning here that the relativistic

Journal of Molecular Liquids
Volume 314, 15 September 2020, 113642

Utilisation of cobalt doped Iron based MOF for enhanced removal and recovery of methylene blue dye from waste water

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https://doi.org/10.1016/j.molliq.2020.113642

Highlights

- Synthesis of Co doped Fe BDC MOF for enhanced dye removal
- Optimization of batch and column process for dye removal
- Investigations of adsorption isotherms and kinetic model
- Calculation of thermodynamic parameters

Abstract

In the present study attempts have been made to improve the adsorption performance of Fe-Benzene dicarboxylic acid metal organic framework for the removal of methylene blue dye from waste waters through cobalt doping. The removal efficiency of Co doped Fe-BDC MOF improved from 8.56 to 23.92 mg/g. Batch and column methods have been used to evaluate

Desalination and Water Treatment
www.deswater.com

doi: 10.5004/dwt.2020.26387

205 (2020) 386–399
November

Removal of crystal violet from aqueous solution using iron based metal organic framework

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Received 24 June 2019; Accepted 25 July 2020

ABSTRACT

Iron-benzene dicarboxylic acid (BDC) metal-organic framework (MOF) has been synthesized by solvothermal method at room temperature and tested for the adsorptive removal of the organic dye crystal violet from aqueous solution. Dye removal efficiency and adsorption characteristics were determined to investigate factors such as the effect of dye concentration, contact time, temperature, dose, and pH. Maximum dye removal efficiency was recorded to be 100% with an initial dye concentration of 5 mg/L. Langmuir, Freundlich, and Temkin adsorption isotherm models were used to investigate the adsorption process. The adsorption isotherm of crystal violet onto Fe-BDC-MOF can be described by Freundlich isotherm model and Langmuir isotherm model. Pseudo-second-order kinetic model with rate constant 1.22×10^{-2} g/mg.min is found to be the best fit for the adsorption. Thermodynamic parameters viz. free energy; enthalpy, and entropy have been calculated with the help of adsorption isotherm data. The values of enthalpy and entropy have been obtained as 0.0947 kJ/mol and 0.325 kJ/mol/K, respectively, indicating an endothermic process with an increase in randomness at the solid-solution interface during adsorption. Negative value of ΔG illustrates the process to be spontaneous. Column adsorption capacity of Fe-BDC-MOF has been recorded 26.65 mg/g.

Keywords: MOF; Crystal violet; Adsorption; Kinetics; Thermodynamics

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3.4.5

Carbon Management

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ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tcmt20

Tree species suitable for roadside afforestation and carbon sequestration in Bilaspur, India

Anil Ragula & Krishna K. Chandra

To cite this article: Anil Ragula & Krishna K. Chandra (2020): Tree species suitable for roadside afforestation and carbon sequestration in Bilaspur, India, Carbon Management, DOI: 10.1080/17583004.2020.1790243

To link to this article: https://doi.org/10.1080/17583004.2020.1790243

Published online: 21 Jul 2020.

Conserving environment through Sericulture: A Case Study on Silk producer WSG of central India

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Abstract:

Transformation and diversification of agricultural practices is one of the best solution and aspects which need to be emphasized to achieved the objective of alleviation of rural poverty. Sericulture, basically an agro-industry and an economically rewarding enterprise consisting of several sets of activities of growing silkworm, food plants, rearing silkworms and production of silk. SHG is a small voluntary association of poor people, preferably from the same socio economic background. From 1970's self – help group (SHG) movement has got a successful path not only as financial supporting group but also as a platform for the poor and women to empower themselves psychologically, socially and economically. For present paper study was conducted in Silk Research, Development and Training centre of *Ramtala, Bilaspur, Chhattisgarh of central India. The study have given out results that women self group faces* many unavoidable circumstances during their work in spite of that they get substantial return to fulfill the needs of their family. It shows that sericulture practices would be the best alternative source of income for rural household. sericulture and industry is an ideal tool for women empowerment and gender equality shows women empowerment women self help group of *Ramtala* demonstrate the best model.

Key Words: Sericultre, Women self group,

Introduction :

Farming is back – bone of Indian economy and recognized as main sector for rural people's employment and income. The substantial share of rural livelihood is derived from agricultural occupation that cannot provide full and satisfactory employment to farmers under the era of products competition and nature, industrialization, urbanization, current climate change, etc. thus, transformation and diversification of agricultural practices is one of the best solution and aspects which need to be emphasized to achieved the objective of alleviation of rural poverty. Besides the farming, the activities that generate employment potentially and substantially are – collection of NTFPs, dairy, fisheries, poultry, horticulture, sericulture, etc.(Kumar, March 2018)

The livelihood among tribal communities in India is complex, dynamic and multidimensional phenomenon, the perception of which varies with geographic location, type of communities, age, gender, education, fluctuations in resource. The word "sericulture" has been derived from the word "su" (Si) which means silk. Sericulture, the art and science of growing silkworm, food plants, rearing

Source details

Xi'an Dianzi Keji Daxue Xuebao/Journal of Xidian University

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Publisher: Science Press

ISSN: 1001-2400

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Plant Archives Vol. 20, No. 1, 2020 pp. 619-1623 e-ISSN:2581-6063 (online), ISSN:0972-5210

SUSTAINABLE ENERGY MANAGEMENT IN LOW FOREST DENSITY SITES OF CENTRAL INDIA : SIGNIFICANCE OF WOMEN PARTICIPATION

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Abstract

Women in India are playing a crucial role in protection and conservation of environment. Women in our country have brought a different perspective to the environment debate, because of their different experience base. In India about approximately 96% of rural household are estimated to be using bio fuels. One of the important features of rural energy is the dependence on locally available biomass resources. Fuel wood is the primary energy source for cooking used by rural households. Mostly village women spent 3 to 6 hr a day for collection of fuel wood. They understand clearly that economics and environment are compatible. Their experience reveals to them that soil, water and vegetation, necessary for their day-to-day living, requires care and good management. Environmental degradation is related not only to the biosphere alone, but to the social sphere as well. Women are also the active members of most of the community forests. women are providing an important role in sustainable development of community forests. However, their role is neither properly identified nor explored. A study was done in remote villages of central Chhattisgarh, India to examine the relationship between fuel consumption pattern and certain influencing factors. To formulate a systematic approach for studying about women's participation an elaborate exercise was taken for data collection. It was observed that enhanced use of alternative sources of energy can balance the increasing demand of fuel wood and make use of fuel more economic. Utilization of non conventional sources of energy as solar cooker and bio gas and energy saving devices, promotion of the fuel wood plantation system near the villages not only reduce the biotic pressure from vegetation but also promote the green cover which could support the environment. This paper explores and analyzes women's role in development and conservation of forest for through sustainable energy management.

Key words : Sustainable energy management, bio-diversity, women participation.

Introduction

Women have always been the major conservers of bio-diversity. Traditionally, women have been responsible for subsistence and survival for water, food, fuel, fodder and habitat, though they rarely get the credit for nurturing these life support systems. Even today they perform duties such as seed selection, multiplication and conservation. The on-farm conservation traditions of rural and tribal women, with reference to agro-biodiversity are well known. Janjgeer district of Chhattisgarh is a typical example of severe deforestation, soil erosion and destruction of natural resources resulting in degradation of environment, and social problems such as poverty unemployment and unrest. Frequent drought had made the situation worse. To Arrest forest degradation and rehabilitation of degraded forests the Government of India issued guidelines on June 1, 1990. Joint forest management advocates strong community participation, bottom up planning and sustainable use of forest resources. Women are also the active members of these committees. Thus, women are providing an important role in sustainable development of community forests. This paper explores and analyzes women's role in development and conservation of forest for its sustainable development.

Wood constitutes the principal source of energy for the rural people. They usually collect fuel wood from neighbouring forest or fields at no cost except the labour

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Plant Archives Vol. 21, No. 2, 2021 pp. 427-429 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2021.v21.no2.067

HABITAT DIVERSITY OF EDIBLE WILD MUSHROOMS IN SEMARSOT WILDLIFE SANCTUARY, CHHATTISGARH, INDIA

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(Date of Receiving : 21-08-2020; Date of Revision : 10-05-2021; Date of Acceptance : 11-07-2021)

ABSTRACT

The number of mushroom species documented in India is about 1,200, out of which 300–315 species are considered edible. The tropical forests of Semarsot provide favorable growth conditions for wild edible mushrooms. Extensive surveys and interviews conducted in the Semarsot sanctuary forest reveals 41 wild mushrooms in the forest area of sanctuary. Out of these 20 are edible wild mushrooms, most common of them are *Asteraus hygromertricus, Russula* spp. and *Termitomyces* spp. 05 are medicinal of which *Ganoderma lucidium* is the important one, 02 fairly edible, 13 non edible and 01 poisonous Species of wild mushroom. Of these 20 edible wild mushrooms

Keywords **:** Semarsot sanctuary, edible mushrooms, habitat.

INTRODUCTION

India being a tropical country shows diversity climatic conditions making it a natural habitat of a wide variety of wild mushrooms. Wild edible mushrooms play an important role in ecological process. Most of them are symbiotically associated with trees of tropical forests. In India, 232 genera have been reported out of the 357 genera of Basidiomycetes in the world. The number of mushroom species documented in India is about 1,200, out of which 300–315 species are considered edible. Chhattisgarh a state in central India has 44.215% of its geographical area under forest. Forests in northern Chhattisgarh are tropical forests, which favor the growth conditions for wild edible mushroom.

Mushrooms comprise largely the group of fleshy fungi. The saprophytic wild edible mushrooms are very crucial in nutrient recycling and also providing economical benefits to rural/tribal people by collecting them from wild and selling in the markets. They are the traditional collectors and consumers of varieties of wild mushrooms. Even though, wild edible mushrooms contribute towards livelihood and economy of the rural and tribal folks, information on their diversity and demand are very limited in Northern Chhattisgarh.

MATERIALS AND METHODS

Semarsot is a wildlife sanctuary situated in balrampur district of northern Chhattisgarh. Semarsot is about 50 kms from Ambikapur district headquarters of Surguja district. The area is situated in the northern extension of Ramgarh hills in a north-easterly direction. The area has a border with Bihar state in the east. Tropic of Cancer passes through the area. The area of the sanctuary is 430.36 Sq. Kms. It is located at Latitude : 22° 45′ (N), Longitude: 84° (E). The forest types found in the sanctuary are Sal forest, Mixed deciduous forest and Riverine forest. The tree species that generally occur are *Shorea robusta, Terminalia alata, Terminalia chebula, Terminalia arjuna, Terminalia bellerica, Lagerstroemia parviflora, Anogeissus latifolia, Adina cordfolia, Madhuca indica, Emblica officinalis, Butea monosperma, Pterocarpus marsupium* and *Grewia* species etc.

Frequent visits to Semarsot forest, Balrampur were made in pre monsoon, monsoon and late monsoon times from July to September 2019. The survey for occurrence of wild mushrooms was made on both sides of road and extending 1 km inside the forest along the road in the sanctuary. The survey was made in the morning 7:00am to 9:00 am. Visit to local markets in Ambikapur, Rajpur, and Balrampur were undertaken and interview was conducted on sellers and collectors of wild mushrooms about their edibility and economic values. Necessary equipments for collection of mushrooms such as digging tools, knife, paper for wrapping mushrooms, camera for photography.

RESULT AND DISCUSSION

During the survey of the Semarsot forest, Balrampur 41 mushrooms fungi were observed and collected during monsoon and late monsoon. These mushrooms were found in a variety of habitats. Soil, dead wood logs, tree trunks and organic matter are some common habitats. The most common species observed are *Russula, Termitomyces* and *Astreaus hygrometricus.* Former being observed from monsoon to late monsoon period in leaf litter and termite mounds respectively whereas the last is usually observed

ISSN 2347 - 3983
Volume 9. No. 2, February 2021
International Journal of Emerging Trends in Engineering Research
Available Online at http://www.warse.org/IJETER/static/pdf/file/ijeter12922021.pdf
https://doi.org/10.30534/ijeter/2021/12922021

Probabilistic Seismic Hazards Analysis of Ambikapur-Chhattisgarh (India)

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ABSTRACT

The present study reveals the seismic hazard analysis of district headquarter Ambikapur, in the state of Chhattisgarh. Usually, seismic hazard study attempts to analyze two different kinds of anticipated ground motions, "the Deterministic Seismic Hazard Analysis (DSHA)" and "the Probabilistic Seismic Hazard Analysis (PSHA)". The maximum Peak Ground Acceleration (PGA) has been estimated by using Iyengar and Raghu Kanth (2004) attenuation relationship. The regional recurrences relation is obtained by using available historical data and 33 numbers of seismic sources (liner faults) that are likely to cause ground motion, around the study area. The probabilistic seismic hazard analysis has been applied over Ambikapur, to assess the probability of exceedance for various PGA(g)values the seismic hazard curve has been developed by using Raghu Kanth and Iyengar (2007) attenuation relationship. The probability of exceedance for PGA(g) values as 0.01g,0.05g,0.10g,0.15g for their corresponding return periods have also been assessed. The liner seismic source having length 46kM, produced maximum peak ground motion as 0.15259g for recurrence period of 100 years. For Ambikapur district headquarter the probability of exceedance for 0.1g with a return period of 8788 years is estimated as 63.22%. Maximum Peak Ground Acceleration value and % probability of exceedance reflects that the seismicity of Ambikapur district headquarter is found to have exceeded from 0.1g as recommended by IS:1893 (Part 1): 2016 (Sixth Revision) for Chhattisgarh. Hence, it is recommended from present study that, Ambikapur should be included in zone III instead of zone II.

Key words : Ground Motion Attenuation, Peak Ground Acceleration, Uncertainty, Seismic Hazard Curve.

1. INTRODUCTION

Since the dawn of human civilization, seismic tremor is known to be one of the primary complex phenomenon that the present world is facing. Efforts are being made to develop realistic and probabilistic models, for determining the location and time of
upcoming earthquakes. It is indispensable that the after effects can be reduced to some extent. Regional seismic hazard maps that are developed, give an idea of seismic hazard vulnerability of an area. So various researchers have carried out seismic microzonation of different Indian cities and states using probabilistic approach. In seismic map of India Chhattisgarh state is located in "low" seismically active region Ambikapur, is said to be one of the oldest but prominent city there, the name being derived from the Hindu Goddess worshipped in that area. The location can be traced towards the east of central India, at 23º 12' N 83º 2' E. The city is said to be a proud owner of many valuable heritage structures, outlining the precious constituents of history, culture and human evolution. There are many evidences existing to the olden construction technology, aesthetics, civilizing practices, arts, defenses and governance of the region. These ancient masonry structures were constructed based on empirical acquaintance of structural behavior by trial-and-error processes, essentially taking into consideration dead loads only. Not overlooking their bulky mass due to masonry walls, poor connections between structural elements and structural distress due to deteriorated material properties they are often found to undergo destruction. Conservation of such historical buildings from natural disasters like an earthquake becomes a paramount responsibility of the modern society, so that it may be conserved for the future generations.

2. PIONEER RESEARCH IN INDIA

As Peninsular India (PI) lies within intra-plate setting (a region far from well-defined plate boundaries) very little crustal deformation is expected [1]. When compared to the foothills of mighty Himalayas, earthquakes are generally less likely to occur near the plate boundaries. Although the frequency of occurrence of large earthquakes is low, their impact on civilization is high. Thus, it becomes imperative to compute the seismic hazard for Peninsular India for future

Research Article

An Integrated Approach of Proposed Pruning Based Feature Selection Technique (PBFST) for Phishing E-mail Detection

(E-pub Ahead of Print)

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Journal Name: Recent Advances in Computer Science and Communications

Formerly Recent Patents on Computer Science (https://www.eurekaselect.com/node/676/)

DOI : 10.2174/2666255814666210322162129 (https://doi.org/10.2174/2666255814666210322162129)

Article ID: e220321192418 (https://www.eurekaselect.com/192418/article)

Journal Home (/node/174415)

Abstract:

Introduction: The entire world is shifting towards electronic communication through Email for fast and secure communication. Millions of people, including organization, government, and others, are using Email services. This growing number of Email users are facing problems; therefore, detecting phishing Email is a challenging task, especially for non-IT users. Automatic detection of phishing Email is essential to deploy along with Email software. Various authors have worked in the field of phishing Email classification with different feature selection and optimization techniques for better performance.

Objective: This paper attempts to build a model for the detection of phishing Email using data mining techniques. This paper's significant contribution is to develop and apply Feature Selection Technique (FST) to reduce features from the phishing Email benchmark data set.

Methods: The proposed Pruning Based Feature Selection Technique (PBFST) is used to determine the rank of feature based on the level of the tree where feature exists. The proposed algorithm is integrated with already developed Bucket Based Feature Selection Technique (BBFST). BBFST is used as an internal part to rank features in a particular level of the tree.

Results: Experimental work was carried out with open source WEKA data mining software using a 10-fold cross-validation technique. The proposed FST was compared with other ranking based FSTs to check the performance of C4.5 classifier with Phishing Email data set.

Conclusion: The proposed FST reduces 33 features out of 47 features which exist in phishing Email dataset and C4.5 algorithm produces remarkable accuracy of 99.06% with only 11 features and it has been found to be better than other existing FSTs.

Keywords: Phishing e-mail detection (https://www.eurekaselect.com/search/aws_search.php?searchvalue=Phishing e-mail detection), Pruning Based Feature Selection Technique (PBFST) (https://www.eurekaselect.com/search/aws_search.php?searchvalue= Pruning Based Feature Selection Technique (PBFST)), classification (https://www.eurekaselect.com/search/aws_search.php?searchvalue= classification), Decision Tree (DT) (https://www.eurekaselect.com/search/aws_search.php?searchvalue= Decision Tree (DT)), gain ratio (https://www.eurekaselect.com/search/aws_search.php?searchvalue= gain ratio), data mining. (https://www.eurekaselect.com/search/aws_search.php?searchvalue= data mining.)

Article Details

Article ID: e220321192418 (https://www.eurekaselect.com/192418/article)
(E-pub Ahead of Print)
DOI: 10.2174/2666255814666210322162129
(https://doi.org/10.2174/2666255814666210322162129)
Price: $95

Article Metrics

PDF: 458

(/terms/termandcondition.html?1)

(https://www.projectcounter.org/counter-user/bentham-science/)

PalArch's Journal of Archaeology of Egypt / Egyptology

A NOVEL META-ENSEMBLE MODEL OF GENE-EXPRESSION BIG DATA

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Prem Kumar Chandrakar , Akhilesh Kumar Shrivas , Neelam Sahu: A Novel Meta-Ensemble Model Of Gene-Expression Big Data– Palarch's Journal Of Archaeology Of Egypt/Egyptology 17(6). ISSN 1567-214x

Keywords: Big data, Gene expression, DNA Microarray, Lung cancer, Ensemble methods, Decision tree, Classifier.

ABSTRACT

Big Data is turning intoone ofthe foremostimportant areas in current analysis in applied science, and data processing. There are severaldifficultproblemsrelated tomanaging theinformation and one vital issue is that the high-dimensional data analysis. High-dimensional information is relevant to a field reminiscent oforganic phenomenonidentification. Organic phenomenon data set manufacturingimmense amounts of information. Organic phenomenon levels are vital for un-wellness, such as gene-expression profiling. Gene expression levels are important for disease, such as Lung Cancer diagnosis.Continue to this, classification strategiesutilized in high dimensional big data studies for gene-expression are numerouswithin themethod they alter the underlying complexness of the info, also as within the technique wont to build the classification model. The classification of variousgene-expression datasets like carcinomasorts is important in cancer identification and drug discovery This paper planneda choice tree-based mostly ensemble classifier to classify the management and cancer teamssupportedorganic phenomenon levels from microarray information. A combinative algorithm with the choice tree formula is developed to pick outvitaloptionsand stylethe correct

EAI Endorsed Transactions
on Pervasive Health and Technology
Research Article EAI.EU

Design of Novel ETL Model to Analyse Corona Virus Data

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Abstract

INTRODUCTION:
The corona disease was first recognized in 2019 in Wuhan, which is the capital of China's Hubei-province, and from then it continued spreading and as a result declared as a pandemic by all nations. The COVID-19 virus has different effects on people in various ways. It is a kind of respiratory disease. The confirmed cases are increasing day to day in India, which leads to complete lockdown throughout the nation.
OBJECTIVE:
The objective of this research is to design a novel Extract-Trandform and Load NETL model to analyse covid-19 data in india.
METHODS:
The extraction of useful information from a large database is a well-connected research field of text mining. This paper is proposed a novel extract-transform-load ETL model to process the COVID-19 data of India to get the exact recovery data from the multiple data sources from different states of India. In this, a knowledge-based model that generate knowledge based on three different module split, validation, and join is discussed.
RESULTS:
The outcomes of the proposed NETL process are, output file which has the description of total positive cases, active cases, recovery cases, and death rate, based on different regions. The analysis of NETL is done based on accuracy, failure count, and execution time. The proposed NETL process is more accurate and taking less compilation time with minimum failure count as compared with existing models.
CONCLUSION:
To analyze the coronavirus data in India, a novel ETL (NETL) model is proposed. In this model, a total of 9 CSV files is processed as input files to get different results in different categories. This model is having three modules namely splitting, verification, and join. The dataset is split into based on its coupling attributes and then joined with a single value to produce the updated results as per the current dataset. The last stage of this process is to join the data which is generated through splitting. The proposed NETL model is more accurate as compared with existing ETM models.

Received on 20 May 2020; accepted on 14 July 2020; published on 22 July 2020

Keywords: Corona Virus, Text Mining, Data Analytics, ETL, Covid-19, Pandemic.

doi:10.4108/eai.13-7-2018.165671

1. Introduction

Self-information extraction is consistently been a significant application and research area since the origin of digital records. Therefore, classification and clustering of text is a need because of the extremely huge measure of content archives that we need to manage in day to day life. All in all, content order incorporates the text characterization based on topic, keyword, and cluster which have common properties. Moreover, text mining is a technique in which a document is classified under some predefined

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Multimedia Tools and Applications
https://doi.org/10.1007/s11042-020-09216-7

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Received: 6 March 2019 / Revised: 31 March 2020 / Accepted: 15 June 2020
Published online: 06 July 2020

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Article

A Two-Phase Approach for Semi-Supervised Feature Selection

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Received: 19 July 2020; Accepted: 25 August 2020; Published: 31 August 2020

Abstract: This paper proposes a novel approach for selecting a subset of features in semi-supervised datasets where only some of the patterns are labeled. The whole process is completed in two phases. In the first phase, i.e., Phase-I, the whole dataset is divided into two parts: The first part, which contains labeled patterns, and the second part, which contains unlabeled patterns. In the first part, a small number of features are identified using well-known maximum relevance (from first part) and minimum redundancy (whole dataset) based feature selection approaches using the correlation coefficient. The subset of features from the identified set of features, which produces a high classification accuracy using any supervised classifier from labeled patterns, is selected for later processing. In the second phase, i.e., Phase-II, the patterns belonging to the first and second part are clustered separately into the available number of classes of the dataset. In the clusters of the first part, take the majority of patterns belonging to a cluster as the class for that cluster, which is given already. Form the pairs of cluster centroids made in the first and second part. The centroid of the second part nearest to a centroid of the first part will be paired. As the class of the first centroid is known, the same class can be assigned to the centroid of the cluster of the second part, which is unknown. The actual class of the patterns if known for the second part of the dataset can be used to test the classification accuracy of patterns in the second part. The proposed two-phase approach performs well in terms of classification accuracy and number of features selected on the given benchmarked datasets.

Keywords: feature selection; semi-supervised datasets; classification; clustering; correlation

1. Introduction

Pattern classification [1] is one of the core challenging tasks [2,3] in data mining [4,5], web mining [6], bioinformatics [7], and financial forecasting [8,9]. The goal of classification [10,11] is to assign a new entity to a class from a pre-specified set of classes. As a particular case, the importance of pattern classification can be realized in the classification of breast cancer. There are two classes of patients, one belonging to the "benign" class, having no breast cancer, while the other class of patients belong to the "malignant" class, which shows strong evidence of breast cancer. A good classifier will reduce the uncertainty of misclassifying patients from being in one of these two classes. Recently,

sustainability

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Article

An Early Flame Detection System Based on Image Block Threshold Selection Using Knowledge of Local and Global Feature Analysis

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Received: 4 August 2020; Accepted: 22 October 2020; Published: 27 October 2020

Abstract: Fire is one of the mutable hazards that damage properties and destroy forests. Many researchers are involved in early warning systems, which considerably minimize the consequences of fire damage. However, many existing image-based fire detection systems can perform well in a particular field. A general framework is proposed in this paper which works on realistic conditions. This approach filters out image blocks based on thresholds of different temporal and spatial features, starting with dividing the image into blocks and extraction of flames blocks from image foreground and background, and candidates blocks are analyzed to identify local features of color, source immobility, and flame flickering. Each local feature filter resolves different false-positive fire cases. Filtered blocks are further analyzed by global analysis to extract flame texture and flame reflection in surrounding blocks. Sequences of successful detections are buffered by a decision alarm system to reduce errors due to external camera influences. Research algorithms have low computation time. Through a sequence of experiments, the result is consistent with the empirical evidence and shows that the detection rate of the proposed system exceeds previous studies and reduces false alarm rates under various environments.

Keywords: feature extraction; video surveillance; image processing; fire detection; block-based analysis

1. Introduction

Fire is one of the most uncontrollable phenomena with respect to time and space and directly endangers human life and property and nature. Based on the National Fire Protection Association (NFPA) report, 1,342,000 fire incidents were reported. Moreover, there was 10.6 billion U.S. Dollars in property damage in the U.S. in 2016 [1]. There are fast ways of detecting it: (1) heat detection (e.g., Fixed Temperature Detectors), (2) chemical-compound-smoke detection (e.g., ionization and gas sensors), and (3) flame detection (e.g., ultraviolet and infrared sensors) [2]. Traditional methods

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Article

An Intelligent Automatic Human Detection and Tracking System Based on Weighted Resampling Particle Filtering

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Received: 13 July 2020; Accepted: 23 September 2020; Published: 9 October 2020

Abstract: At present, traditional visual-based surveillance systems are becoming impractical, inefficient, and time-consuming. Automation-based surveillance systems appeared to overcome these limitations. However, the automatic systems have some challenges such as occlusion and retaining images smoothly and continuously. This research proposes a weighted resampling particle filter approach for human tracking to handle these challenges. The primary functions of the proposed system are human detection, human monitoring, and camera control. We used the codebook matching algorithm to define the human region as a target and track it, and we used the practical filter algorithm to follow and extract the target information. Consequently, the obtained information was used to configure the camera control. The experiments were tested in various environments to prove the stability and performance of the proposed system based on the active camera.

Keywords: color distribution; particle filter; human tracking; codebook matching; PID controller; GMM; active camera

1. Introduction

Recently, security surveillance has applied visual-based tracking and detection techniques for improving convenience and safety for humans. Human tracking and detection are essential topics in a surveillance system. Human recognition and moving object extraction are the two parts of any typical human detection system. Human recognition identifies an object as nonhuman or human, and objects are extracted from the background by means of moving object extraction, which determines the related size and position of the object in an image. The tracking system is essentially able to predict the location during and after occlusion, as the tracked object or human is possibly occluded by other objects while tracked.

Surveillance systems typically use two kinds of the cameras: fixed camera and active camera. The fixed camera has the benefit of being low cost but comes with limited field of view (FOV), whereas

Multilevel Color Image Segmentation using Modified Fuzzy Entropy and Cuckoo Search Algorithm

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Abstract: To handle the fuzziness and spatial uncertainties among pixels entailed in color images, this paper proposes a novel fuzzy entropy function for multi-threshold image segmentation based on the energy curve concept and minimum fuzzy entropy criterion. The proposed energy curve based new fuzzy entropy function (ECFE) considers intensity distribution and spatial contextual information among the pixels. To improve efficiency and threshold selection process of the method, cuckoo search algorithm is employed. For comparison, backtracking search algorithm, and Lévy flight based firefly algorithm included. Comparison with recent color image multilevel segmentation techniques presented to test the effectiveness of the proposed algorithm. The performance of the proposed technique is evaluated using different satellite and natural color images. Quantitative and Qualitative results demonstrate that the proposed algorithm is highly accurate, robust, and efficient for color image multilevel segmentation.

Keywords: Multi-level thresholding, Energy curve, minimum fuzzy entropy, Cuckoo search algorithm, Optimization algorithms

1 Introduction

Segmentation is a classic example of multichannel information processing. Multichannel information processing is very important owing to evolution of the fields of remote sensing (RS), multispectral data management, geographical information system (GIS), biomedical imaging, etc. [1-4]. In satellite imaging, segmentation is one of the most important processes to retrieve important and useful information or to detect the region of interest. Satellite images contain large and dense information which is used for processing and analysis. But, these images normally have ill-defined features and ambiguous regions, very low spatial resolution, poor illumination, and high dependency over environmental conditions [5]. Therefore, proper segmentation of satellite images is demanded in many practical applications including forest-type classification, sea-ice-type classification, soil moisture and vegetation, measurement, land cover classification, etc. [6]. Currently, various image segmentation techniques are presented in the literature [7,8].

In the field of image segmentation, information entropy theory-based thresholding is most popular area in theoretical research and applications as it is fit for the images exhibiting distinct gray levels of objects and background. The advancements in the information theory have intensified the scope to investigate different entropy models for efficient thresholding based segmentation [9, 10]. Various entropy models such as Shannon Entropy, Kapur's entropy, Otsu method, Rényi entropy, Tsalli's entropy, and minimum cross entropy (MCE) reported in [11], [12] have been proposed. The goal of thresholding is to select the single pixel (bi-level thresholding) or multiple pixels (multilevel thresholding) which can distinguish the region of interest from its background.

Due to the development of multi-object technology such as multi-object tracking and multi-object optimization, multilevel image thresholding (MIT) is an appropriate method to fulfill the requirements of most machine vision and pattern recognition applications. MIT segmentation techniques can be broadly categorized into: (a) classical approach [13, 14] (b) Swarm Intelligence (SI)/Evolutionary Algorithms (EA) based approach [15, 16]. In past few decades, large amount of techniques have been developed in the field of image segmentation, and it has been noticed that multilevel thresholding based on classical implementations is computationally complex and time inefficient as they optimize the objective function by exhaustively searching for the optimum values. To determine acceptable sub-optimal thresholds quickly, applications of some well-known meta-heuristics can be found in literature meant for thresholding based segmentation of Satellite images and other color images [5], [13-21] this paper, a new fuzzy based entropy function is proposed using minimum fuzzy entropy criterion. Histogram based thresholding techniques has been unable to consider the contextual and local information for selecting an optimum threshold. As a consequence, the images of different characteristics may have very similar 1-D histogram to yield close thresholding results, which may lead to inaccurate satellite image segmentation. To mitigate these limitations, MFE has been proposed to search optimal thresholds based on information derived from energy

International Journal of Software Science and Computational Intelligence
Volume 13 • Issue 1 • January-March 2021

An Empirical Study on Initializing Centroids in K-Means Clustering for Feature Selection

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ABSTRACT

One of the main problems in K-means clustering is setting of initial centroids which can cause misclustering of patterns which affects clustering accuracy. Recently, a density and distance-based technique for determining initial centroids has claimed a faster convergence of clusters. Motivated from this key idea, the authors study the impact of initial centroids on clustering accuracy for unsupervised feature selection. Three metrics are used to rank the features of a data set. The centroids of the clusters in the data sets, to be applied in K-means clustering, are initialized randomly as well as by density and distance-based approaches. Extensive experiments are performed on 15 datasets. The main significance of the paper is that the K-means clustering yields higher accuracies in majority of these datasets using proposed density and distance-based approach. As an impact of the paper, with fewer features, a good clustering accuracy can be achieved which can be useful in data mining of data sets with thousands of features.

KEYWORDS

Centroid, Classification, Feature Selection, Information Gain, K-Means Clustering, Laplacian Score, Ranking Methods of Features in Data Sets, Variance

1. INTRODUCTION

The curse of dimensionality is a major problem in large datasets. A dimension is commonly known by names like feature or attribute or property or even column in a dataset. In order to save more and more information, many irrelevant features are also preserved in a dataset and these features can be contributing nothing while classifying the dataset for taking some inference out of it and sometimes even adding to misclassification of patterns. A dataset with large dimensionality may increase the time and space complexity wile classifying it. More specifically, the performance of a classifier depends on several factors: i) number of training instances. ii) Dimensionality, *i.e.*, number of features, and iii) complexity of the classifier (Saxena et al., 2010). Feature selection is an important component in pattern recognition (Duda et al., 2001). Feature Selection can be done in supervised or unsupervised manner. When feature selection techniques use the knowledge of class given in the data sets, it is called supervised feature selection. Feature selection without using class information is called unsupervised feature selection. For unsupervised feature selection, Mitra (Mitra et al., 2010), proposed a method that partitions original feature set into distinct subsets or clusters so that features in one cluster are highly similar while those in different clusters are dissimilar. A single feature is then selected from each cluster to form a reduced feature subset. Feature Selection for clustering is discussed in (Dash et al., 2000). Dy and Brodley (2000) presented a wrapper framework for feature

DOI: 10.4018/IJSSCI.2021010101

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Design of a Novel Ensemble Model of Classification Technique for Gene-Expression Data of Lung Cancer with Modified Genetic Algorithm

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Abstract

INTRODUCTION: Gene expression levels are important for identifying and diagnosing diseases like cancer. Gene expression microarray information contains a high extent feature set, which minimizes the performance and the accuracy of classifiers.
OBJECTIVES: This paper proposes a Modified Genetic Algorithm (MGA) that is based on Classifier Subset Evaluators – Genetic Search (Eval-CSE_GS) for selecting the relevant feature subsets. The MGA feature selection procedure is applied to microarray information for cancer patients that minimize a high dimension feature subset into low dimension feature subsets.
METHODS: The various data mining methods for classifying the various kinds of cancer disease patients are presented. The proposed model refers to an ensemble model (PEM) for the organization of cancer disease by reducing the feature subsets, which results show improvements in the success rate.
RESULTS: The proposed ensemble model obtains the accuracy of 94.58%, 96.56% and 97.04% for PEM-1 to PEM-3, respectively.
CONCLUSION: Our proposed MGA-PEM model gives satisfactory results for cancer identification and classification.

Received on 27 August 2020; accepted on 12 December 2020; published on 08 January 2021

Keywords: Gene Expression, Modified Genetic Algorithm (MGA), Ensemble, Proposed Ensemble Model (PEM), Microarray, Lung Cancer.

doi:10.4108/eai.8-1-2021.167845

1. Introduction

Gene-expression patterns are attributes of disorder diagnosis, which can be applied to accurately classify cancer. Nowadays, many data mining and classification strategies like Naive Bayes and J-48 are being developed in the research community, in which most of the methods are applied to cancer disorder data and its organization [1, 2]. This supported organic phenomenon amounts from microarray information and gene-disease relationships may be detected using machine-learning algorithms and owing to the high dimensionality of microarray information data sets, which is often challenged with over-fitting, poor performance, and low potency. Given these challenges, there are some discrimination methods for the classification of tumors proposed by Dudoit [3] through the use of high-density DNA sequences and oligonucleotides. Feature choice [4], ensemble call trees [5], and ensemble neural networks [6] also appear to be effective and possible solutions. Although many researchers have explored cancer classification, few of them have centered on the combinatory ensemble methodology with a support vector machine or are inconclusive in terms of the classifiers' performance. This paper proposes a Modified Genetic-Algorithm (MGA) and Projected Ensemble Model (PEM) as a learning algorithmic rule that remarkably improves the accuracy and strength of

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Research Article

Differential evolution based radial basis function neural network model for reference evapotranspiration estimation

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Received: 2 April 2020 / Accepted: 22 December 2020

Abstract
The present study is an effort to examine the capability of a differential evolution based radial basis function neural network (RBFDE) to model weekly reference evapotranspiration (ET_0) as a function of climatic parameters in different agro-climatic zones (ACZs) of a moist sub-humid region in East-Central India. The ET_0 computed using the empirical equation of Penman–Monteith suggested by the Food and Agricultural Organization (FAO56-PM) is considered as a target variable for investigation. The performance of the proposed RBFDE model is compared with particle swarm optimization based radial basis function (RBFPSO), radial basis function neural network (RBFNN), multilayer artificial neural network (MLANN) models and conventional empirical equations of Hargreaves, Turc, Open-Pan, and Blaney-Criddle. Weekly ET_0 estimates that are obtained using RBFDE, RBFPSO, and RBFNN and MLANN are observed to be more consistent than equivalent empirical methods. For a critical analysis of simulation results, mean absolute percentage error (MAPE), root means square error (RMSE), determination coefficient (R^2) and Nash–Sutcliffe efficiency factor (NSE) is computed. Low MAPE and RMSE values along with higher R^2 and NSE close to 1, obtained with soft computing models exhibit that, soft computing models produce better estimates of ET_0 than empirical methods. Among the soft computing models, RBFDE provides improved results as compared to RBFPSO, RBFNN, and MLANN models. This method can be extended for ET_0 estimation in other ACZs.

Keywords ET_0 estimation · FAO56-PM · RBFNN · RBFDE · RBFPSO · MLANN · Empirical methods

1 Introduction

In response to atmospheric demand, soil surface evaporation and transpiration from plant occurs simultaneously in a cropping field and is termed as evapotranspiration (ET) in a combined manner [1]. Approximately two-thirds of the total precipitation is consumed by the atmosphere in the form of ET [2]. Therefore, ET is considered one of the most important water balance components for the determination of crop water requirement, length of the crop growing season, and associated agro-climatic studies. Hence, accurate measurement or estimation of ET is essential for the planning and effective implementation of irrigation and water management practices for practical applications. Accurate measurement of ET by volumetric and gravimetric lysimeter is practically very difficult because various factors affect the ET process, which includes climatic parameters, crop characteristics, soil properties, and management practices. Therefore, consumptive use of water from a uniformly distributed grass reference crop under nonlimiting conditions is estimated for practical purposes and termed as ET_0 [3]. In general, ET_0 is computed employing empirical equations as climatic parameters being the only factor affecting the ET process.

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Published online: 10 January 2021

Solar radiation, temperature, humidity, wind speed, and sunshine are the most influential climatic factors which contribute to the ET process [1]. Precise estimation of ET_0 is vital for the efficient utilization of available water resources for agricultural purposes.

Several physicals, empirical equations based on radiation, temperature, mass transfer, and water budget methods have been derived in the past to determine ET_0 with different input combinations of meteorological parameters. Among these empirical methods, the Penman–Monteith equation is recommended by the Food and Agricultural Organization for ET_0 estimation (FAO56-PM) because of its preciseness [1]. FAO56-PM equation requires meteorological parameters such as maximum and minimum temperatures, relative humidity, sunshine hours, wind speed, and solar radiation to determine ET_0. In developing countries, like India, it is invariably very difficult to obtain long term meteorological parameters to compute ET_0 using the FAO56-PM model [4]. Therefore, other empirical models like Hargreaves [5], Turc [6], Open Pan [7], Blaney-Criddle [7], and Christianson [8], etc., are also in use. These empirical equations involve fewer complex variables as compared to FAO56-PM to compute ET_0. However, ET_0 estimates obtained using these models are not comparable with FAO56-PM as these methods yield more errors and hence their practical applications become limited [9].

To address this issue, in recent decades, researchers have successfully demonstrated the application of a variety of computational intelligence based conventional and hybrid soft computing techniques for modeling extremely complex and non-linear relationship between climatic factors and ET_0 [10–19]. Improved predictions of FAO56-PM ET_0 are obtained by Wen et al. [20] using a support vector machine (SVM) as compared to the artificial neural network (ANN) and empirical methods in extremely arid regions of China. Partal [21] has developed a hybrid model combining wavelet transformation and radial basis function neural network (W-RBF) that outperformed conventional RBF, wavelet-multi-linear regression (W-MLR) and empirical methods of Hargreaves and Turc for daily ET_0 estimation with improved accuracy. Kisi and Demir [22] have evaluated the potential of multi-layer perceptron (MLP) with six different weight update algorithms for modeling ET_0 and found MLP with the Levenberg-Marquard algorithm produced a better estimate of ET_o. In a recent study, Dou and Yang [23] have recommended hybrid extreme learning machine (ELM) and adaptive neuro-fuzzy inference system (ANFIS) based models that are more robust and flexible in comparison to traditional ELM and ANFIS. Adamala [24] has reported improved generalized performance of wavelet neural network (WNN) and ANN model for estimation of ET_0 as compared to linear regression (LR), wavelet regression (WR) and Hargreaves (HG) methods for the studied locations in different agro-ecological regions of India. Sanikhani et al. [25] have applied several artificial intelligence models including multi-layer perceptron (MLP), generalized regression neural network (GRNN), integrated ANFIS systems with grid partitioning (ANFIS-GP) and subtractive clustering (AFNIS-SC), radial basis neural network (RBNN) and GEP for modeling ET_0 in a cross-station scenario for different locations in Turkey and demonstrated that AI-based models performed better than the empirical equation of Hargreaves-Samani (HS) and its calibrated version (CHS).

It is also observed from the literature review that researchers have successfully implemented various types of hybrid soft computing models combining conventional neural networks along with evolutionary computing algorithms for estimation of ET_0. Application of nature-inspired algorithms such as genetic algorithm (GA), particle swarm optimization (PSO), artificial bee colony (ABC), etc., in combination with conventional neural networks like ANN and RBNN are investigated in some research publications for ET_0 estimation [26–30]. A study conducted by Feng et al. [31] for estimating FAO56-PM ET_0 in a humid region of Southwest China reveals that ELM and ANN optimized by genetic algorithm (GANN) has resulted in better ET_0 estimates than WNN and empirical approaches of Hargreaves, Makkink, Priestley–Taylor and Ritchie models. Gocić et al. [32] have analyzed the potential of genetic programming (GP), support-vector machine-firefly algorithm (SVM-FFA), ANN, and SVM-Wavelet soft computing approaches and found SVM-Wavelet resulted in improved FAO56-PM ET_0 estimates in Serbia. Mehdizadeh et al. [33] have evaluated the performance of gene expression programming (GEP) and MARS along with two SVM based hybrid models, SVM-Polynomial and SVM-RBF for estimation of monthly mean ET_0 and reported SVM-RBF and MARS outperformed GEP and SVM-Poly and also performed better than 16 other empirical equations considered for comparison. However, Mattar and Alazba [34] have confirmed that the GEP model performed better than the conventional multilinear regression (MLR) approach in Egypt. Most of the soft computing models discussed above are developed under a given scenario in terms of study location, the combination of available input climatic parameters, time scale and duration of climatic data, model structure, learning parameters, and an optimization algorithm, etc. Therefore, practically it becomes very difficult to employ these models in a new location without proper calibration and validation of the model parameters.

To examine the potential of an evolutionary optimized soft computing technique, RBFNN in combination with the differential evolution algorithm (RBFDE) is introduced here for the estimation of ET_0 under three different ACZs in the

Chhattisgarh region of East-Central India. Differential evolution (DE) is considered because it is a simple algorithm in comparison to GA which requires intensive calculations. Due to its simplicity, DE is used in various applications [35–37]. Technical analysis of DE parameters, hybridization of DE with other soft computing techniques, and its practical applications have been discussed by Das et al. [38]. Different variants over state-of-the-art DE have also been presented in the literature. Among these, Hui and Sugunthan [39] suggested ensemble and arithmetic recombination-based speciation DE for multimodal optimization of common benchmark problems. Ramdas et al. [40] developed a reconstructed mutation strategy for DE and applied the same with multilevel image thresholding for improved weather radar image segmentation [41]. A DE variant with multi-donor mutation strategy and annealing-base local search has been developed by Ghosh et al. [42] for optimization of Lennard-Jones potential function-based molecular clustering. The effect of DE-based constraint handling techniques has been evaluated by Biswas et al. [43] for the optimization of power flow systems. One of the authors of this investigation has also been engaged in DE based training of adaptive autoregressive moving average (ARMA) model for exchange rate forecasting [44] and development of a hybrid system using functional link artificial neural network (FLANN) and DE for Odia handwritten numeral recognition [45]. The proposed evolutionary optimized hybrid structure of RBFDE is developed and used for the first time to model FAO56-PM ET_0, and therefore it may be considered as a novel scientific approach for such application. Conventional soft computing techniques like MLANN, RBFNN along with empirical methods of Hargreaves, Turc, Open Pan, and Blaney-Criddle are considered for comparison purposes. Results obtained with RBFDE is also compared with RBFPSO under similar condition. This paper is organized into different sections. Section 1 introduces the problem formulation, literature reviews, and motivation behind the investigation. The detailed description of the data sets, soft computing techniques, and empirical methods are described in the Materials and methods of Sect. 2. Simulation results and comparative performance evaluation of different models are outlined in the results and discussion of Sect. 3. The salient findings of the study are summarized in the conclusion section.

2 Materials and methods

2.1 Study area and dataset

This investigation is carried out to model weekly ET_0 using soft computing techniques. Long term weekly meteorological data (2001 to 2019) of maximum temperature (T_{max}), minimum temperature (T_{min}), bright sunshine hours (BSS), wind speed (WS), morning relative humidity during (RH_1), afternoon relative humidity (RH_2) and weekly cumulative pan evaporation (EP) are collected from Raipur, Jagdalpur and Ambikapur stations located in three distinct ACZs of Chhattisgarh region in central India (Fig. 1). The climate of Chhattisgarh is moist sub-humid in general with an average annual rainfall of 1200–1400 mm and annual ET_0 losses between 1400 and 1600 mm in different ACZs. Data sets are collected from the India Meteorological Department (IMD) (https://mausam.imd.gov.in/) certified observatories located in these stations. These surface meteorological observatories follow the World Meteorological Organization (WMO) guidelines for data collection [46]. WMO guidelines for the observational procedure and quality control are adopted uniformly in these surface meteorological observatories while data acquisition, tabulation, and computation. The online data entry system, itself has an inbuilt quality control mechanism to test the errors like data format, duplicate records, and incorrect units of measurement, impossible values, extremes, and outliers.

Descriptive statistics of different meteorological parameters in terms of mean, high, low, range, standard deviation (SD), and coefficient of variation (CV) are also computed to understand data patterns and to ensure the quality check of data (Table 1). To measure the strength and direction of a linear relationship between two variables, correlation coefficient (R) between meteorological parameters (T_{max}. T_{min}, BSS, WS, RH_1, RH_2, and EP) with FAO56-PM ET_0 are also computed (Table 1). Weekly totals of ET_0 are computed using the FAO56-PM equation which is considered as the target output for model development [1].

The pattern of different meteorological parameters considered as input variables for model development along with target variable FAO56-PM ET_0 in selected stations is represented as box plot arrangements in Fig. 2. The middle line of the box plot signifies the median value while the upper and lower edges signify 75% and 25% of the data set respectively. The highest and lowest limits of the upper and lower vertical lines indicate the highest and lowest values respectively. The square depicts the simulated mean, and the straight-line shows the observed mean.

2.2 Design of soft computing models

2.2.1 Radial basis function neural network (RBFNN) based estimator

RBFNN is a category of feed-forward neural network with a single hidden layer and an output layer formulated by Broomhead and Lowe [47]. Pictorial representation of the

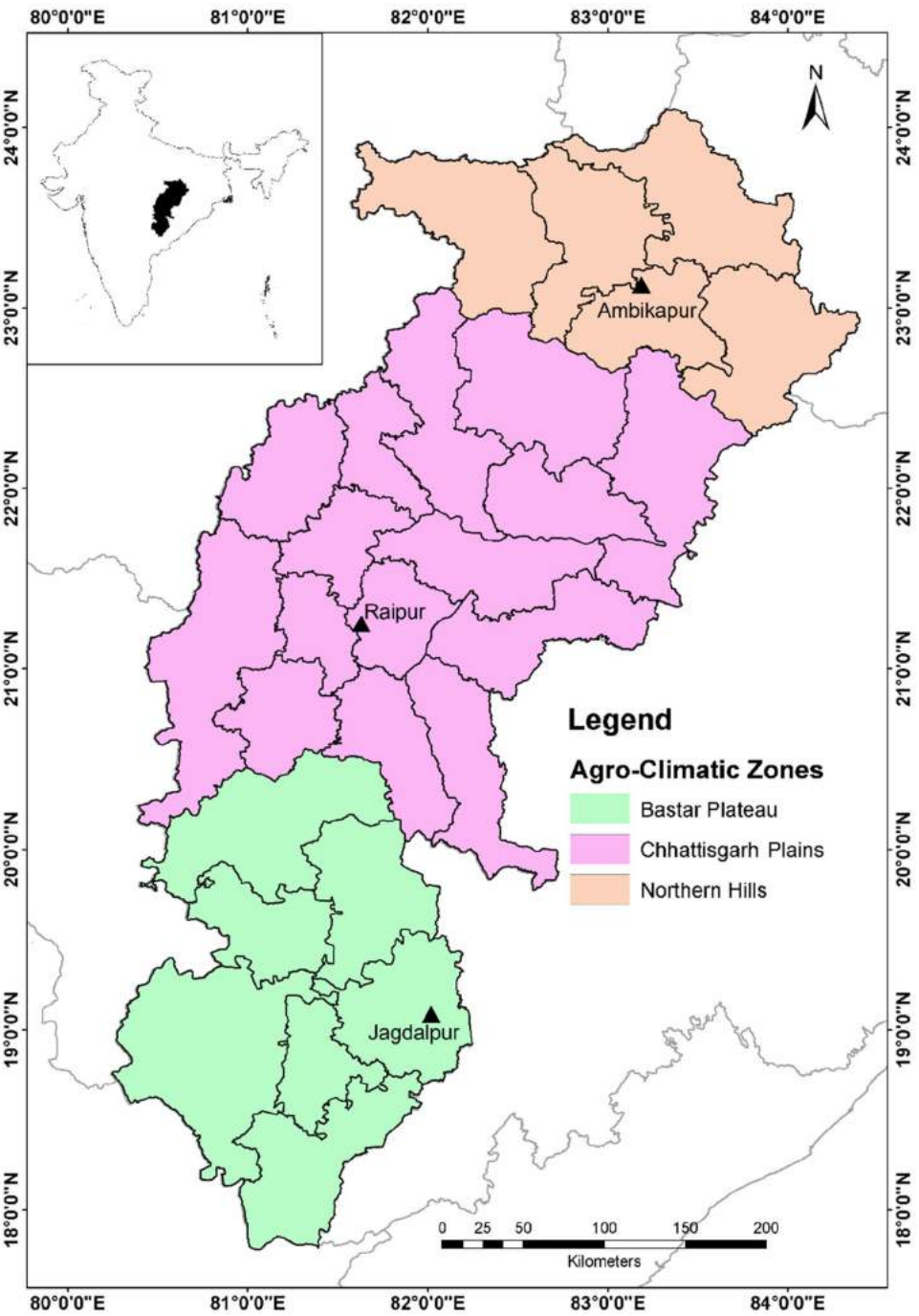

Fig. 1 Location map of the study area

RBFNN is given in Fig. 3. The processing units termed as neurons in the hidden layer are associated with centers, $c = c_1, c_2, c_3, ., ., c_h$, and their width $\sigma = \sigma_1, \sigma_2, \sigma_3, ., ., .\sigma_h$, where h is the number of neurons in the hidden layer. Each neuron in the hidden layer receives the same set of input data $(X = x_1, x_2, x_3, ., ., ., x_n)$. The centers of every hidden neuron have the same dimension as that of the input data, i.e. $c_i \in R^n, X \in R^n$. The output of hidden layer neurons $(\varphi_1, \varphi_2, \varphi_3, ., ., ., \varphi_h)$ are associated with synaptic weights $(w_1, w_2, w_3, ., ., ., w_h)$. Output, $\emptyset_i$ of ith hidden layer neuron is basically a Gaussian function and is represented by:

$$\emptyset_i(z) = e^{\frac{-z^2}{2\sigma_i^2}} \tag{1}$$

where $z = ||x - c_i||$, represents the Euclidian distance between input data and the corresponding centers and $\emptyset_i = \emptyset(||X - c_i||)$. The Gaussian function used in each hidden layer neuron is a category of radial basis function.

Table 1 Descriptive statistics of weekly meteorological parameters (2001–2019) at different locations

Parameters	Mean	High	Low	Range	SD	CV	R
Raipur (21.14°N, 81.38°E, 289 m*)*							
T_{max} (°C)	32.9	46.0	22.0	24.0	4.9	14.8	0.95
T_{min} (°C)	20.4	31.5	6.6	24.9	5.8	28.6	0.62
BSS (hours)	6.7	11.1	0.0	11.1	2.6	39.5	0.33
WS (Kmph)	4.9	14.9	0.5	14.4	3.1	62.7	0.44
RH_1 (%)	79.5	96.4	25.9	70.5	16.5	20.7	−0.87
RH_2 (%)	43.8	91.0	6.7	84.3	22.2	50.6	−0.47
EP (mm week^{-1})	38.0	127.2	10.5	116.7	22.0	58.0	0.97
FAO56-PM ET_0 (mm week^{-1})	29.7	68.7	11.0	57.7	12.2	41.1	1.00
Jagdalpur (19.08°N, 82.01°E, 564 m*)*							
T_{max} (°C)	31.0	42.6	23.3	19.3	4.0	12.8	0.93
T_{min} (°C)	18.1	28.1	4.3	23.8	5.7	31.2	0.47
BSS (hours)	6.2	11.0	0.0	11.0	2.8	44.9	0.43
WS (Kmph)	4.5	11.6	1.0	10.6	2.0	44.3	0.36
RH_1 (%)	86.9	97.7	34.0	63.7	9.4	10.8	−0.83
RH_2 (%)	51.1	95.7	7.4	88.3	20.5	40.1	−0.56
EP (mm week^{-1})	29.1	93.4	3.8	89.6	14.6	50.0	0.91
FAO56-PM ET_0 (mm week^{-1})	26.8	61.2	13.0	48.2	8.9	33.3	1.00
Ambikapur (23.12°N, 83.20°E, 604 m*)*							
T_{max} (°C)	30.4	43.6	18.9	24.7	5.12	16.9	0.931
T_{min} (°C)	17.8	28.9	3.1	25.8	6.32	35.5	0.647
BSS (hours)	7.2	11.1	0.2	10.9	2.59	36.1	0.351
WS (Kmph)	3.5	10.4	0.3	10.1	1.79	50.6	0.616
RH_1 (%)	78.8	98.9	25.7	73.2	17.12	21.7	−0.837
RH_2 (%)	46.6	91.6	9.6	82.0	21.62	46.4	−0.452
EP_0 (mm week^{-1})	31.7	92.5	8.8	83.7	16.19	51.0	0.909
FAO56-PM ET_0 (mm week^{-1})	26.7	61.8	11.5	50.4	10.52	39.4	1.000

Finally, the response of the RBFNN at the output layer, for a given set of input data is linear in terms of weights and computed using the following expression.

$$y = \sum_{i=1}^{h} w_i \emptyset_i \tag{2}$$

Development of the RBFNN for each instant of input data and its corresponding output {*X*, *y*} is obtained recursively by updating the network parameters $\{w_i, c_i, \sigma_i\}$ to minimize the instantaneous error cost function given as.

$$e = \frac{1}{2}\left(y^d - y\right)^2 \tag{3}$$

The weight update rules to optimize the network parameters $\{w_i, c_i, \sigma_i\}$ at time t are given by following equations which are derived using gradient descent algorithm [48].

$$w_i(t+1) = w_i(t) + \eta_1\left(y^d - y\right)\emptyset_i \tag{4}$$

$$c_{ij}(t+1) = c_{ij}(t) + \frac{\eta_2}{\sigma_i^2}\left(y^d - y\right)w_i\emptyset_i\left(x_j - c_{ij}\right) \tag{5}$$

$$\sigma_i(t+1) = \sigma_i(t) + \frac{\eta_3}{\sigma_i^3}\left(y^d - y\right)w_i\emptyset_i z_i^2 \tag{6}$$

where y^d desired output or target value, c_{ij} j^{th} element of the i^{th} center, η_1, η_2, η_3 learning rates for network parameters $\{w_i, c_i, \sigma_i\}$ respectively.

2.2.2 Differential evolution based RBF neural network estimator

Differential evolution (DE) [49, 50] is a simple and efficient global optimization technique based on a heuristic method for minimizing a nonlinear function. Using this efficient heuristic approach a hybrid structure, RBFDE is developed in which total *d* number of network parameters, represented by a parameter vector, $\vec{x}_i = \{w_i, c_i, \sigma_i\}$, is optimized by the differential evolution algorithm (DE).

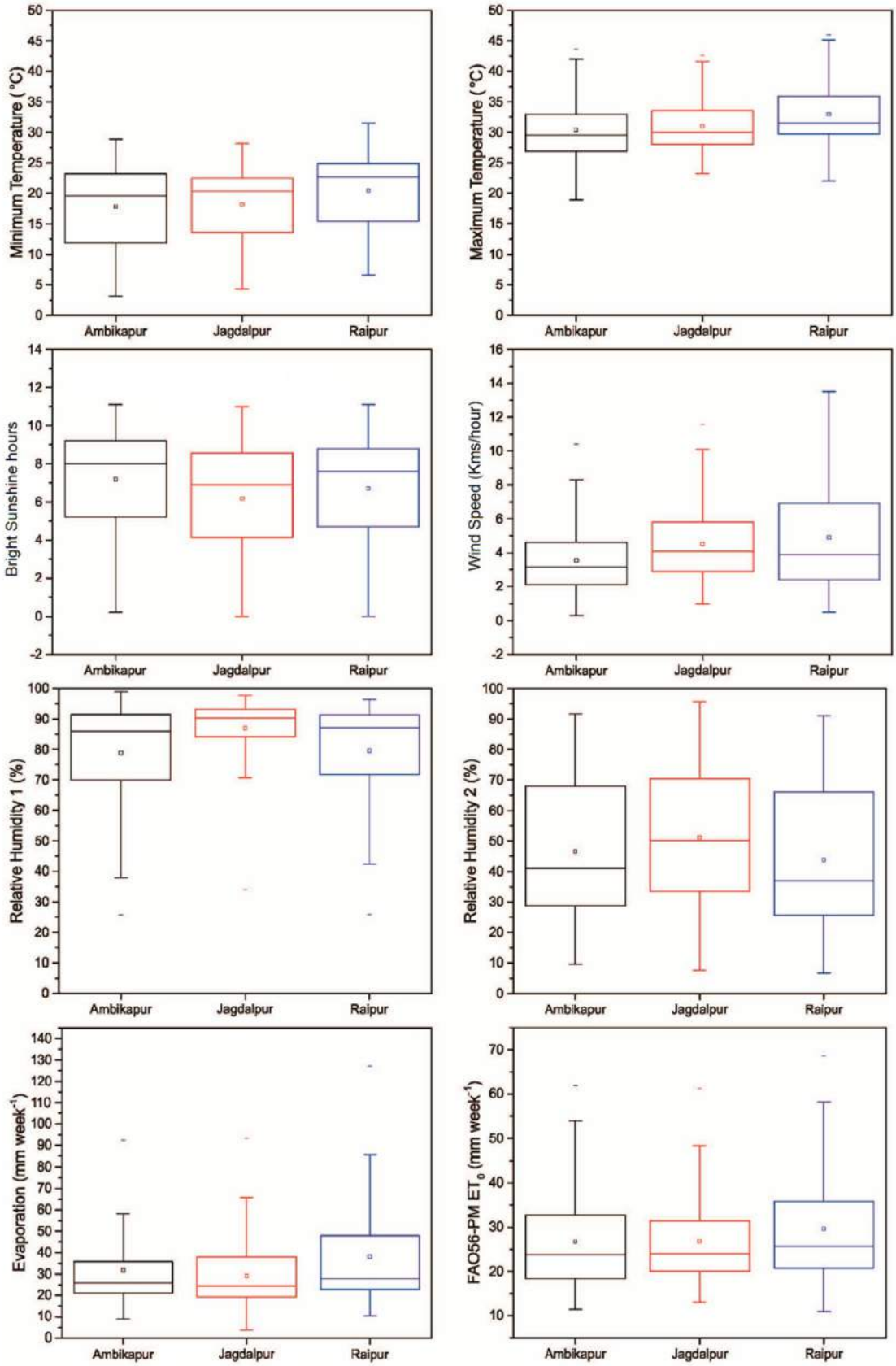

Fig. 2 Box plot of input meteorological parameters and FAO56-PM ET0 in different stations