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Title of paper	Name of the author/s	Department of the teacher	Name of journal	Calendar Year of publication	ISSN number		
						Link to website of the Journal	Link to article / paper / abstract of the article
Experimental and theoretical studies of structural and photophysical properties of a novel heteroleptic cyclometalated iridium(III) complex with 8-hydroxyquinolinephenylazo ligand	Dr. Amit Maity	Department of Chemistry	Journal of Molecular Structure	2018	1872-8014	https://www.sciencedirect.com/journal/journal-of-molecular-structure	https://doi.org/10.1016/j.molstruc.2006
अभिलेखकवयः एका समीक्षा	Dr. Shyamal Panda	Department of Sanskrit	Sanskrit Sahitya Parishat Patrika	2019	2249-0620	https://www.ugc.gov.in/pdfnews/5283580_UGC-Cancelled-List.pdf	https://www.ugc.gov.in/pdfnews/5283580_UGC-Cancelled-List.pdf
Tuning the selectivity of aggregation induced enhanced emission active terepthalohydrazide template via modulating the terminal sensory side Chain	Amit Maity	Department of Chemistry	Journal of Luminescence	2019	0022-2313	https://www.sciencedirect.com/journal/journal-of-luminescence	https://doi.org/10.1016/j.jlumin.2018.09.018
Photo induced trans®cis isomerisation of heteroleptic iridium complex with 8-quinolinol-5-phenylazo ligand: Photophysical and electrochemical studies and their theoretical investigation	Dr. Amit Maity	Department of Chemistry	Journal of Molecular Structure	2019	1872-8014	https://www.sciencedirect.com/journal/journal-of-molecular-structure	https://doi.org/10.1016/j.molstruc.2018.12.060
Synthesis and comparative studies of photophysical and electrochemical properties of three different types of new heteroleptic 5-arylazo-8-hydroxyquinoline complexes of rhodium including Trans ® Cis isomerism studies	Amit Maity	Department of Chemistry	Journal of Organometallic Chemistry	2019	0022-328X	https://www.sciencedirect.com/journal/journal-of-organometallic-chemistry	https://doi.org/10.1016/j.jorganchem.2019.02.012
College Teachers Perceptions towards Action Research	Mudassar Nazar Baidya	Department of Education	Edulight	2019	2278-9545	http://udaynarayanpurmahavidyalaya.org/UploadedFiles/42266A14022020122704Journals-Removed-from-UGC-Approved-List-of-Journals_removed%20(1).pdf	http://udaynarayanpurmahavidyalaya.org/UploadedFiles/42266A14022020122704Journals-Removed-from-UGC-Approved-List-of-Journals_removed%20(1).pdf
প্রেম বৈচিত্র্যে ঝুমুর নায়িকা	Dipak Kumar Mandal	Department of Bengali	Ebong Mahua	2020	NA	http://udaynarayanpurmahavidyalaya.org/UploadedFiles/506098AEbong%20Mahua%20(UGC%20Care%20Listed,%20Discontinued%20from%20January,%202022%20).pdf	http://udaynarayanpurmahavidyalaya.org/UploadedFiles/506098AEbong%20Mahua%20(UGC%20Care%20Listed,%20Discontinued%20from%20January,%202022%20).pdf
Synthesis, crystal structure, DFT calculation and trans-cis isomerisation studies of bipyridyl ruthenium(II) complexes bearing 8-oxyquinolate azo ligands	Amit Maity	Department of Chemistry	Journal of Chemical Sciences	2020	0974-3626 (print); 0973-7103 (web	https://www.ias.ac.in/Journals/Journal_of_Chemical_Sciences/	https://doi.org/10.1007/s12039-020-01846-6

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Title of paper	Name of the author/s	Department of the teacher	Name of journal	Calendar Year of publication	ISSN number	Link to website of the Journal	Link to article / paper / abstract of the article
হেমন্তবালাদেবীর নতুন রূপকথা: একটি বিকল্প পাঠ	Dr. Sreemoye e Banerjee	Department of Bengali	Ebong Mahua	2020	NA	http://udaynarayanpurmahavidyalaya.org/UploadedFiles/506098AEbong%20Mahua%20(UGC%20Care%20Listed,%20Discontinued%20from%20January,%202022%20).pdf	http://udaynarayanpurmahavidyalaya.org/UploadedFiles/506098AEbong%20Mahua%20(UGC%20Care%20Listed,%20Discontinued%20from%20January,%202022%20).pdf
आधुनिक परिपेक्ष्य में रामायण के औषधीय पौधे : एक अन्वेषण	Anirban Chakraborty	Department of Sanskrit	Bharatiya Jyotisham Private Limited	2021	2278-0327	https://bharatiyajyotisham.com/jvp/	http://udaynarayanpurmahavidyalaya.org/UploadedFiles/588674AJyotirveda%20Prasthanam.pdf
Influence of Ion Beam Irradiation on Optical and Magnetic Properties of Transparent Mn Doped ZnO Thin Films, Suitable for Sensor Applications.	Soumyadev Ghosh	Department of Physics	ECS Journal of Solid State Science and Technology	2022	ISSN: 2162-8777	https://iopscience.iop.org/journal/2162-8777	https://iopscience.iop.org/article/10.1149/2162-8777/ac6895/meta
दाराशिकोह-विरचिते समुद्रसङ्गमे भूतव्याख्यानावसरे सृष्टिक्रियाविमृष्टिः	Dr. Shyamal Panda	Department of Sanskrit	Aranyakam	2022	0975-0061	https://www.aranyakam.in/index.php/about	https://www.aranyakam.in/images/download/sep_2022.pdf
Physical property modifications with transition metal doping in nanostructured Zn1-xNixO (x = 0.03, 0.05); synthesized by chemical co-precipitation technique	Soumyadev Ghosh	Department of Physics	Journal of Physics: Conference Series	2022	ISSN: 1742-6596	https://iopscience.iop.org/journal/1742-6596	https://iopscience.iop.org/article/10.1088/1742-6596/2349/1/012012
Synthesis of ZnO nanoparticles by co-precipitation technique and characterize the structural and optical properties of these nanoparticles	Soumyadev Ghosh	Department of Physics	Journal of Physics: Conference Series	2022	ISSN: 1742-6596	https://iopscience.iop.org/journal/1742-6596	https://iopscience.iop.org/article/10.1088/1742-6596/2349/1/012014

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RESEARCH PUBLICATION

1. **Article/Journal**: Experimental and theoretical studies of structural and photophysical properties of a novel hetero leptic cyclometalated iridium(III) complex with 8-hydroxyquinolinephenylazo ligand

Tabular representation : Paper Detail

Authors	**AmitMaity**, DebopamSinha, Kajal Krishna Rajak
Title of the paper	Experimental and theoretical studies of structural and photophysical properties of a novel hetero leptic cyclometalated iridium(III) complex with 8-hydroxyquinolinephenylazo ligand
Name of the journal	**Journal of Molecular Structure**
Volume(Issue), page range	1158(122-132)
Date of publications	April 2018
URL of Paper	https://doi.org/10.1016/j.molstruc.2018.01.006
URL of Journal	https://www.sciencedirect.com/journal/journal-of-molecular-structure
ISSN number	1872-8014
Publisher	Jadavpur University

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RESEARCH PUBLICATION

Journal of Molecular Structure
Volume 1158, 15 April 2018, Pages 122-132

Experimental and theoretical stu structural and photophysical pro of a novel heteroleptic cyclometa iridium(III) complex with 8-hydroxyquinoline-phenylazo liga

Amit Maity, Debopam Sinha, Kajal Krishna Rajak

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https://doi.org/10.1016/j.molstruc.2018.01.006 Get righ

Abstract

One novel heteroleptic iridium(III) complex with cyclometalated 2 phenylquinoline(2-phq) was synthesized by the stoichiometric rea phq)$_2$Cl]$_2$, i.e, Bis-[μ-chlorodi-(2-phenylquinoline)iridium(III)] and where L$^-$ is deprotonated form of azo ligand prepared from 8-hydr and aniline in a 1:1 proportion of dichloromethane and ethanol so atmosphere in presence of mild base triethylamine in stoichiomet prepared complex was characterized by ^{1}H NMR, ESI-mass spectro spectroscopy and most accurately by X-ray single crystallography. physical properties like absorption and emission, i.e, photolumines liquid state as well as solid state were studied exclusively. The exp electrochemical study was also done with cyclic voltammetry. The investigations of the photo physical properties were done by DFT a calculations. The ground state excitation transitions of the comple ^{1}ILCT and ^{1}MLCT transition. The UV–Vis and photoluminescence t also investigated by NTO analysis. The triplet state emission transi characterized by ^{3}MLCT and some portion of ^{3}ILCT transition.

Graphical abstract

One mononuclear Ir(III) complex has been synthesized using *O, N*

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RESEARCH PUBLICATION

2. Article/Journal: अभिलेखकवयः एका समीक्षा

Tabular representation : Paper Detail

Authors	Shyamal Panda
Title of the Paper	अभिलेखकवयः एका समीक्षा
Journal Name	Sanskrit Sahitya Parishat Patrika (UGC Old Listed Journal)
ISSN No.	ISSN: 2249-0620
Volume (Issue)	Conference Proceedings
Date of Publication	2019
URL	https://www.ugc.gov.in/pdfnews/5283580_UGC-Cancelled-List.pdf Page: 19 SL. No. 41030
Publisher	Sanskrit Sahitya Parishat

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Sanskrit-Sahitya-Parishat-Patrika
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ISSN : 2249-0620

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RESEARCH PUBLICATION

इयं संस्कृत-साहित्य-परिषत् प्रतिभा रवे:
भावालोकै-र्मन:पद्मं प्र काशयतु धीमताम्

सूचिपत्रम्

अभिलेख-कवय:-एका समीक्षा

श्यामल-पण्डा

उपोद्घात:

स शब्दो न तद् वाच्यं न स न्यायो न सा कला
जायते यन्न काव्याङ्गमहो भारो महान् कवे: ॥[१]

भूमण्डलेऽस्मिन् नास्ति किमपि वस्तु यत् काव्योपक
नैवार्हति। अभिलेखास्तु न व्यतिक्रमा:। कस्यचित् युगस्य
तद्युगीयसाहित्यिकोन्नयनस्य दर्पणस्वरूपा:। यद्यपि सर्वेऽ
काव्यगुणोपेता:। केचित् महाकवयोऽपि अभिलेखानां कविरूपे
आसन्। एतद्दृश्यते यत् अभिलेखरचनं न कवीनामात्यशलाघाया
अभिलेखेषु प्रयुक्तच्छन्दसां वैचित्र्यम्, अनुप्रासोपमाद्यल
महत्काव्येभ्य: श्लोकानुकरणंच साहित्यिकोन्नयनमेव सूचयन्ति

नृपै: प्रचारितेष्वभिलेखेषु दातृभि: प्रदत्तभूमे:, राज्ञां वंशपरिच
वर्णना प्राप्यते। एतत्तथ्यादिकमवलम्ब्य कवय: अभिलेखान् र
तत्रैव ते काव्यिकप्रतिभां काशयितुमवकाशं प्राप्नुवन्। साधारणत
लोकहितता-महानुभवता-समृद्धतादिदिशा आभिलैखिकनृपा: महा
सह उपमीयन्ते स्म। ऐतिहासिकमूल्येऽविद्यमानेऽपि तेष्वभिले
कल्पनाशक्तेर्नैपुण्यं परि स्फुर्यते। इत्थं तु कविप्रजापतीन
प्रतिभाबलेनाभिलेखा इतिहासगन्ध्यणुकाव्येषु पर्यवसिता:। द्वि
प्रभृति द्वादशशताब्दीं यावत् केषुचित् संस्कृताभिलेखेषु क
प्रभाव: प्राचुर्येण परि दृश्यते। तेभ्योऽभिलेखेभ्य: प्राप्त

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RESEARCH PUBLICATION

3. **Article/Journal**: Tuning the selectivity of aggregation induced enhanced emission active terepthalohydrazide template via modulating the terminal sensory side Chain

Tabular representation : Paper Detail

Authors	SohiniBasu Roy, **AmitMaity**, Tapashi Das and Kajal Krishna Rajak
Title of the paper	Tuning the selectivity of aggregation induced enhanced emission active terepthalohydrazide template via modulating the terminal sensory side Chain
Name of the journal	***Journal of Luminescence***
Volume(Issue), page range	206(649-659)
Date of publications	February 2019
URL of Paper	https://doi.org/10.1016/j.jlumin.2018.09.018
URL of Journal	https://www.sciencedirect.com/journal/journal-of-luminescence
ISSN number	0022-2313
Publisher	Jadavpur University

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RESEARCH PUBLICATION

ELSEVIER

Journal of Luminescence
Volume 206, February 2019, Pages 649-659

Tuning the selectivity of aggregat induced enhanced emission activ terepthalohydrazide template via modulating the terminal sensory chain

Sohini Basu Roy, Amit Maity [1], Tapashi Das [1], Kajal Krishna Rajak

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Abstract

Here we report, design and synthesis of two chemosensors based terepthalohydrazide template. We want to explore how the chang the overall sensing property. To our surprise both the sensors **L1** a Aggregate Induced Enhanced Emission showing capability and ana recognizing ability. Ligand **L1** shows a 14 fold increase in the fluor intensity with the addition of selective CN^- ions by hampering the phenomenon exhibiting in the ligand. While **L2** shows a strong sel Cu^{2+} accompanied by a red shift of 96 nm in the emission spectra. response of **L2** towards Cu^{2+} is a result of Chelation Induced Enhan Quenching (CHEQ). Ligand **L1** shows a strong Aggregation active b bright green fluorescence while **L2** shows Aggregation with cyan b fluorescence. The DFT and TDDFT calculations were performed in demonstrate the structure of ligand, complexes and its electronic

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RESEARCH PUBLICATION

4. **Article/Journal**: Photo induced trans→cisisomerisation of heteroleptic iridium complex with 8-quinolinol-5-phenylazo ligand: Photophysical and electrochemical studies and their theoretical investigations

Tabular representation : Paper Detail

Authors	**Amit Maity**, Kajal Krishna Rajak
Title of the paper	Photo induced trans→cisisomerisation of heteroleptic iridium complex with 8-quinolinol-5-phenylazo ligand: Photophysical and electrochemical studies and their theoretical investigations
Name of the journal	**Journal of Molecular Structure**
Volume(Issue), page range	1181(38-47)
Date of publications	April 2019
URL of Paper	https://doi.org/10.1016/j.molstruc.2018.12.060
URL of Journal	https://www.sciencedirect.com/journal/journal-of-molecular-structure
ISSN number	1872-8014
Publisher	Jadavpur University

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RESEARCH PUBLICATION

ELSEVIER

Journal of Molecular Structure
Volume 1181, 5 April 2019, Pages 38-47

Photo induced trans → cis isomer studies of heteroleptic iridium c with 8-quinolinol-5-phenylazo l Photophysical and electrochemic studies and it's theoretical investigations

Amit Maity, Kajal Krishna Rajak

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https://doi.org/10.1016/j.molstruc.2018.12.060 Get ri

Abstract

Free rotating azo type ligand in different types of metal complexe isomerism in presence of photon irradiation by UV light. For this new iridium complex has been synthesized with 8-hydroxyquinc phenylazo ligand in which the azo part of the ligand is free from with metal centre. UV light irradiation of the Ir complex with thi hydroxyquinoline-5-arylazo ligand at room temperature promot trans → cis photoisomerization of the N=N bond with formation

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RESEARCH PUBLICATION

5. **Article/Journal**: Photo induced trans→cisisomerisation of heteroleptic iridium complex with 8-quinolinol-5-phenylazo ligand: Photophysical and electrochemical studies and their theoretical investigations

Tabular representation : Paper Detail

Authors	**AmitMaity**, Sachinath Bera and Kajal Krishna Rajak
Title of the paper	Synthesis and comparative studies of photophysical and electrochemical properties of three different types of new heteroleptic 5-arylazo-8-hydroxyquinoline complexes of rhodium including Trans →Cis isomerism studies
Name of the journal	***Journal of Organometallic Chemistry***
Volume(Issue), page range	887(48-63)
Date of publications	May 2019
URL of Paper	https://doi.org/10.1016/j.jorganchem.2019.02.012
URL of Journal	https://www.sciencedirect.com/journal/journal-of-organometallic-chemistry
ISSN number	0022-328X
Publisher	Jadavpur University

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RESEARCH PUBLICATION

Journal of Organometallic Chemistry
Volume 887, 1 May 2019, Pages 48-63

Synthesis and comparative studie photophysical and electrochemic properties of three different type new heteroleptic 5-arylazo-8-hydroxyquinoline complexes of rhodium including trans → *cis* isomerism studies

Amit Maity, Sachinath Bera, Kajal Krishna Rajak

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https://doi.org/10.1016/j.jorganchem.2019.02.012 Get rig

Abstract

Refluxing [Rh(2-phpy)$_2$(Cl)]$_2$ separately with the equivalent amou phenylazo-8-hydroxyquinoline (Hq^1), 5-(4-fluorophenylazo)-8-hydroxyquinoline (Hq^2) and 5-(4-nitrophenylazo)-8-hydroxyquinc toluene in aerobic condition afforded mononuclear orange coloure having general formula [Rh(2-phpy)$_2$(q)] in excellent yields. The c were substantiated by IR, ^{1}H NMR, ESI-mass, EPR, UV–Vis and emi cyclic voltammetry, single-crystal X-ray structure determinations functional theory (DFT) calculations. Synthesis and comparison of photophysical and electrochemical properties of a new branch of r complexes of 8-hydroxyarylazo analogues are presented which ar studied before. The ground and excited-state geometries, absorpti emission properties of the complexes were examined by DFT and methods. The excitations and emissions are investigated by the na transition orbital (NTO) analysis. The emission occurred via ^{3}MLCT transition by theoretical analysis of triplet state DFT calculations. isomerism studies for the azo complexes have been done by exper well as theoretical analysis.

Graphical abstract

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Website:www.udaynarayanpurmahavidyalaya.org

RESEARCH PUBLICATION

6. **Article/Journal**: College Teachers Perceptions Towards Action Research

Tabular representation : Paper Detail

Authors	Mudassar Nazar Baidya
Title of the Paper	College Teachers Perceptions Towards Action Research
Journal Name	Edulight (UGC Old Listed)
ISSN No.	2278-9545
Volume (Issue)	Vol. 8. Issue. 15
Date of Publication	1st May,2019
URL	http://udaynarayanpurmahavidyalaya.org/UploadedFiles/42266A14022020122704Journals-Removed-from-UGC-Approved-List-of-Journals_removed%20(1).pdf
Publisher	Council of Edu light

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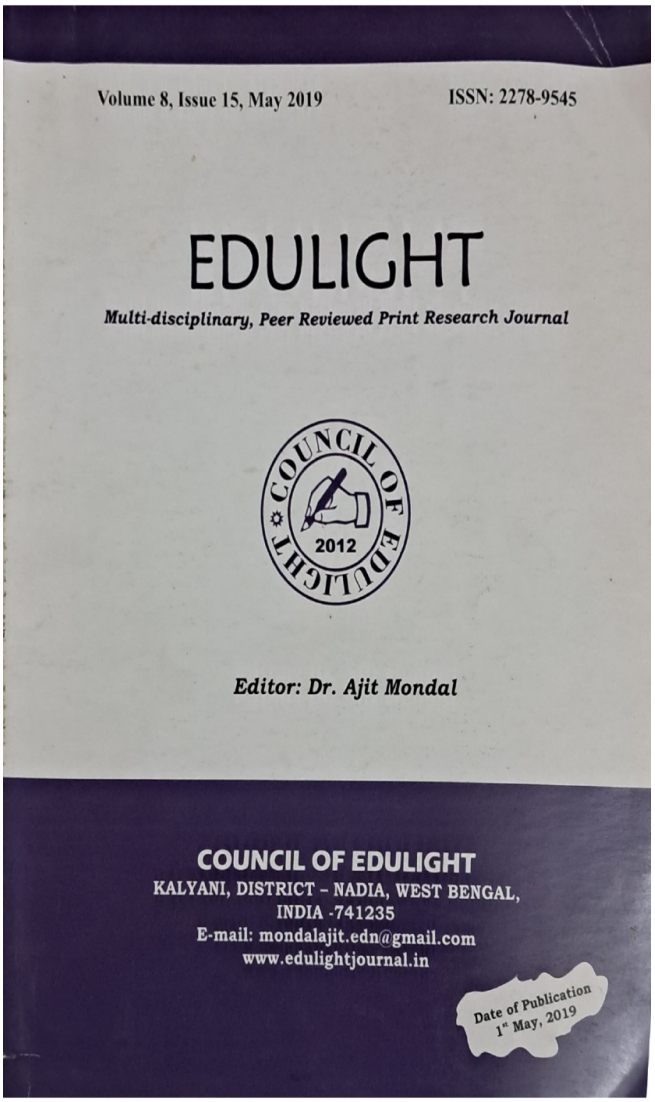
RESEARCH PUBLICATION



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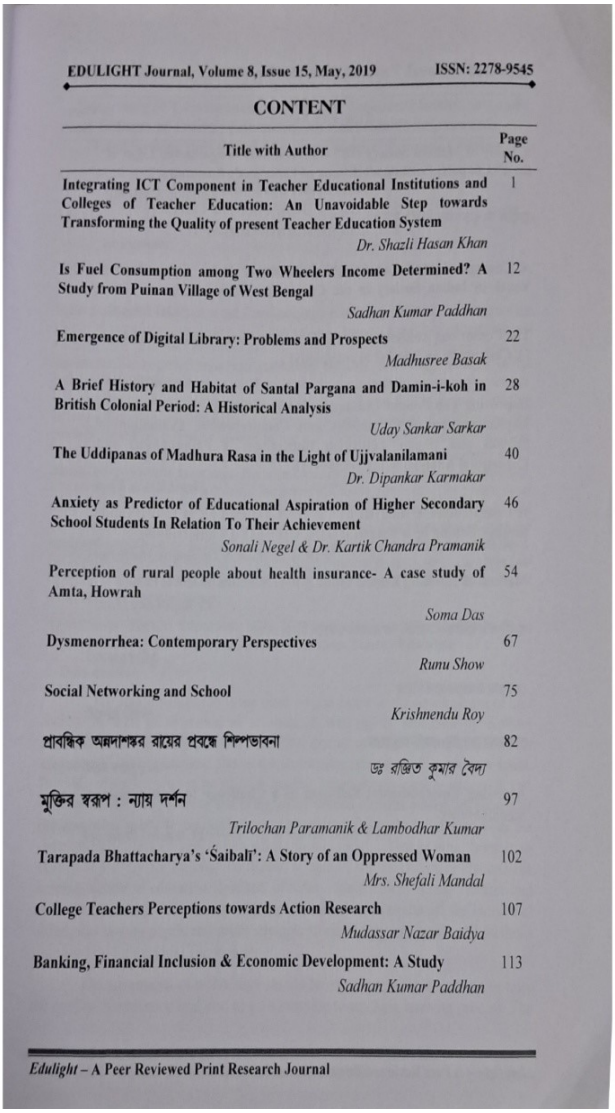

CONTENT

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RESEARCH PUBLICATION

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College Teachers Perceptions towards Action Research

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Udaynarayanpur Madhabilata Mahavidyalaya, Howrah, 711226,
West Bengal, E-mail: mnbaidya@gmail.com

ABSTRACT

The present study is an attempt to explore the perceptions of the general degree college teachers of Arts and Humanities of West Bengal towards the relationship between classroom teaching and action research. College teachers' knowledge about action research, their capabilities and temperament for conducting action research, their views and approaches towards the relationship between classroom teaching and action research and the problems of conducting action research at colleges are the indicators of this study. 90 college teachers from different general degree colleges of West Bengal were selected through purposive sampling and a mixed questionnaire (developed by the researchers) was applied to them. Participatory observation method also used. The availed data were analyzed both qualitatively and quantitatively. The study revealed that college teachers are interested in classroom teaching based action research and they have positive approaches towards action research. Most of the subjects of the study have attended research methodology based seminars, workshops, conferences, symposia and short term programmes and most of them got the opportunity to study research based materials in their academic career as they completed research oriented courses in their own disciplines. In spite of such positive aspects, they have improper and inadequate knowledge, skills and temperament for conducting classroom based action research. Negative approaches of the education manager and administrators, academic and administrative workload, adverse work environment etc. are the obstacles of conducting action research. Awareness campaigning, conducive work environment, opportunities and incentives for action research, development of positive temperament for action research, action research oriented workshops at every colleges and comprehensive policy framing etc. are really needed.

Key Words: Action Research, College Teachers, Perceptions, Classroom Teaching

Introduction

It is rightly opined that "If most classroom teachers are to be involved in research activity, it will be in the area of action research. Modest studies may be conducted for the purpose of trying to improve local classroom practices. It is not likely that many teachers will have the time, resources, or technical background to engage in the more formal aspects of research activity" (Best and Kahn, 2009, p.21). Action research involves actively participating in a change situation, often via an existing organization, whilst simultaneously conducting research. Kurt Lewin first coined the term 'action research' in 1944. In his 1946 research paper "Action Research and Minority Problems" he described action research as "a comparative research on the conditions and effects of various forms of social action" that uses "a spiral of steps, each of which is composed of a circle of planning action and fact-finding about the result of the action". As teaching is continuous research, teacher's involvement in research especially in action research is essential. Teacher's

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RESEARCH PUBLICATION

7. **Article/Journal**: College Teachers Perceptions Towards Action Research

Tabular representation : Paper Detail

Authors	Dipak Kumar Mandal
Title of the Paper	প্রেম-বৈচিত্র্যে ঝুমুর-নায়িকা
Journal Name	Ebong Mahua (UGC Care Listed, Discontinued from January, 2022)
ISSN No.	NIL
Volume (Issue)	22th Year, 123 (A) Volume
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Publisher	K. K. Prakashan

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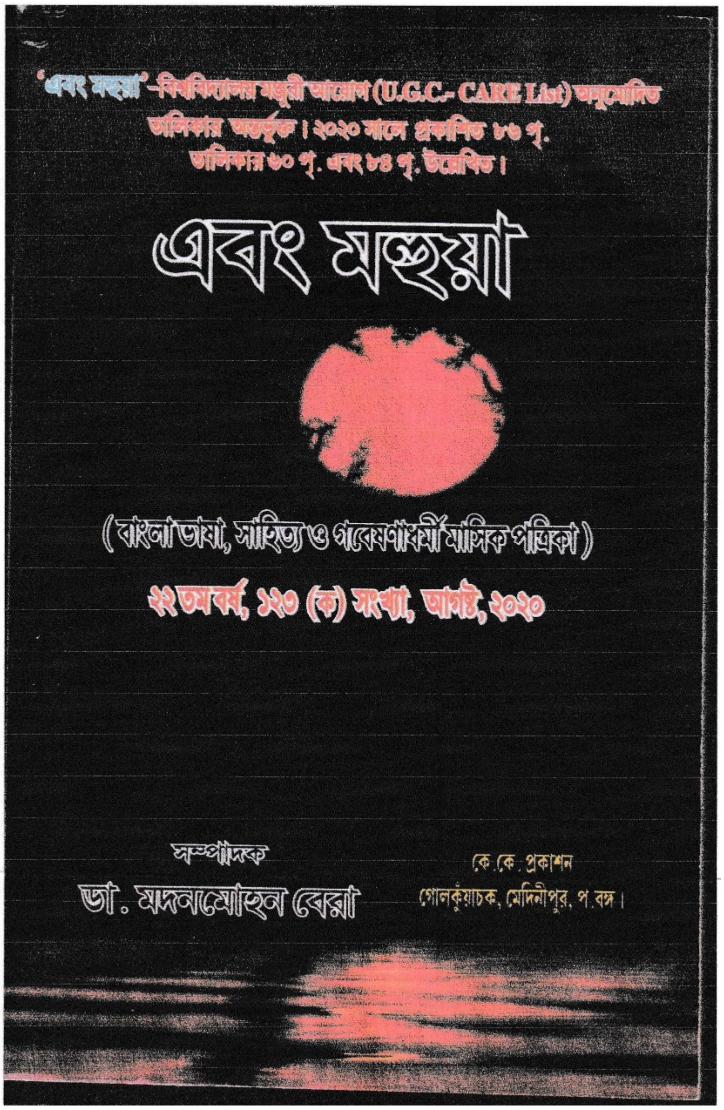

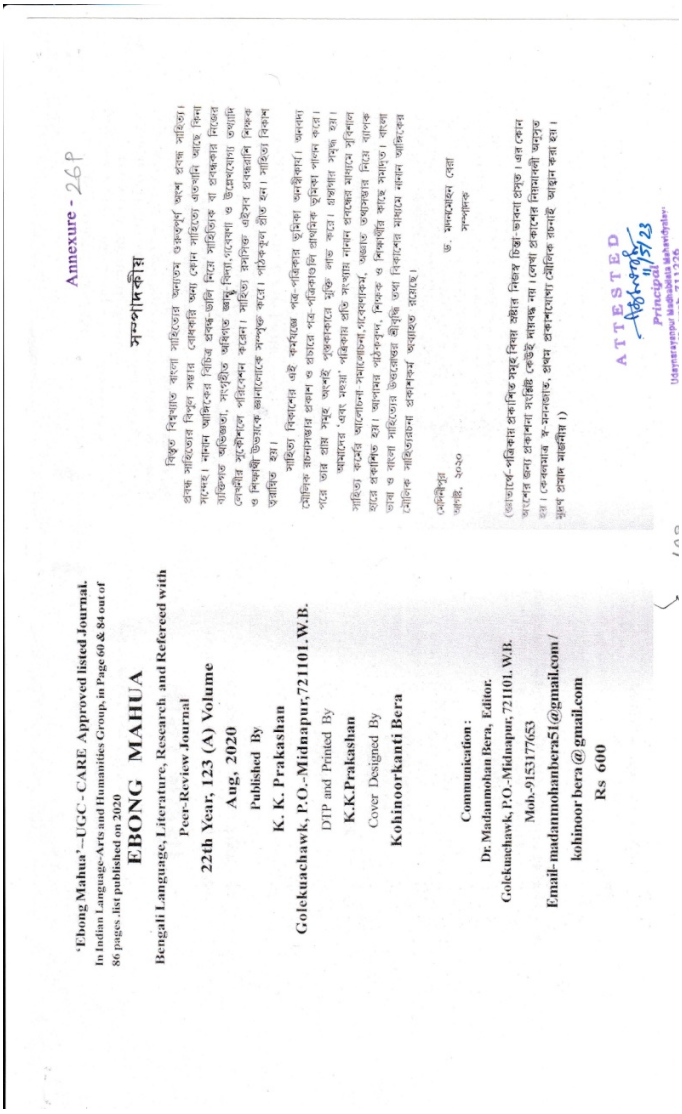

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Annexure - 26P

সম্পাদকীয়

বিস্তৃত বিশ্বখ্যাত বাংলা সাহিত্যের অন্যতম গুরুত্বপূর্ণ অংশ প্রবন্ধ সাহিত্য। প্রবন্ধ সাহিত্যের বিপুল সম্ভার বোধকরি অন্য কোন সাহিত্যে এতখানি আছে কিনা সন্দেহ। নানান আঙ্গিকের বিচিত্র প্রবন্ধ-ডালি নিয়ে সাহিত্যিক বা প্রবন্ধকার নিজের ব্যক্তিগত অভিজ্ঞতা, সংগৃহীত অধিগত জ্ঞান-বিদ্যা,গবেষণা ও উল্লেখযোগ্য তথ্যাদি লেখনীর সুকৌশলে পরিবেশন করেন। সাহিত্য রসসিক্ত এইসব প্রবন্ধরাশি শিক্ষক ও শিক্ষার্থী উভয়কে জ্ঞানালোকে সম্পৃক্ত করে। পাঠককুল প্রীত হন। সাহিত্য বিকাশ ত্বরান্বিত হয়।

সাহিত্য বিকাশের এই কর্মযজ্ঞে পত্র-পত্রিকার ভূমিকা অনস্বীকার্য। অনবদ্য মৌলিক রচনাসম্ভার প্রকাশ ও প্রচারে পত্র-পত্রিকাগুলি প্রাথমিক ভূমিকা পালন করে। পরে তার প্রায় সমূহ অংশই পুস্তকাকারে মুক্তি লাভ করে। গ্রন্থাগার সমৃদ্ধ হয়।

আমাদের 'এবং মহুয়া' পত্রিকায় প্রতি সংখ্যায় নানান প্রবন্ধের মাধ্যমে সুবিশাল সাহিত্য কর্মের আলোচনা-সমালোচনা,গবেষণাকর্ম, অজ্ঞাত তথ্যসম্ভার নিয়ে ব্যাপক হারে প্রকাশিত হয়। আপামর পাঠকবৃন্দ, শিক্ষক ও শিক্ষার্থীর কাছে সমাদৃত। বাংলা ভাষা ও বাংলা সাহিত্যের উত্তরোত্তর শ্রীবৃদ্ধি তথা বিকাশের মাধ্যমে নানান আঙ্গিকের মৌলিক সাহিত্যরচনা প্রকাশকর্ম অব্যাহত রয়েছে।

মেদিনীপুর
আগষ্ট, ২০২০

ড. মদনমোহন বেরা
সম্পাদক

(জ্ঞাতার্থে-পত্রিকায় প্রকাশিত সমূহ বিষয় স্রষ্টার নিজস্ব চিন্তা-ভাবনা প্রসূত। এর কোন অংশের জন্য প্রকাশনা সংশ্লিষ্ট কেউই দায়বদ্ধ নয়। লেখা প্রকাশের নিয়মাবলী অনুসৃত হয়। কেবলমাত্র স্ব-মননজাত, প্রথম প্রকাশযোগ্য মৌলিক রচনাই আহ্বান করা হয়। মুদ্রণ প্রমাদ মার্জনীয়।)

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RESEARCH PUBLICATION

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প্রেম-বৈচিত্র্যে ঝুমুর-নায়িকা

দীপক কুমার মণ্ডল

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RESEARCH PUBLICATION

8. **Article/Journal:** Synthesis, crystal structure, DFT calculation and trans-cis isomerisation studies of bipyridyl ruthenium(II) complexes bearing 8-oxyquinolate azo ligands

Tabular representation : Paper Detail

Authors	Roumi Patra, **Amit Maity**, Kajal Krishna Rajak
Title of the paper	Synthesis, crystal structure, DFT calculation and trans-cis isomerisation studies of bipyridyl ruthenium(II) complexes bearing 8-oxyquinolate azo ligands
Name of the journal	**Journal of Chemical Sciences**
Volume(Issue), page range	140(132)
Date of publications	October 2020
URL of Paper	https://doi.org/10.1007/s12039-020-01846-6
URL of Journal	https://www.ias.ac.in/Journals/Journal_of_Chemical_Sciences
ISSN number	0974-3626 (print); 0973-7103 (web)
Publisher	Jadavpur University

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RESEARCH PUBLICATION

Regular Article | Published: 20 October 2020

Synthesis, crystal structure, DFT calculation and trans isomerisation studies of bipyridyl ruthenium(II) comp bearing 8-oxyquinolate azo ligands

Roumi Patra, Amit Maity & Kajal Krishna Rajak

Journal of Chemical Sciences **132**, Article number: 140 (2020) | Cite this article

362 Accesses | **3** Citations | Metrics

Abstract

Two stable Ru(II) bipyridyl complexes were synthesized with the deprotonated forms of th hydroxyquinoline (hq) as analogues and they were chromatographically separated. The ex coordinated as a bidentate ligand and chelates to ruthenium(II) through 8-quinolinolate n azo part free from coordination. The general formula of the complexes are $[Ru(bpy)_2(q)]^+$. deprotonated form of 5-phenylazo-8-hydroxyquinoline (Hq^1) and 5-(2-naphthylazo)-8-hyd The complexes were verified by ^1H NMR, ESI-mass, absorption-emission spectra, cyclic vo single-crystal X-ray structure determination. UV light-induced trans → cis isomerization ar isomerism i.e. cis → trans around -N=N- bond at room temperature were proposed from th changes as well as the changing of the colour of the solution of the complexes. In aid of un electronic charge distribution and charge-transfer properties, computational studies empl TDDFT method have been executed.

Graphic abstract

Significant alteration in absorption spectra and colour change was observed for trans-cis of the complexes upon UV light irradiation due to presence of free rotating azo groups

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RESEARCH PUBLICATION

9. Article/Journal: হেমন্তবালাদেবীর নতুন রূপকথা: একটি বিকল্প পাঠ

Tabular representation : Paper Detail

Authors	Dr. Sreemoyee Banerjee
Title of the Paper	হেমন্তবালাদেবীর নতুন রূপকথা: একটি বিকল্প পাঠ
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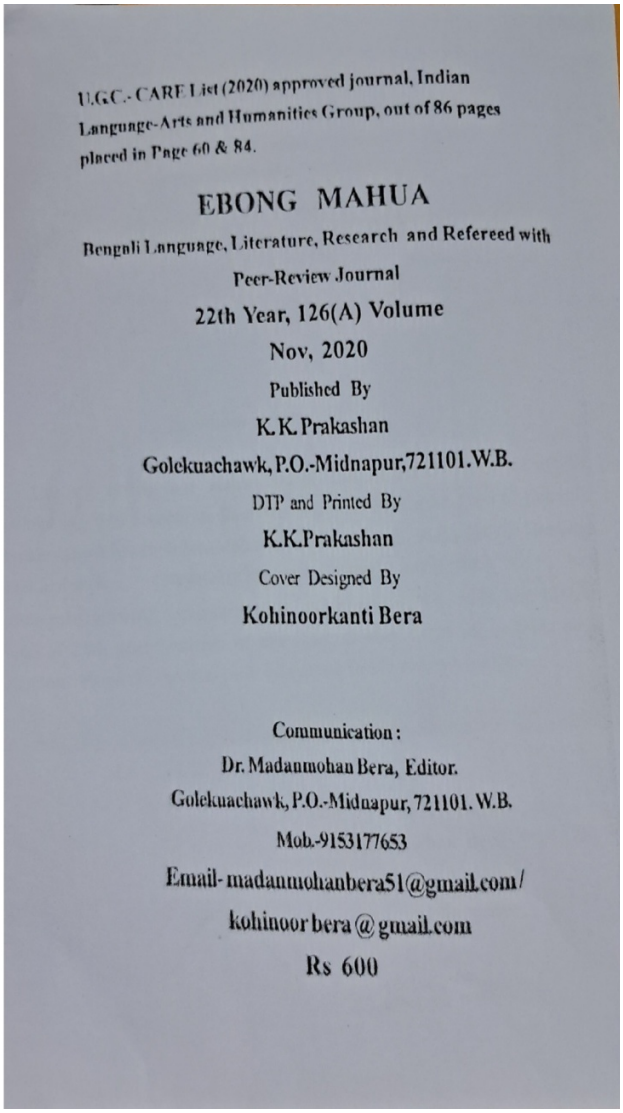

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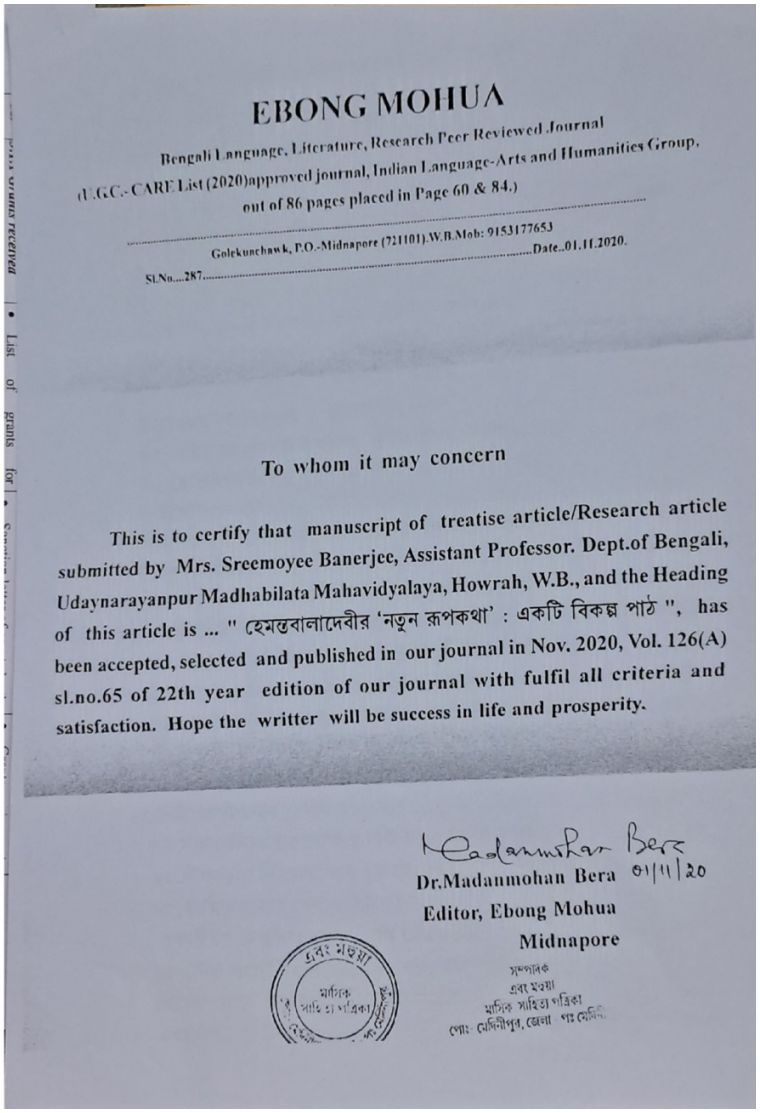

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To whom it may concern

This is to certify that manuscript of treatise article/Research article submitted by Mrs. Sreemoyee Banerjee, Assistant Professor. Dept.of Bengali, Udaynarayanpur Madhabilata Mahavidyalaya, Howrah, W.B., and the Heading of this article is ... " হেমন্তবালাদেবীর 'নতুন রূপকথা' : একটি বিকল্প পাঠ ", has been accepted, selected and published in our journal in Nov. 2020, Vol. 126(A) sl.no.65 of 22th year edition of our journal with fulfil all criteria and satisfaction. Hope the writter will be success in life and prosperity.

Madanmohan Bera 01/11/20

Dr.Madanmohan Bera

Editor, Ebong Mohua

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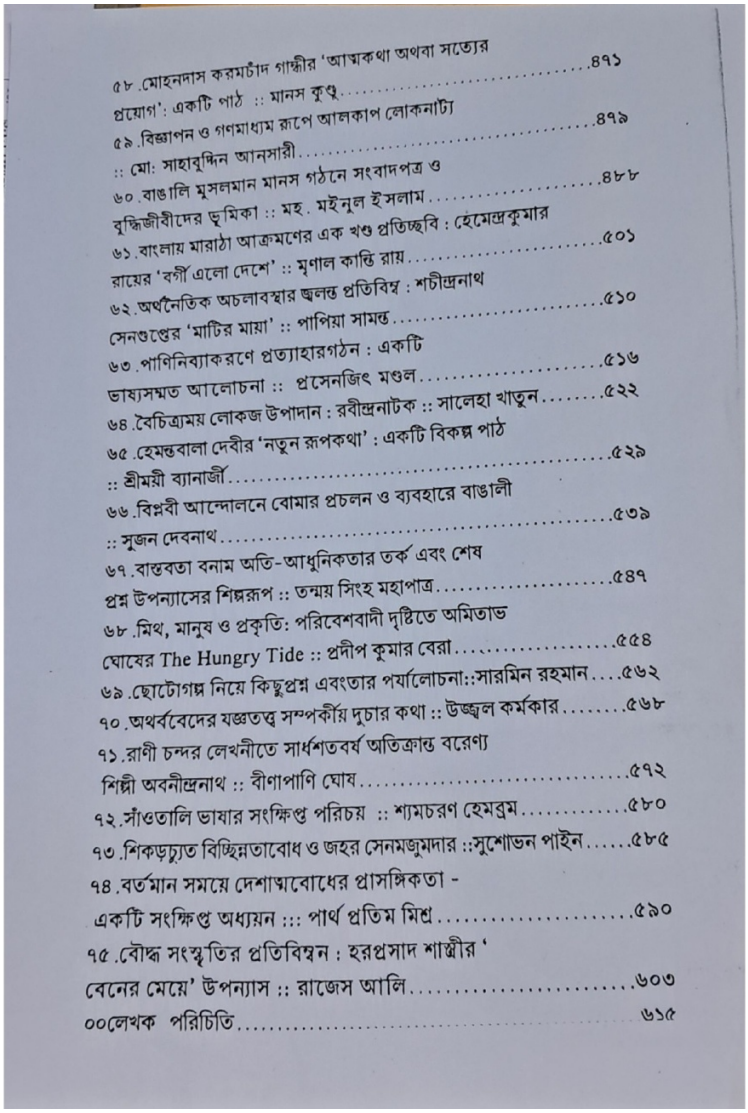

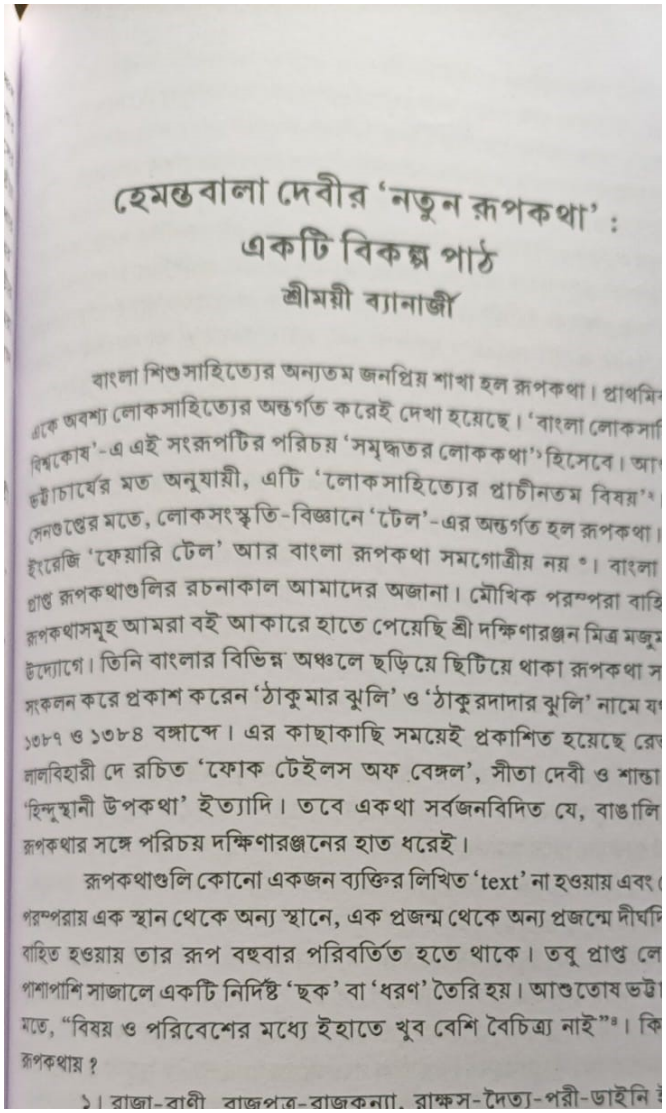

হেমন্তবালা দেবীর 'নতুন রূপকথা' : একটি বিকল্প পাঠ

শ্রীময়ী ব্যানার্জী

বাংলা শিশুসাহিত্যের অন্যতম জনপ্রিয় শাখা হল রূপকথা। প্রাথমি
একে অবশ্য লোকসাহিত্যের অন্তর্গত করেই দেখা হয়েছে। 'বাংলা লোকসা
বিশ্বকোষ'-এ এই সংরূপটির পরিচয় 'সমৃদ্ধতর লোককথা'[১] হিসেবে। আ
ভট্টাচার্যের মত অনুযায়ী, এটি 'লোকসাহিত্যের প্রাচীনতম বিষয়'[২]
সেনগুপ্তের মতে, লোকসংস্কৃতি-বিজ্ঞানে 'টেল'-এর অন্তর্গত হল রূপকথা।
ইংরেজি 'ফেয়ারি টেল' আর বাংলা রূপকথা সমগোত্রীয় নয়[৩]। বাংলা
প্রাপ্ত রূপকথাগুলির রচনাকাল আমাদের অজানা। মৌখিক পরম্পরা বাহি
রূপকথাসমূহ আমরা বই আকারে হাতে পেয়েছি শ্রী দক্ষিণারঞ্জন মিত্র মজু
উদ্যোগে। তিনি বাংলার বিভিন্ন অঞ্চলে ছড়িয়ে ছিটিয়ে থাকা রূপকথা স
সংকলন করে প্রকাশ করেন 'ঠাকুমার ঝুলি' ও 'ঠাকুরদাদার ঝুলি' নামে য
১৩৮৭ ও ১৩৮৪ বঙ্গাব্দে। এর কাছাকাছি সময়েই প্রকাশিত হয়েছে রে
লালবিহারী দে রচিত 'ফোক টেইলস অফ বেঙ্গল', সীতা দেবী ও শান্তা
'হিন্দুস্থানী উপকথা' ইত্যাদি। তবে একথা সর্বজনবিদিত যে, বাঙালি
রূপকথার সঙ্গে পরিচয় দক্ষিণারঞ্জনের হাত ধরেই।

রূপকথাগুলি কোনো একজন ব্যক্তির লিখিত 'text' না হওয়ায় এবং
পরম্পরায় এক স্থান থেকে অন্য স্থানে, এক প্রজন্ম থেকে অন্য প্রজন্মে দীর্ঘদি
বাহিত হওয়ায় তার রূপ বহুবার পরিবর্তিত হতে থাকে। তবু প্রাপ্ত লে
পাশাপাশি সাজালে একটি নির্দিষ্ট 'ছক' বা 'ধরণ' তৈরি হয়। আশুতোষ ভট্ট
মতে, "বিষয় ও পরিবেশের মধ্যে ইহাতে খুব বেশি বৈচিত্র্য নাই"[৪]। কি
রূপকথায় ?

১। রাজা-রাণী, রাজপুত্র-রাজকন্যা, রাক্ষস-দৈত্য-পরী-ডাইনি

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RESEARCH PUBLICATION

10. Article/Journal: आधुनिक परिपेक्ष्य में रामायण के औषधीय पौधे : एक अन्वेषण

Tabular representation : Paper Detail

Authors	Anirban Chakraborty
Title of the Paper	आधुनिक परिपेक्ष्य में रामायण के औषधीय पौधे : एक अन्वेषण
Journal Name	Jyotirveda Prasthanam (UGC Care Listed, Discontinued from July, 2023) http://udaynarayanpurmahavidyalaya.org/UploadedFiles/588674AJyotirveda%20Prasthanam.pdf
ISSN No.	2278-0327
Volume (Issue)	Volume. 10. Issue. 4
Date of Publication	October, 2021
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पर्येति भावयन् लोकान्

ज्योतिर्वेद-प्रस्थानम्

संस्कृत वाङ्मय की शोधपत्रिका-संस्कृत छात्रों की मार्गदर्शिका

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आधुनिक परिप्रेक्ष्य में रामायण के औषधीय पौधे : एक अन्वेषण

श्री अनिर्वाण चक्रवर्ती

सहकारी अध्यापक, संस्कृत विभाग

उदयनारायणपुर माधबीलता महाविद्यालय, हावड़ा, पश्चिम बंगाल, पिन - 711226.

भूमिका - रामायण शास्त्रीय संस्कृत साहित्य का सबसे पुराना साहित्यिक प्रमाण है। यह महाकाव्य महर्षि वाल्मीकि द्वारा लिखा गया है। वाल्मीकि की रामायण की मुख्य अवधारणा का पालन करते हुए बाद के संस्कृत कवियों ने कई संस्कृत रामायणों की रचना की जैसे कि- अद्भूतरामायण, योगवाशिष्ठरामायण, अध्यात्मरामायण, आनन्दरामायण, तत्त्वसंग्रहरामायण, भुसुण्डिरामायण, श्रीमद्रामायण आदि। श्रीमद्रामायण सात कांडों (खंडों) और लगभग पाँच सौ सर्गों (अध्यायों) में विभाजित है। इसे संस्कृत साहित्य का 'आदि-काव्य' माना जाता है। महाकाव्य कौशल साम्राज्य के महान् राजकुमार श्री रामचंद्र के जीवन का वर्णन करता है। रामायण की कहानी अपनी विमाता कैकेयी से अपने पिता के वचनों को निभाने के लिए राम के राज्य से निर्वासित होने जैसी है। भारत के जंगलों में निर्वासन में उनकी यात्रा उनकी पत्नी सीता देवी और भाई लक्ष्मण के साथ पूरी हुई। उस समय लंका के राजा रावण ने सीता देवी का अपहरण कर लिया था। श्री राम ने रावण को पराजित कर युद्ध में उसका वध किया था। उसके बाद वे अयोध्या लौट आए और अयोध्या के राजा बने।

साहित्यिक मूल्य के अलावा, रामायण का सामाजिक मूल्य अपार है। रामायण में हमें रामचंद्र की यात्रा के वर्णन में कई पौधों के नाम मिलते हैं जो आयुर्वेद-शास्त्र के अनुसार अद्भुत औषधीय महत्व रखते हैं। इस शोध पत्र में मैं उनमें से कुछ पौधों और उनके औषधीय गुणों का पता लगाना चाहूंगा।

उद्देश्य -

1. रामायण में वर्णित औषधीय पौधों की खोज।
2. आधुनिक आयुर्वेद के अनुसार उन पौधों के औषधीय गुणों की खोज करना।
3. मानव कल्याण के लिए इन औषधीय पौधों के महत्व पर प्रकाश डालते हुए पौधों की विविधता को संरक्षित करें।

मुख्यबिन्दु - रामायण, औषधीय पौधे, विशालाकरणी, शमी, पंचवटी वन, पम्पा झील।

हम अयोध्याकांड में देखते हैं, श्री राम अपनी विमाता कैकेयी के षडयन्त्र से अपने पिता के वचनों को पूरा करने के लिए अपनी पत्नी सीता देवी और भाई लक्ष्मण के साथ वनवास गए थे। वनवास की अवधि चौदह वर्ष थी। उस लंबी अवधि में, उन्होंने भारत के कई पहाड़ों और जंगलों की यात्रा की। इस यात्रा में हमें कई ऐसे पौधों के नाम मिलते हैं, जिनके चमत्कारी चिकित्सीय मूल्य हैं। उनमें से, मैं नीचे कुछ पौधों और उनके औषधीय मूल्यों पर चर्चा कर रहा हूं।

1. अग्निमुख - इस पौधे का वैज्ञानिक नाम सेमेकार्पस एनाकार्डियम है। भारत में इसे आमतौर पर भिलावा, भेला, भल्लाटक के नाम से जाना जाता है। रामायण में हम इस पौधे को महर्षि मातंग के आश्रम में पाते हैं जैसा कि अरण्यकाण्ड में वर्णित है।[1]

औषधीय मूल्य - फल का उपयोग सूजन-रोधी के रूप में किया जा सकता है, एंटीट्यूमर का उपयोग संधिशोथ में और ट्यूमर और घातक वृद्धि के उपचार के लिए किया जा सकता है।

तंत्रिका संबंधी दुर्बलता के लिए बार्क गम का उपयोग किया जा सकता है। ऊतक संवर्धन में नासो-ग्रसनी के मानव एपिडर्मोइड कार्सिनोमा के खिलाफ फल के अर्क को प्रभावी पाया गया।

2. अर्जुन - इस पौधे का वैज्ञानिक नाम टर्मिनलिया अर्जुन है। भारत में इसे आमतौर पर अर्जुन, सनमदत, वेल्लामर्दा आदि के नाम से जाना जाता है। रामायण में हम इस पौधे को पम्पा झील के किष्किंधाकांड में पाते हैं।[2]

औषधीय मूल्य-

छाल- एनजाइना और खराब कोरोनरी परिसंचरण में

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RESEARCH PUBLICATION

11. **Article/Paper:** Influence of Ion Beam Irradiation on Optical and Magnetic Properties of Transparent Mn Doped ZnO Thin Films, Suitable for Sensor Applications.

Tabular representation: Paper Detail

Author(s)	Swarup Kumar Neogi, Soumyadev Ghosh, Aritra Banerjee,and Sudipta Bandyopadhyay
Title of the paper	Influence of Ion Beam Irradiation on Optical and Magnetic Properties of Transparent Mn Doped ZnO Thin Films, Suitable for Sensor Applications.
Journal name / Name of the proceeding	ECS Journal of Solid State Science and Technology
Volume (issue) , page range	**11** 056001
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Influence of Ion Beam Irradiation on Optical and Ma Properties of Transparent Mn Doped ZnO Thin Film for Sensor Applications

S. Neogi, Soumyadev Ghosh, +1 author S. Bandyopadhyay

• Published in ECS Journal of Solid State... 20 April 2022 • Materials Scien

The present work describes modification in physical properties of Zn0.95Mn0.05O films by ion beam irr prepared by spin coating and annealed at 500°C. XRD patterns of these films show wurzite structure wit However, low-energy irradiation could modify and induce new defect states. Characterization of those d performed by analyzing the UV-Visible absorption spectroscopy and photoluminescence (PL) spectrosc PL emission of Zn0.95Mn0.05O film shows a broad UV emission and pronounced visible emission ~53(broad UV band become more prominent; however, it is completely quenched after irradiation. For all irra visible emission of comparable intensities, confined within the region 475 to 550 nm. Irradiated films are at room temperature and most importantly the film irradiated at fluence F: 1016 ions/cm2 exhibit maxin moment of 0.83 emu g-1. The magnetic response is strongly influenced by irradiation and we could say strongly correlated with intrinsic defects present in these films. Defect-induced formation of bound mag control the ferromagnetic property of these films. These transparent ferromagnetic films could be used

Collapse

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RESEARCH PUBLICATION

12. Article/Paper: दाराशिकोह-विरचिते समुद्रसङ्गमे भूतव्याख्यानावसरे सृष्टिक्रियाविमृष्टिः

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Authors	Shyamal Panda
Title of the Paper	दाराशिकोह-विरचिते समुद्रसङ्गमे भूतव्याख्यानावसरे सृष्टिक्रियाविमृष्टिः
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Publisher	Sanskrita-prasar-parishad

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आरण्यकम्

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विश्वविद्यालयानुदानायोगस्य (UGC) यत्नसूच्याम् (Carelist) अन्तर्भुक्ता

संस्कृतप्रसारपरिषद्
आरा (बिहारः)

त्रिंशं वर्षम्-द्वितीयोऽङ्कः
सितम्बर 2022

आरण्यकम्

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विश्वविद्यालयानुदानायोगस्य (UGC) यत्नसूच्याम् (Carelist) अन्तर्भुक्ता

वर्षाङ्कौ - त्रिंशं वर्षम् - द्वितीयोऽङ्कः

चैत्रः, वि.सं.२०७९
सितम्बर २०२२

प्रतिवर्षं प्रकाशनकालः
चैत्रः, आश्विनः-विक्रमाब्दः
मार्च, सितम्बर

प्रत्यङ्कम् - 50 रूप्यकाणि
संयुक्ताङ्कः - 100 रूप्यकाणि

वार्षिकं शुल्कं 100 रूप्यकाणि

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RESEARCH PUBLICATION

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श्यामल पण्डा

उपोद्घातः

निखिलविश्वस्य वाङ्मयेषु प्राचीनतमेष्वन्यतमा सर्वदेशव्यापिका सभ्यमात्रगौरवास्पदीभूता भाषा संस्कृतभाषा। तद्भाषया विरचितस्य साहित्यस्य प्रचारे प्रसारे च भूमावस्यां युगपद् विद्यमानानां नैकेषां धर्माणामवदानन्तु अनस्वीकार्यम्। महम्मदीयधर्मस्तु न व्यतिक्रमो विषयेऽस्मिन्। वङ्गीयसाहित्यं प्रति महम्मदीयनरपतीनां महम्मदीयकवीनाञ्चानुरागस्तु सुविदितः। तत्र लक्षणीयो विषयो यद् महम्मदीयानाम् उत्साहेन परिपुष्टं वङ्गीयसाहित्यं महम्मदीयसंस्कृतेः प्रचारे न व्यापृतमपितु हिन्दुसंस्कृतेः अनुकूलविश्लेषणे परिपूर्णम्। भारतीयसंस्कृतिं प्रति महम्मदीयीनामनुरागः प्रादेशिकसाहित्येन अभिव्यक्तो नासीदिति विषये संस्कृतसाहित्येऽपि तन्निदर्शनं दरीदृश्यते, यस्य प्रकृष्टमुदाहरणन्तु सप्तदश–ईशवीयाब्दे शाहजहानज्येष्ठ-पुत्रदाराशिकोहविरचितः समुद्रसङ्गमः इति ग्रन्थः। तेनैव फारसीभाषायां विरचितस्य मज्म-उल-वहरेन इति ग्रन्थस्य संस्कृतरूपान्तरमिदं ग्रन्थकुसुमम्। अत्र वेदान्तः सूफी चेति द्वयोर्दर्शनयोः समन्वयसाधने यत्नः कृतो ग्रन्थकृता। तन्नये द्वयोर्धर्मयोः विरोधः आपाततः प्रतीयते परिभाषाभेदादतिरिक्तः कोऽपि भेदश्च स्वरूपावाप्तौ न दृश्यत इति। सादृश्यमिदमव-बोधयितुं तेन ग्रन्थे द्वाविंशतिः विषयाः उपस्थापिताः। तत्र आदौ अनासिरपरपर्यायभूतव्याख्या भूतनिरूपणं वा। भूतनिरूपणमाध्यमेन ग्रन्थकारेण पूर्वोक्तयोर्दर्शनयोः सृष्टिप्रक्रियायाः वर्णनं विहितम्। प्रसङ्गतः अत्र प्राप्यन्ते सूफीनां मतानि, कोराणस्य (Quran) उद्धृतयः क्वचित् भारतीयदर्शनस्य भिन्नानि च तत्त्वानि।

निबन्धस्यास्य आलोचनायामादौ समुद्रसङ्गमानुसारं ग्रन्थकृतः स्वमतं प्रस्तुतम्, ततः तुलनात्मिका चर्चा च चर्चिता मया।

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13. **Article/Paper:** Physical property modifications with transition metal doping in nanostructured Zn1-xNix O (x = 0.03, 0.05); synthesized by chemical co-precipitation technique.

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Physical property modifications with transition metal doping in nanostructured $Zn_{1-x}Ni_xO$ (x = 0.03, 0.05); synthesized by chemical co-precipitation technique

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Abstract. Present work demonstrate the structural and optical property study of $Zn_{1-x}Ni_xO$ (x= 0.03, 0.05) nanoparticles (NPs). These samples have been prepared by simple chemical co-precipitation method. Finally these samples are annealed at 500°C for 3 hours. Structural characterization has been performed by doing X-Ray diffraction (XRD) at room temperature. The XRD patterns confirm the hexagonal wurzite structure for these samples. We have estimated the lattice parameters (*a* & *c*) and determine the c/a ratio of respective samples after structural analysis. Morphology of these nanoparticles has been investigated by performing SEM. In addition UV-visible and Photoluminescence (PL) study has been performed. PL emission spectra show a broad UV emission peak. Doping at the Zn-site by Ni ions could induce inter-band levels within the band gap. Transition between those levels may responsible for broadening of the UV peak. In addition defect mediated visible emission has also been observed in the PL study. Further to investigate the effect of doping on microstructure, Raman spectra of $Zn_{1-x}Ni_xO$ samples are taken. Wurzite ZnO belongs to space group: C_{6v}^4 and consequently six first order phonon modes are expected to appear in the Raman spectra. Raman scattering has been analysed according to the existing literature and details of analysis are presented in this work.

1. Introduction

There is great interest of studying zinc-oxide (ZnO) semiconductor because it has wide range of applications in photonic, photovoltaic and electronic devices [1-4]. The material ZnO has some unique physical and chemical properties such as high electron mobility, high chemical and thermal stability, wide and direct band-gap (3.37 eV) and large excitonic binding energy (~ 60 meV) [3-5]. All these properties of ZnO make it very promising for developing light emitting diodes (LEDs), gas sensors, UV-detectors, solar-cells [3, 5] etc. Further ZnO is also used in developing transducers and surface acoustic wave (SAW) devices [6]. Doping at the Zn-site by transition metal ions (like; Mn, Co, Fe, Ni) may introduce magnetic property in these materials. In the year 2000, Dietl *et. al* [7] theoretically demonstrates that ferromagnetic property at room temperature can be achieved in case of Mn doped

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ZnO samples. Science then transition metal doped ZnO has been studied extensively. However doping concentrations has been kept small because the solubility limit of these metal ions (Mn^{2+}, Co^{2+}, Ni^{2+}) is quite low in ZnO structure [8]. These dilute transition metal doped ZnO samples are belonging to the family of diluted magnetic semiconductors (DMS).

Multifunctional ZnO nanoparticles have been investigated quite extensively because of their wide range of applications. Also transition metal ion doping may induce modification in optical, magnetic and microstructural properties. ZnO nanoparticles can be synthesized by different methods like hydro-thermal method [5], co-precipitation method [5, 11], sono-chemical process [9-10], ball-milling technique [4] and sol-gel process [8 and 12]. All these methods have their limitations and advantages. Simple and cost effective chemical co-precipitation synthesis technique is used here for synthesis of ZnO and $Zn_{1-x}Ni_xO$ (x = 0.03 and 0.05) samples. The main advantage in co-precipitation synthesis technique is that common solvents such as ethanol, methanol and distilled water are used. Further at low temperature and using simple equipment, samples are synthesised. Detail of synthesis procedure is described in section 2.

Nanoparticles of $Zn_{1-x}Ni_xO$ have been studied quite extensively and magnetic properties of $Zn_{1-x}Ni_xO$ samples are mainly focused in those work [13-16].The present work describe synthesis and study of structural, optical and micro-structural property of $Zn_{1-x}Ni_xO$ (x = 0.03 and 0.05) samples. The samples were prepared by simple chemical reaction method. For the chemical co-precipitation synthesis process, the concentration of NaOH [17] and the reaction atmosphere [9-10] plays the crucial role and control the morphology, size and band-gap of the ZnO nanoparticles. The precipitation was done (here ZnO and $Zn_{1-x}Ni_xO$) in an ultrasonic bath with application of high frequency ultrasound waves. The sono-chemical process is based on acoustic cavitation phenomenon that promotes the formation and collapse of many bubbles in the aqueous solution [10]. Under such extreme condition molecular bonds are broken and these molecules could produce radicals which finally control the properties of the prepared samples [10]. Structure and morphology of these nanoparticles are characterised by X-ray diffraction (XRD) and scanning electron microscopy (SEM). Optical Properties have been studied by UV-visible and photoluminescence (PL) spectroscopy and micro-structural properties have been studied by Raman spectroscopy. The results of various measurements have been analysed and compared with that of the un-doped ZnO sample which has been prepared by similar chemical reaction method.

2. Experimental Work.

2.1. Synthesis of Samples

Present work describes synthesis of Ni doped ZnO ($Zn_{1-x}Ni_xO$, x = 0.03 and 0.05) samples by chemical co-precipitation technique. The raw materials used for preparation of $Zn_{1-x}Ni_xO$ samples are zinc acetate [$Zn_2(CH_3COO)_2 2H_2O$] and nickel acetate [$Ni(CH_3COO)_2.4H_2O$]. During synthesis appropriate stoichiometric amount of zinc-acetate and nickel-acetate was taken and dissolved in methanol [CH_3OH] through continuous stirring in a conical flux. In a separate container a solution of 0.1M of NaOH is dissolved in 40 ml CH_3OH. Drop wise NaOH solution was added into the solution that contains zinc and nickle acetate under sonication and a white precipitate has been found. The sono-chemical reaction method has been used to produce smaller size nanoparticles with uniform shape [9]. During sonication the temperature was maintained at 300 K by continuously changing the water of the sonication bath by cold water. After complete precipitation the product is kept un-disturbed for 24 hours in a glass container. Finally the product has been collected by using a centrifuge machine. In order to separate out the un-reacted raw material, the precipitate (end product) has been washed several times by using double distilled water and ethanol. After cleaning, the $Zn_{1-x}Ni_xO$ (x = 0.03 and 0.05) samples were taken in a crucible and annealed at 500°C for 3 hours inside a box furnace. Finally these annealed samples were grind in an agate motor and finally used for various characterizations.

2.2. Characterization of Samples

We did structural and optical and micro-structural characterizations of $Zn_{1-x}Ni_xO$ samples. Room temperature XRD measurements had been carried out by using powder X-ray diffractometer with Cu-K_α radiation (wavelength: λ= 1.54Å) and the scanning rate was maintained at 0.5° per second. The XRD data for these samples were taken in range 2θ =25° to 80°. Band-gap of $Zn_{1-x}Ni_xO$ (x = 0.03 and 0.05) samples were determined by analysing the UV-visible absorption data. Room temperature PL emission for these samples was taken by using Agilent Cary Eclipse fluorescence spectrometer. The excitation wavelength used for PL emission is 320 nm. In order to study surface morphology and particle size we have performed SEM measurement. Raman spectra of respective samples have taken in the range 50 cm^{-1} to 800 cm^{-1}. A laser source of wavelength 532 nm has been used for the Raman Spectroscopy measurement. A detailed analysis on structural optical and vibrational properties of respective samples has been presented in section 3.

3. Results and Discussion.

3.1. *Structural characterization of Samples:*

The X-ray diffraction pattern of ZnO and $Zn_{1-x}Ni_xO$ (x = 0.03 and 0.05) samples were depicted in Figure 1. The diffraction peaks in figure 1 can be indexed to a hexagonal wurtzite structure (space group: $P6_3mc$) of ZnO. The strong diffraction peaks of the $Zn_{1-x}Ni_xO$ samples may indicate good crystalline quality and polycrystalline nature of these samples. The (101) diffraction peak is the strongest among others for these samples. However a week impurity peak (near 2θ = 43.22°) was seen and identified as (111) diffraction peak of NiO in case of Ni doped ZnO samples [13]. It further indicates that the solubility limit of Ni in wurzite ZnO structure is really small.

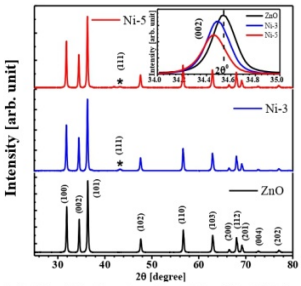

Figure 1: Represents the X-ray diffraction pattern of pure ZnO and $Zn_{1-x}Ni_xO$ (x = 0.03 and 0.05) samples. Inset of Figure 1 shows the enlarged view of (002) XRD peak of respective samples. A very prominent low angle shift has been noticed in Ni doped samples.

The average grain size: D of respective samples is estimated by using Scherrer equation [11] as described in equation (1).

$$D = \frac{0.9\lambda}{\beta \cos\theta} \quad \text{..... (1)}$$

Here λ is wavelength of the X-ray (λ= 1.54Å) used and β is the FWHM (full width at half maxima) of (101) diffraction peak. It has been observed that with Ni doping the grain size reduces. Further lattice constant (a & c) and bond-length (Zn-O) of Ni doped ZnO samples has been estimated following the procedure as described in [9 and 18]. The calculated lattice parameters of $Zn_{0.97}Ni_{0.03}O$ sample are a = 3.244±0.002 Å and c = 5.197±0.002 Å, which are slightly larger than un-doped ZnO sample. The small enhancement in lattice constant values could be explained by considering that ionic radius of Ni^{2+} (0.68 Å) ion is larger than Zn^{2+} (0.60 Å) ion [13]. Also a slight enhancement in the values of Zn-O bond length and cell volume has been observed. The values of grain size, lattice parameters and bond length (Zn-O) are all presented in Table 1.

Table1. *Calculated values of Lattice parameters & grain size of ZnO & $Zn_{1-x}Ni_xO$ samples*

Sample	FWHM (101)	D (nm) ±2 nm	2Θ (002)	c(Å) ±0.002	a(Å) ±0.002	c/a	l	V
ZnO	0.249	65.21	34.538	5.10	3.238	1.603	1.959	46.216
ZnO:3% Ni	0.319	50.82	34.491	5.197	3.244	1.602	1.974	47.362
ZnO:5% Ni	0.341	47.10	34.460	5.202	3.247	1.602	1.976	47.496

Inset of Figure 1 shows a systematic shift towards lower angle of the (002) peak in Ni doped ZnO samples which further supports the increase of lattice constants of Ni doped samples. It is important to note that c/a ratio for the doped and un-doped ZnO samples is smaller than 1.633 (the c/a ratio of ideal wurzite structure) [19]. It indicates structural distortion in wurzite structure in these synthesized samples [20]. However the c/a ratio in nearly constant for all these samples, possibly due to nearly same size of the Ni^{2+} and Zn^{2+} ions. Figure 2 depicts the SEM images of Ni doped ZnO samples. The SEM pictures were taken with an accelerating voltage 15 kV with magnification 50.00 KX. The grains are more or less spherical in shape for these samples.

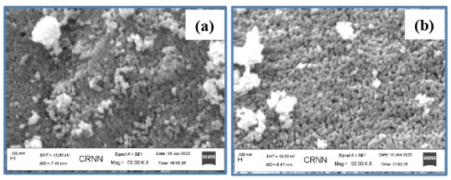

Figure 2: SEM micrographs of (a) $Zn_{0.97}Ni_{0.03}O$ and (b) $Zn_{0.93}Ni_{0.05}O$ samples

3.2. *Optical Property Study by UV-Visible and PL Emission Spectroscopy.*

ZnO is a direct wide band-gap semiconductor. The optical band gap E_g can be determined by Tauc relation [20].

$$\alpha h\nu = B(h\nu - E_g)^{1/2} \quad \ldots\ldots\ldots\ldots\ldots [2]$$

Here α is the absorption coefficient, h is the Planck's constant and ν is the frequency and B is a constant. Figure 3 (a) shows the $(\alpha h\nu)^2$ vs $h\nu$ plots for the Ni doped ZnO samples. Figure 3 (b) shows the absorbance against wave-length for the $Zn_{0.97}Ni_{0.03}O$ sample. The $(\alpha h\nu)^2$ vs $h\nu$ plots clearly exhibit a strong exciton peak at E_{ex} = 3.353 eV and E_{ex} =3.349 eV for Ni-3 and Ni-5 sample respectively. Here E_{ex} is the exciton energy can be calculated from relation $E_{ex} = hc/\lambda_{ex}$ [9]. A small but lower energy shift of the exciton peak position has been noticed from Figure 3.The optical band-gap: E_g for the $Zn_{1-x}Ni_xO$ (x = 0.03 and 0.05) samples has been determined from the maximum of 1st derivative of absorbance with respect to photon energy at the lower energy side, as shown inset of Figure 3(b) [9]. The E_g values are found as 3.26 eV and 3.30 eV respectively for ZnO:3%Ni and ZnO:5%Ni samples.

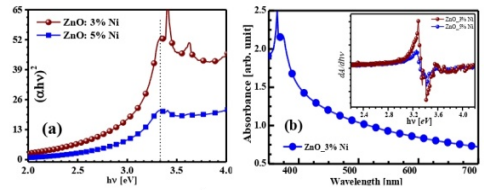

Figure 3: In Figure 3(a) the variation of $(\alpha h\nu)^2$ vs $h\nu$ plots for the $Zn_{1-x}Ni_xO$ (x = 0, 0.03 and 0.05) samples are shown. Figure 3(b) shows the plot of absorbance against wave-length of the $Zn_{0.93}Ni_{0.07}O$ sample. Inset of Figure 3(b) shows the enlarged view of the 1st derivative of absorbance with respect to photon energy.

The room temperature PL spectra of ZnO and $Zn_{1-x}Ni_xO$ (x = 0, 0.03 and 0.05) samples are shown in Figure 4. The PL emission spectra are taken at excitation wave-length: λ_{ex} = 320 nm. Figure 4(a) shows the PL emission plot for ZnO and $Zn_{0.95}Ni_{0.05}O$ samples in the range 340 nm to 525 nm.

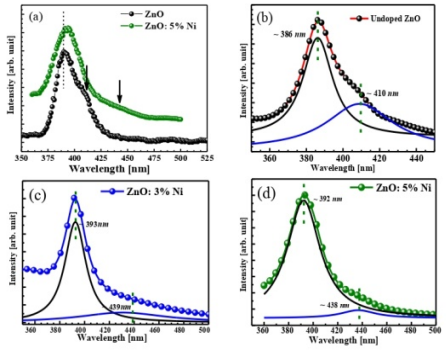

Figure 4: (a) represents the PL Spectra of un-doped and $Zn_{1-x}Ni_xO$ (x = 0, 0.03 and 0.05) samples. Figure 4 (b) (c) & (d) shows the Gaussian fitting of the broad PL emission peak. The peak positions are also indicated in the figure.

In Figure 4(a) we could see broad and asymmetric PL emission peak ranging between 370 nm to 430 nm). However, it is important to note that strong defect related visible emission has not been observed

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between 2 eV to 3 eV for these samples. The broad UV emission peak was de-convoluted into two Gaussian peak and positions of respective peak determined from the fitting are mentioned in Figure 4 (b), (c) and (d) for un-doped and doped samples. In case of ZnO with the excitation wave-lengths: λ_{ex} = 320 nm, the 1st peak is observed is near 386 nm (3.21 eV) and that peak corresponds to near band edge (NBE) emission. The second peak is located around 410 nm (3.02 eV) is possibly due to transition between shallow donor level created by interstitials Zn_i defects to the upper level of the valance band [20, 21]. In case of $Zn_{0.93}Ni_{0.07}O$ and $Zn_{0.93}Ni_{0.07}O$ samples the near band edge emission was found at 393 nm and the defect related emission peak has been observed near 440 nm. This particular peak (440 nm) has been identified as due the transition between shallow donor levels due to Zn_i defects to the levels created by singly ionised V_{Zn} [22] above the valance band. Even after extensive work on PL emission characteristic on ZnO nanoparticles, understanding of the origin visible PL emission is still under debate. Here in this work we could only identify Zn_i and V_{Zn} defects from PL emission. However, PL emission with higher excitation wavelength (λ_{ex}) may be helpful to understand the deep level emission more clearly for these $Zn_{1-x}Ni_xO$ nanoparticles and in future will continue to do the PL study with higher λ_{ex}.

3.3. *Micro-structure and vibrational property study by Raman Spectroscopy.*

In Figure 5 the room temperature Raman spectra of un-doped and Ni doped ZnO samples are plotted. Raman Study could helped us to investigate the effect of doping on micro-structure and vibrational property of $Zn_{1-x}Ni_xO$ (x = 0, 0.03 and 0.05) samples. We could identify the A_1, E_1, E_2 vibrational modes and the corresponding peak positions are mentioned in Figure 5. In case of wurzite phase of ZnO (space group C^4_{6v}) the strongest characteristic peaks are the two E_2 modes, are observed near 102 cm^{-1} and 439 cm^{-1} and are identified as E_2^{Low} and E_2^{High} [4, 11] modes respectively. We must note here that E_2^{Low} mode is associated with the vibration of Zn atoms whereas E_2^{High} is associated vibration oxygen atoms [23]. The Raman peak near 334 cm^{-1} can be identified as: E_2^{High}- E_2^{Low} mode. It is a 2nd order Raman mode involving multi-phonon process [24]. The Raman mode E_2^{High} (439 cm^{-1}) represents the band characteristic in wurzite phase of ZnO [18]. With increase of Ni doping lowering of peak intensity and broadening of the E_2^{High} peak could be seen, in Figure 5(b). Particularly the broadening is quite noticeable in case of $Zn_{0.95}Ni_{0.05}O$ sample. It may indicate change in the band structure of the $Zn_{1-x}Ni_xO$ (x = 0, 0.03 and 0.05) samples and it is also consistent with changes as observed in UV-visible absorption and the PL emission spectra of respective samples. However, Kharroubi *et al.* have argued that variation of peak intensity of E_2^{High} mode is due to change in exciton-phonon coupling strength [18]. The peak intensity of this E_2^{High} mode is found as decreased strongly with Ni doping concentration. Inset of Figure 5(b) shows the variation in peak intensity ratio [I_O/I_B] of the E_2^{High} mode. A noticeable change in the ratio of I_O/I_B has been observed and is the result of deformation in the structure [11] induced by doping with Ni ions and that might also affect the properties of free-exciton in these samples [18].

We could further identify the A_1 and E_1 modes in the Raman spectra of the $Zn_{1-x}Ni_xO$ (x = 0, 0.03 and 0.05) samples and are highlighted in Figure 5. It is important to note that the A_1 and E_1 mode both are Raman and Infrared active and are split into transverse optical (TO) and longitudinal optical (LO) components [4] with different frequencies. The intensity corresponding to the A_1(TO) mode (~384 cm^{-1}) is very week and the E_1(TO) mode observed near 412 cm^{-1} is practically invisible (supressed within the background) in case Ni doped samples. Also A_1(LO) mode has been identified near ~583 $cm^{-1}$for the un-doped ZnO sample although the intensity of that corresponding peak is very week. This particular mode [A_1(LO)] is associated with oxygen vacancy (V_O) or interstitial-zinc (V_{Zn}) defects or their complexes present in the samples [25]. Low intensity of A_1(LO) mode may indicate low level of defects concentrations in these samples. However, for Ni doped samples a broad hump like feature has been observed within the range 500 cm^{-1} to 600 cm^{-1}, indicating that doping could induce more vacancy type defects and also structural deformations in $Zn_{1-x}Ni_xO$ (x = 0.03 and 0.05) samples.

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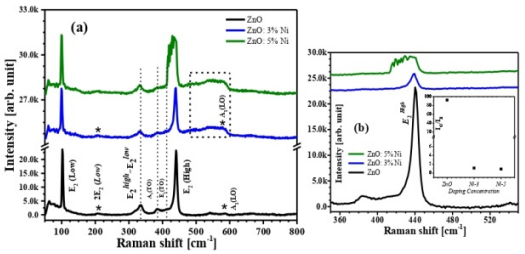

Figure 5: Represent the Raman spectra of ZnO and $Zn_{1-x}Ni_xO$ (x = 0, 0.03 and 0.05) samples and Figure 5(b) describes the enlarged view of E_2^{High} characteristic mode of respective samples. Inset of Figure 5 (b) shows the variation Intensity ratio I_O/I_B for the particular E_2^{High} mode of respective samples.

4. *Conclusions.*

In summary Ni doped ZnO [$Zn_{1-x}Ni_xO$ (x = 0, 0.03 and 0.05)] samples were synthesized by simple chemical co-precipitation method using an ultrasonic bath. During synthesis the temperature has been maintained at room temperature. Based on XRD and Raman study we could say that samples are forming in wurzite phase of ZnO. However the solubility limit of Ni in ZnO is found to be quite low. In the XRD pattern we could identify the NiO phase even when doping concentration is just 3at% of Ni. The lattice constants of $Zn_{1-x}Ni_xO$ (x = 0, 0.03 and 0.05) samples are estimated and with the increase of doping a small but systematic increase in lattice constants (a & c) values has been observed. The analysis of UV-visible absorption spectra indicates that band gap (E_g) is increased with doping. Further PL emission study with the excitation wave-length (λ_{ex} = 320 nm) shows a strong NBE emission around 393 nm for these doped samples. However, defect related emission is quite low in case of doped and pure samples. It may indicate that relative concentration of defects, like vacancy type defects (V_O and V_{Zn}) or interstitial defects (Zn_i) are small for these samples. However, at this point we can only say that PL study with higher excitation wave-length (i.e. λ_{ex} > 320 nm) could unfold the deep level defect emission with more clarity for these nanoparticles. With increasing doping concentration the wurzite structure degrade gradually. Raman spectra of the $Zn_{1-x}Ni_xO$ (x = 0, 0.03 and 0.05) samples exhibit broadening of 439 cm^{-1} peak quite significantly in comparison with un-doped sample. It is possibly due to the change appearing in the band structure with doping. In case of Ni doped ZnO samples reduction in grain size and structural disorder is increased and that may contribute to the broadening of E_2^{High} characteristic peak also.

5. *Acknowledgement.*

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14. Article/Paper: Synthesis of ZnO nanoparticles by co-precipitation technique and characterize the structural and optical properties of these nanoparticles.

Tabular representation : Paper Detail

Author(s)	**Soumyadev Ghosh**, Abhishek Ghosh , Subhamay Pramanik , Probodh K. Kuiri , Rupam Sen , and Swarup Kumar Neogi
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Synthesis of ZnO nanoparticles by co-precipitation technique and characterize the structural and optical properties of these nanoparticles

Synthesis of ZnO nanoparticles by co-precipitation technique and characterize the structural and optical properties of these nanoparticles

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Abstract. The present work demonstrates synthesis and study of physical properties of chemically synthesized ZnO nanoparticles by co-precipitation technique. Detailed synthesis procedure had been described in the experimental section. Chemically synthesized ZnO samples were annealed at 300°C and 500°C. These samples have been characterized by doing X-Ray diffraction (XRD), photoluminescence (PL) and Raman spectroscopy. XRD patterns indicate wurzite structure of these samples. SEM pictures shows growth of grain size with annealing temperature treatment. The lattice parameters (a & c) of ZnO samples are showing increasing tendency with annealing treatment. PL spectra with excitation wavelength : λ_{ex}=330 nm exhibit a broad and asymmetric UV band centred around 386 nm (~ 3.212 eV) and 390 nm (~ 3.179 eV) respectively for the 300°C and 500°C annealed samples. Broad UV emission band indicating that, it has defect related origin. The Raman spectra of these samples indicate that intensity of Raman peaks improves with annealing at the higher temperature. Possibly high temperature annealing (500°C) brings modification into the micro-structure. The micro-structure and optical properties of these synthesized samples are compared with that of pure ZnO powder samples. Finally correlation between structural and optical properties has been made based on the analysis of experimental data.

Key words: Oxide semiconductor, Band gap, Photoluminescence, Raman spectroscopy

1. Introduction

Zinc oxide (ZnO) is the most promising compound in the II-VI semiconductor family. The material ZnO is a wide direct band-gap semiconductor [1-2]. In comparison to the excitonic binding energy of GaN (21 meV) and ZnSe (22 meV), ZnO has much larger excitonic binding energy (60 meV) at room temperature [2]. Direct band-gap and large excitonic binding energy at room temperature make it a potential candidate for application in optoelectronics [3]. Moreover ZnO shows high radiation resistance [4] and therefore suitable for developing photodiodes, photo-detectors [3], piezoelectric transducers and gas sensors [4-5]. ZnO nanoparticles (NPs) have application in spin electronics [6]. Generally ZnO crystalize in wurtzite crystal structure. Inside the wurtzite structure we

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could see tetrahedral coordination between 4-oxygen atoms with Zinc atom. The wurtzite structure has hexagonal unit cell with space group C^4_{6v} [3] and the lattice constants are a = 3.25 Å & c = 5.21 Å respectively [7]. For the ideal structure the ratio of the lattice constants (c/a) is found as ~ 1.633 [4]. In chemically synthesised ZnO samples, the actual structure may deviate a little from ideal wurtzite structure and therefore c/a ratio is generally found less than 1.633 [8].

Different synthesis technique could be used to prepare ZnO NPs [4, 7-10]. Also ZnO can be synthesized in different nanostructures [11] and these nanostructures have unique optical properties. Actually different microstructure i.e. grain size, lattice constant, lattice strain and defects at grain boundaries strongly influence the optical properties of ZnO. Moreover ZnO is a non-toxic material and therefore NPs of ZnO have been used for delivering drugs to the infected areas of the body [11]. Also ZnO NPs have been used as catalysis for organic reactions [3]. Therefore synthesis of nanoparticles of ZnO with controlled size and shape by some suitable chemical synthesis techniques is indeed an important area of study. Simple and widely used co-precipitation technique has been used in this work for preparing ZnO NPs. The co-precipitation synthesis technique for preparation of nanostructures is based on bottom up approach [3, 12]. In this process the product yield is low and the final product may contain some impurities or un-reacted raw materials. Therefore it is necessary to wash the final product several times by distilled water or by alcohol. However, this simple technique is very useful for synthesis of control nanostructure (i.e. size and shape) and for doping by other elements into semiconductor nano-crystals.

Nano-crystalline ZnO is found as enriched with defects (vacancies or interstitial type) and lattice imperfections [1-3, 8]. These structural defects are present on the grain surfaces mostly of these nanoparticles and could modify the electronic [3] and optical [4] properties. It has also been reported that defects of particular type (Zinc vacancy: V_{Zn}) [8] possess magnetic moment and therefore could induce ferromagnetic interaction in NPs of ZnO. This phenomenon is described as d^0 ferromagnetism [6]. Characterization of those defects is important to explain the modification as observed in optical properties of ZnO nanoparticles. In this present work physical properties of chemically synthesized nanoparticles have been studied. Structure and morphology of the samples are characterised by X-ray diffraction (XRD) and scanning electron microscopy (SEM). Optical and microstructural properties have been studied by Photoluminescence (PL) and Raman spectroscopy. Finally the results of different measurements have been analysed and compare with the results of pure ZnO samples.

2. Experimental Work.

2.1. Synthesis of Samples

The present work describes synthesis and study of physical properties of chemically synthesized ZnO nanoparticles prepared by co-precipitation technique. Raw materials used for preparation of ZnO are Zinc Acetate [$Zn_2(CH_3COO)_2H_2O$] and Sodium Hydroxide [NaOH] and both these raw materials are dissolved in methanol in two separate containers. During synthesis, NaOH solution has been added drop wise into the transparent Zinc-Acetate solution under sonication in an ultrasonic bath. The temperature of the ultrasonic bath was maintained at 30°C during reaction. A white precipitate appears at the end of the reaction. After complete reaction the end product was collected by using a centrifuge machine. To separate out the un-reacted raw materials the precipitate has been washed several times by using double distilled water and ethanol. Finally the ZnO NPs were taken in a crucible and annealed at 300°C and 500°C for 3 hours inside a box furnace. These two samples are denoted as ZnO_S1 and ZnO_S2 respectively. Also pure ZnO powders (purchased from Sigma Aldrich with purity 99.99%) are annealed at 300°C and 500°C for 3 hours. These two samples are denoted as ZnO_P1 and ZnO_P2 respectively in this manuscript. Characterization of both chemically synthesised and pure samples has been performed and described.

2.2. Characterization of Samples

We did structural and optical property measurements of synthesised samples. XRD measurements at room temperature have been performed with the scanning rate 0.5° per second and Cu-K_α radiation (wavelength: λ= 1.54Å) is used. XRD data were taken in the 2θ range 25°-80°. Also room temperature PL emission measurement of these samples has been performed by using Agilent Cary Eclipse fluorescence spectrometer. The excitation wave lengths used for PL experiment are 330 nm and 350 nm. To study surface morphology and grain size we did SEM measurement. Raman spectra of respective samples have taken in the range 50 cm^{-1} to 800 cm^{-1}. A laser source of wavelength 532 *nm* is used for Raman Spectroscopy. A detailed analysis on structural and optical and vibrational properties is presented in section 3.

3. Results and Discussion.

3.1. Structural characterization of Samples:

Figure 1 shows the XRD pattern of chemically prepared and pure samples. The XRD pattern reveals polycrystalline nature of these samples. The diffraction peaks located at 2θ° = 31.88°, 34.54°, 36.37°, 47.68°, 56.69°, 62.94°, 66.44°, 68.10°, 69.17°, 72.62° and 77.04° could be identified as (100), (002), (101), (102), (110), (103), (200), (112), (201), (004) and (202) diffraction peaks of wurzite ZnO [1]. However, all these powder samples exhibit strong (101) diffraction peak in the XRD pattern. The diffraction peaks of ZnO_S1 sample are broad that indicates grain sizes are small. We could see from Figure 1(c) that with annealing at higher temperature broadening of the diffraction peaks are reduced and intensity of peaks are getting improved with respect to the background, as seen for the sample ZnO_S2. The FWHM (full width at half maxima) of the (101) diffraction peak of respective samples are used to estimate the average size of grains by using the relation known as Scherrer equation as described in equation (1).

$$D = \frac{0.9\lambda}{\beta \cos\theta} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Here λ is wavelength (λ= 1.54Å) of the X-ray used and β is the FWHM (on 2θ scale) of the diffraction peak and D is the grain size. The FWHM of the diffraction peaks contain contribution of many factors like; effect of finite crystallite size and their distribution, presence of defects or disorder and strain due to deformation in the Lattice. Also instrumental broadening contributes to the overall broadening of the XRD peaks. However, instrumental broadening could be eliminated from the XRD data easily as described in [13]. Structural changes occurring with annealing at 300°C and at 500°C could be seen from XRD Pattern [inset of Figure 1 (c)]. Improvement in crystalline quality has been observed after annealing at 500°C temperature. For commercially purchased samples no significant change in the XRD line width (FWHM) and intensity of the corresponding XRD peak with respect to background has been observed. FWHM values of the (101) peak of ZnO_P1 and ZnO_P2 samples are found as 0.286 and 0.295 [in degrees] and therefore grain sizes are also found as nearly same 56.39 nm and 54.67 nm respectively. However, in case of ZnO_S1, the estimated grain size is 24.19 nm and for ZnO_S2 the calculated grain size is found as 64.77 nm. Estimated values of average grain size of these 4 samples are tabulated in Table 1.

It is important to note that Scherrer equation gives information only about the average size of the crystallite and ignore the effect strain in the lattice. The calculated values of grain size according to equation (1) may vary about 2 nm on the average. Inset of Figure 1 shows that the XRD peaks are shifted towards lower angle when annealing temperature is increased to 500°C. It implies lattice constants (a & c) are increased. The lattice parameters and the cell volume of these samples have been calculated by using the following equation (2) and (3) and are listed in Table 1. In the XRD measurements of pure and annealed samples (annealed at 300°C and 500°C) we could not see any such low angle shifting in XRD peak positions and therefore lattice constants in this case are found as comparable. The bond length of Zn-O bond has been calculated by using equation (4) as described in [14].

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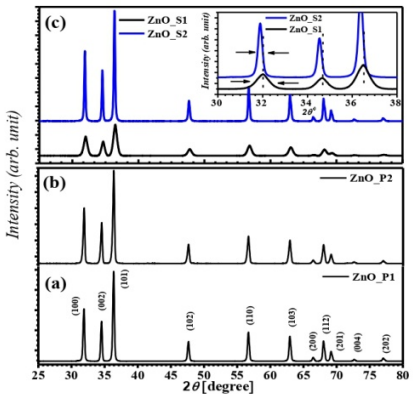

Figure 1: X-ray diffraction pattern of pure and synthesised ZnO samples. Inset of Figure 1(c) shows the enlarged view of the XRD pattern of ZnO_S1 and ZnO_S2 samples. A very prominent lower angle shift was noticed for 500°C annealed sample.

$$\frac{1}{d_{hkl}^2} = \left[\frac{4}{3}\left(\frac{h^2+hk+k^2}{a^2}\right) + \frac{l^2}{c^2}\right] \quad \text{.....(2)}$$

$$V = \frac{\sqrt{3}}{2}a^2c \quad \text{.....(3)}$$

$$l = \sqrt{\frac{a^2}{3} + \left(\frac{1}{2} - u\right)^2 c^2} \quad \text{.....(4)}$$

In equation (2), d_{hkl} represents the inter-planar spacing corresponding to the Miller indices (h k l) and in equation (4) 'u' is the positional parameter. The estimated values of 'l' for these samples are given in the Table 1. For the sample ZnO_S1, the estimated value of a = 3.238±0.003 Å and c = 5.174±0.003 Å which are comparable with the reported values of lattice parameters of chemically synthesized ZnO [7]. We could see a little enhancement in values of lattice constants and bond-lengths of Zn-O when annealing temperature is increased to 500°C. The wurzite structure of ZnO is composed of two inter-penetrating hexagonal closed packed sub-lattices. The lattice constant 'a' represents the length of the basal plane of hexagon and the constant 'c' represents the axial height normal to that basal plane [15]. Therefore it is important to note variation of the c/a ratio for the ZnO_S1 and ZnO_S2 samples and it is found to be 1.598 and 1.603 respectively. The c/a ratios are smaller than 1.633, the c/a ratio of ideal wurzite structure [8]. It further indicates distortion in wurzite structure particularly in ZnO_S1. However, c/a ratio is increased with annealing.

Figure 2 depicts the SEM images of ZnO_S1 and ZnO_S2 samples respectively. The grain sizes for these samples are found as larger than that we have estimated from XRD data. SEM images of ZnO_S1 shows that nanoparticles are more or less spherical in shape. In this context we should highlight the work by M. Ghosh *et. al.* [15], they had demonstrated that spherical shaped nano-particles are formed when NaOH-ethanol solution is added in the ethanolic solution of Zn-acetate at 60°C to 75°C. We had prepared the nano-particles of ZnO following the similar co-precipitation technique but methanol is used as solvent in this work. Further annealing at higher temperature

(500°C) we could see grains are agglomerated and thereby forming bigger size grains. The SEM images of ZnO_S1 and ZnO_S2 also indicate the distribution in grain sizes.

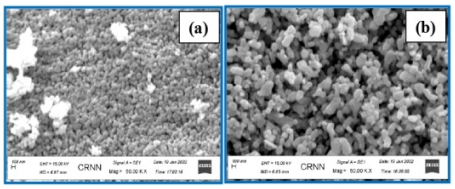

Figure 2: SEM micrographs of (a) ZnO_S1 and (b) ZnO_S2 samples.

Table1. *Lattice parameters & grain size of respective samples*

Sample	FWHM (101)	D (nm) ±2 nm	2Θ (200)	c(Å) ±0.003	a(Å) ±0.003	c/a	*l*	V
ZnO_S1	0.667	24.19	34.65	5.174	3.238	1.598	1.967	46.98
ZnO_S2	0.249	64.77	34.54	5.189	3.238	1.603	1.970	47.12
ZnO_P1	0.286	56.39	34.54	5.189	3.239	1.602	1.969	47.15
ZnO_P2	0.295	54.67	34.56	5.187	3.237	1.603	1.970	47.10

3.2. *Optical Property Study by PL Emission Spectroscopy.*

The PL spectra of ZnO samples are depicted in Figure 3. We have taken the room temperature PL emission spectra at the two different excitation wave-lengths: λ_{ex} = 330 nm and λ_{ex} = 350 nm. In case of pure and annealed samples the near band edge emission (NBE) could be seen near 386 nm (3.21 eV) irrespective of the excitation wave-length. The UV peak near ~ 3.21 eV is due to bound excitonic transition [15]. Figure 3 shows broad and asymmetric UV band for these samples. The experimental PL data of chemically synthesized samples (range between: 360 nm to 425 nm) has been fitted with two Gaussian line shape and peak positions are extracted from the fitted curves, shown in Figure 3 (e) and (f). For the sample ZnO_S2 with excitation wave-length: λ_{ex} = 330 nm, the 1st peak : P1 observed at 389 nm (3.19 eV) is identified as near band edge emission whereas the 2nd peak : P2 centred at ~396 nm (3.13 eV) is possibly due to band to band transition into the band tails states [16]. When excitation wave-lengths is increased to : λ_{ex} = 350 nm the 1st and 2nd peak are found to be ~389 nm (3.19 eV) and ~399 nm (3.10 eV) respectively for the same ZnO_S2 sample. The Gaussian fitting of the UV emission peak for the ZnO_S1 has also been performed and presented in Figure 3 (e) and (f).

The peak positions for the two excitation wave-length are comparable with one other. In literature several conflicting reports on the PL study of ZnO NPs are present. We have assigned the peak P2 (near 400 nm) due to transition into the band tails states. However, Xu *et. al* [17] theoretically predicted that the PL emission near 3.07 eV is associated with the electronic transition from the bottom of the conduction band to the shallow acceptor level formed by Zn-vacancies (V_{Zn}). Here in this work we have found that peak P2 is situated ~3.10 eV, therefore the contribution of V_{Zn} or V_{Zn} defect complexes to that peak (~ 3.10 eV) could not be ignored completely. Important to note here that defect related green emission in the visible range (2-3 eV) is very small for both the excitation wavelengths.

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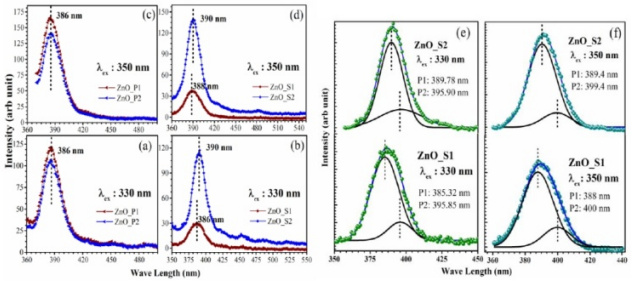

Figure 3: Room temperature PL emission (*a*, *b*, *c* and *d*) of all pure and synthesised ZnO samples. Figure (e) & (f) indicates Gaussian fitting of broad emission peak extending from near UV region to the blue green region (360 nm to 425nm) of ZnO_S1 and ZnO_S2 samples. The peak positions are indicated by P1, P2 respectively.

3.3. Study of *Vibrational modes by Raman Spectroscopy.*

Figure 4 shows the room temperature Raman spectra of wurzite structured ZnO (space group: C^4_{6v}) samples and it contain several 1st order and 2nd order phonon modes. Based on existing literature those modes have been identified. From Figure 4 we could identify the A_1, E_1, E_2 vibrational modes for all these 4 samples. The E_2 modes are labelled as E_2^{Low} and E_2^{High} and are observed in these 4 samples [4]. These E_2 modes are nonpolar and E_2^{High} (~ 439 cm^{-1}) is associated with the vibration of oxygen atoms and the mode: E_2^{Low} (~ 101 cm^{-1}) is due to vibration of Zn sub-lattice [3]. Giri *et al.* [3] had described the strong E_2^{High} mode as characteristic mode of the wurzite crystal structure. Another Raman peak ~ 334 cm^{-1} has been observed and represented as E_2^{High}- E_2^{Low} mode, which is a 2nd order Raman mode involving acoustic phonons. Also the presence of E_2^{High}- E_2^{Low} mode indicates good structural quality of these 4 samples. We should mention here that position of the E_2 peaks (E_2^{Low} and E_2^{High}) matches closely for synthesized (ZnO_S1 & ZnO_S2) and pure (ZnO_P1 & ZnO_P2) samples. Further a strong enhancement in intensity of the peak ~ 439 cm^{-1} (E_2^{High} mode) for ZnO_S2 is seen in Figure 4. In case of pure (ZnO_P1 & ZnO_P2) samples E_2 peaks are of comparable intensities however, intensity of the E_2 mode is improved much when annealing temperature is 500°C. We could see further that peak corresponds to E_2^{High} mode is asymmetric. The asymmetric line shape and line-width of the E_2^{High} mode reflects variation of residual stress and structural damages or defects in these synthesized samples [7]. The relative intensity variation with respect to background of the E_2^{High} mode for ZnO_S1 & ZnO_S2 samples qualitatively describes presence of disorder in the crystal lattice.

The Raman active A_1 and E_1 mode are polar modes and therefore split into longitudinal optical (LO) and transverse optical (TO) modes [18], also shown in Figure 4. In case of pure and annealed ZnO samples a very faint signal of A_1 (TO) and E_1(TO) modes could be seen near ~381 cm^{-1} and 412 cm^{-1}. Only A_1 (TO) (near 385 cm^{-1}) mode could be seen for the for the synthesised ZnO_S2 sample. Further Raman spectra of these ZnO (both pure and synthesised) samples show a hump like peak although very weak in intensity in the range between 510 cm^{-1} to 610 cm^{-1}. We have made Gaussian fitting (only for the synthesized and annealed ZnO samples) and the broad peak de-convoluted into two 2 peaks centred near 544 cm^{-1} and 580 cm^{-1}, shown in Figure 4 (b) and Figure 4 (c). The peak observed near 544 cm^{-1} has been assigned to 2LA mode [19] and the peak near 580 cm^{-1} is due to A_1(LO) mode which is either due to oxygen vacancies or due to Zn-interstitial defects [20]. The intensity of A_1(LO) mode is quite weak when we compared it with respect to E_2^{High} peak intensity

for all these samples, indicating low defect concentrations level in these pure and synthesised ZnO samples. This observation is coherent with the PL emission of ZnO samples where nearly suppressed defect related green emission in the range 450 nm to 550 nm has been observed. Improvement in crystalline quality in ZnO_S2 with annealing has been supported further very strongly by Raman spectroscopy.

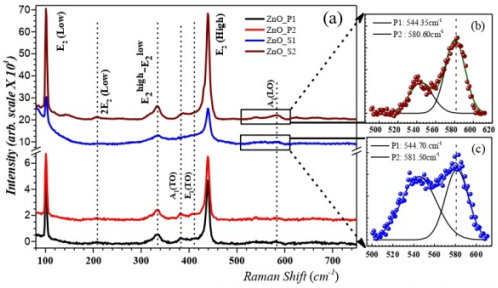

Figure 4: Room temperature Raman spectra of all pure and synthesised ZnO samples. Figure 4 (b) & (c) indicates Gaussian fitting of broad peak extending from 510 cm^{-1} to 610 cm^{-1} of ZnO_S2 and ZnO_S1sample respectively. The peak positions are indicated by P1, P2 respectively in the figure.

4. *Conclusion*

The present work describes simple synthesis techniques for the preparation of nanoparticles of ZnO. Structural, optical and vibrational properties of the synthesised ZnO nano-particles have been investigated and results of measurements are compared with that of pure ZnO nano-powder. The XRD measurement shows wurzite structure of the chemically synthesised samples; however lattice constant varying with the annealing temperature treatment. The crystalline quality of ZnO_S2 sample is much improved than ZnO_S1 sample as reflected by variation of c/a ratio of respective samples. In PL emission for excitation λ_{ex} = 330 nm and λ_{ex} = 350 nm of the chemically processed ZnO_S2 sample we could see the NBE emission ~ 389 nm (3.19 eV) which is quite closed to the observed NBE transition ~386 nm (3.21 eV) for pure ZnO sample. However, defect emission particularly green PL emission is very insignificant for these synthesised and pure samples. Further Raman study has been used to probe the structural disorder in these samples and it is clearly manifested from figure 4. The characteristic E_2^{High} mode (~ 439 cm^{-1}) are of comparable intensity for the pure samples but the same peak become quite strong after annealing at 500°C in case of ZnO_S2. In future we will continue this work and study modification of physical properties of ZnO nanoparticles as a function of particle sizes and shapes.

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