

Study of Compression-Induced Supramolecular Nanostructures of an Imidazole Derivative by Langmuir–Blodgett Technique

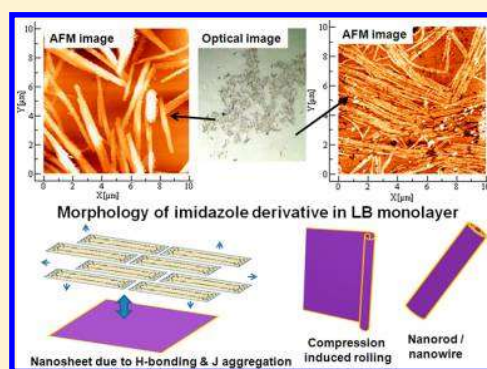
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Supporting Information

ABSTRACT: In this communication, we report the design and synthesis as well as the supramolecular assembly behavior of a 2,4,5-triaryl imidazole derivative (compound **1**) at the air–water interface and in thin films using Langmuir–Blodgett (LB) technique. The main idea for such a chemical structure is that the long alkyl chain and N–H of the imidazole core may help to form supramolecular architecture through the hydrophobic–hydrophobic interaction and hydrogen bonding, respectively. Accordingly, the interfacial behavior as well as morphology of **1** in thin films were studied through a series of characterization methods such as surface pressure–area (π –A) isotherm, hysteresis analysis, ultraviolet–visible (UV–vis) absorption and steady-state fluorescence spectroscopies, Fourier transform infrared, X-ray diffraction, Brewster angle microscopy (BAM), and atomic force microscopy (AFM) measurements, and so forth. Pressure–area isotherm is an indication toward the formation of supramolecular nanostructures instead of an ideal monolayer at the air–water interface. This has been confirmed by the hysteresis analysis and BAM measurement at the air–water interface. AFM images of **1** in the LB monolayer exhibits the formation of supramolecular nanowires as well as nanorods. By controlling different film-forming parameters, it becomes possible to manipulate these nanostructures. With the passage of time, the nanowires come close to each other and become straight. Similarly, nanorods come close to each other and form bundles of several rods in the LB films. H-bonding, J-aggregation, as well as compression during film formation might play a key role in the formation of such nanostructures. Electrical switching behavior of compound **1** was also observed because of the presence of an electron donor–acceptor system in **1**. This type of organic switching behavior may be promising for next-generation organic electronics.



INTRODUCTION

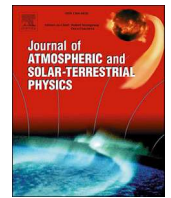
Electronic and optoelectronic devices^{1–7} impact many areas of modern society from simple household appliances to communications and sophisticated medical instruments. Given the demand for ever more compact and powerful systems, there is growing interest in the development of nanoscale devices that can enable new functions and/or have greatly enhanced performance. Recent extensive studies have shown that organic nanomaterials exhibit a variety of interesting optical, electrical, photoelectric, and magnetic properties in the solid state. Accordingly, photo- and electroactive organic materials have been the subject of current research,^{8–10} including organic semiconductors, organic metals, organic superconductors, organic photoconductors, organic photoactive materials for solar cells, organic nonlinear optical materials, liquid crystals, and others. In addition, organic materials have found a number of potential applications for use in electronic and optoelectronic devices,^{11–14} such as sensors, plastic batteries, solar cells, field-effect transistors (FETs), optical data storage, organic electroluminescent devices (OLEDs),

switching devices, and so forth. Over the last few decades, tremendous progress has been made in the development and investigation of such new organic materials^{15–19} with a readily polarizable structure for the fabrication of novel devices. A conjugated π -system end-capped with a strong electron donor group, such as $-\text{NR}_2$ and OR, and a strong electron acceptor group, such as $-\text{NO}_2$, cyano (CN), or imine ($\text{C}=\text{NR}$), in a molecule generates a dipolar push–pull system ($\text{D}-\pi-\text{A}$) that assures intramolecular charge transfer and low energy barrier and shows an intense charge-transfer band. The extent of electronic or optoelectronic behavior depends primarily on their chemical structure, high chemical and thermal robustness, good solubility in common organic solvents, and availability in reasonable quantities. Hence, various five- and six-membered heterocycles are utilized as suitable π -conjugated chromophore backbones because they act as auxiliary donors or acceptors and

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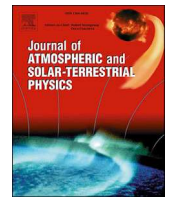
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Aliasing of the Schumann resonance background signal by sprite-associated Q-bursts

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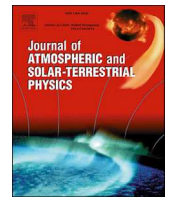
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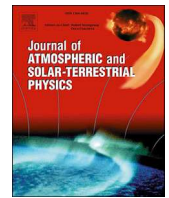
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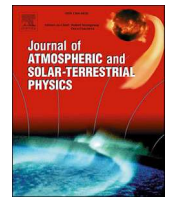
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Organoclay Hybrid Films With Improved Functionality

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1. INTRODUCTION

Clay minerals are natural nanomaterials with layered architecture [1]. They have attracted intense industrial and academic interest because of their unique material properties, colloidal size, layered structure, large surface area, cation exchange capacity (CEC), and nanoscale platelet-shaped dimensions [2]. Research interest in organoclay nanocomposites prepared by organic–inorganic (clay) minerals is gaining day by day and is being extensively investigated in materials science [3,4]. It offers the flexibility of designing new functionalized materials because they possess characteristic behaviors such as an easily changing layer-by-layer (LbL) structure or precisely controllable film thickness, or a variety of physical properties that are not present in each of the separate components. The hybrid nanostructured materials have gained widespread interest because of their potential applications in a number of diverse technological fields. In hybrid nanostructured organic–inorganic ultrathin films the organic materials impart flexibility and versatility, whereas the inorganic clay particles provide mechanical strength and stability and can have unique conducting, semiconducting, or dielectric properties. The properties of intercalation and CEC make it easy to prepare composite materials. Intercalation of organic compounds into the interlamellar space of clay minerals has attracted wide scientific and practical interest. Thus clay particles provide a host medium to assemble and organize organic guest molecules. By studying and adjusting the host–guest interaction, materials can be designed with unique structures, novel chemical and physical properties, and enhanced mechanical properties. If the orientation of the incorporated molecules can be controlled, then the hybrid clay composite materials would be applicable to devices for current rectifying, nonlinear optics, one-way energy transfer, etc. [5–8]. To control

Sustainable Chemistry

Amberlite IR 120H⁺ Catalyzed N-C/C-N Coupled Cyclization Strategy to Give Imidazoles: Design and Fabrication of Organic Nanomaterial with AFM ImagingMithun Chakraborty,^[a] Barnali Deb,^[a] Bapi Dey,^[b] Syed Arshad Hussain,^[b] Dilip K. Maiti,^[c] and Swapan Majumdar^{*,[a]}

Sustainable and highly efficient one-pot multicomponent syntheses of functionalized imidazole derivatives were described using benzil, aldehydes, ammonium acetate/or amines in the presence of Amberlite IR 120H⁺. The products were obtained in the short period of time with high yields through the chromatography-free procedure. The catalyst could be

recycled due to its insolubility in most of the solvents and reused without any noticeable decrease in its catalytic activity. The novel strategy was exploited for synthesis of a designed substituted imidazole, fabrication of its nanostructured materials on LB films and AFM imaging.

Introduction

Multicomponent reaction (MCR)^[1] is an important area of research in the field of organic and medicinal chemistry because functional and complex molecules can be achieved in the fast, efficient, time saving and operationally simple manner without isolation of intermediates. The MCR contributes sustainability through simplifying all aspects of organic synthesis. Thus, development of a new MCR is desirable for diverse syntheses of functional molecules using readily available inexpensive ingredients. Recently tri- and tetra-substituted imidazoles have received considerable attention of researchers because of their presence in the bioactive natural products as well as their therapeutic potentialities.^[2] Many of the substituted imidazoles are known as inhibitor of p38 MAP kinase,^[2c] fungicidal,^[2d] antibacterial^[2e] and antitumor^[2f] activities. Many imidazole derivatives possess rapid fluorescence switching^[3] and semiconducting material properties.^[4] These versatile applicability of imidazole derivatives prompted the synthetic organic chemists for developing efficient methods to achieve well-designed highly substituted imidazole derivatives. A number of catalytic reactions were investigated to afford 2,4,5-trisubstituted and 1,2,4,5-tetrasubstituted imidazoles. The 2,4,5-trisubstituted imidazoles were generally synthesized^[5] through three component cyclo-condensation of a 1,2-diketone, α -

hydroxyketone or α -keto-monoxime with an aldehyde and ammonium acetate in refluxing acetic acid,^[5a] using microwaves,^[5b] ionic liquids,^[5c] p-toluenesulfonic acid,^[5d] solid supported silica-sulfuric acid,^[5e] heteropolyacids,^[5f] InCl₃·3H₂O,^[5g] and NiCl₂·6H₂O/Al₂O₃.^[5h] On the other hand, the syntheses of 1,2,4,5-tetra-substituted imidazoles^[6] were carried out through four-component cyclocondensation using 1,2-diketone, α -hydroxyketone or α -keto-monoxime, aldehyde, primary amine and ammonium acetate in the presence of HBF₄-SiO₂,^[6a] SiO₂-NaHCO₃,^[6b] and ZrCl₄,^[6d] under microwave irradiation, heteropolyacid,^[5f] and HClO₄-SiO₂^[6c] catalyst. Recently nickel (II) catalyzed sp³C α -H activation of primary amines^[6e] for multi C-N bond-forming robust annulation and solvent-free heating protocol^[6f] with Ce(SO₄)₂·4H₂O were also reported. In spite of huge number of literature reports for three or four component synthesis of multi-substituted imidazoles, most of them suffer from serious drawbacks such as prolong reaction time, co-occurrence of side products, use of elevated temperature created by conventional heating or microwave, reacting with expensive reagents and toxic metal catalysts. Thus, development of a new and simple strategy is still desirable using readily available ingredients and inexpensive metal-free recyclable catalyst for direct construction of poly-substituted imidazoles with economic viability and sustainability. Current awareness, tightening environmental legislation and the interest in green chemistry, the chemical industries are driving to investigate efficient solid acid catalysts to replace conventional mineral acids. The use of solid supports, as either reagents or anchors, contributes significantly to progress and practicing green chemistry^[7] because they render the reaction more efficient and environment friendly. Solid acid reagents either polymeric or solid supported have received much attention to the researcher for implementing these reusable catalysts in different synthetic protocols. In this context polystyrene based solid acid Amberlite IR 120H⁺ (Figure 1) has many remarkable features such as air and moisture stability, simple handling,

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Dated: 29th March, 2018

ORDER

Sanction of the President is hereby accorded, under Rule 18 of the Delegation of Financial Powers Rules, 1978, for the implementation of the project entitled "Bioresource and Sustainable livelihoods in North East India" for a period of 3 Year 0 Month at a total cost of Rs. 2318.64243 lakhs (Rupees Twenty Three Crores Eighteen Lakhs Sixty Four Thousand Two Hundred and Forty Three Only) on the terms and conditions detailed here under:-

2. The Project:

2.1 Title: Bioresource and Sustainable livelihoods in North East India

2.2 Overall Project Coordinator: Dr. GanesanRengaian, Fellow, Suri Sehgal Center for Biodiversity and Conservation, Ashoka Trust for Research in Ecology and the Environment (ATREE), Bangalore

Project Co-Coordinator: Professor DinabandhuSahoo, Director, Institute of Bioresources and Sustainable Development (IBSD), Imphal, Manipur

2.3 Project Investigators:

COMPONENT 1 – INVENTORIES AND MAPPING OF BIORESOURCES IN NORTHEAST INDIA

Subproject 1: ATREE, Bangalore

Principal Investigators: 1. Dr. GanesanRengaian, ATREE, Bangalore

Co- Investigator: 1. Dr. RavikanthGudsalmani, (ATREE), Bangalore
2. Dr. MuneeswaranMariappan, (ATREE), Bangalore

Subproject 2: Assam - Balipara Foundation, Assam

Principal Investigator: 1. Dr. Gitamani Dutta, Balipara Foundation, Assam

Subproject 3, 4, 5 Yet to be Identified:

Subproject 6:- Nagaland University, Nagaland

Principal Investigator: 1. Dr. NeizoPuro, Nagaland University, Lumami

Co-Investigator: 1. Dr. Limasenla, Nagaland University, Lumami

Subproject 7: Institute for Bioresources and Sustainable Development (IBSD), Manipur

Principal Investigator: 1. Dr. Biseshwori Thengam, IBSD, Imphal, Manipur,

Subproject 8: Mizoram University, Mizoram

Principal Investigator: 1. Dr. BiankaZote, Mizoram University, Aizawi

Subproject 9: Tripura University, Tripura

Principal Investigator: 1. Dr. BadalDatta, Tripura University, Tripura, Agartala

Subproject 10:- North East Hill University (NEHU), Meghalaya

Principal Investigator: 1. Dr. Uma Shankar, North Eastern Hill University, Shillong

Mohd. Aslam

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Release Order

File No. DBT-NER/AGRI/33/2016 (Group-1)
GOVERNMENT OF INDIA
MINISTRY OF SCIENCE & TECHNOLOGY
DEPARTMENT OF BIOTECHNOLOGY
(NER-BPMC)

Block-2, 7th Floor,
CGO Complex, Lodhi Road
New Delhi-110003
Dated: 22 / 3 /2018

ORDER

In continuation of this department's sanction order of even number dated 22 / 3 /2018, sanction of the President of India is hereby accorded under Rule 18 of the Delegation of Financial Powers Rules, 1978 for the release of **First year grant of ₹ 23.30 Lakhs (Rupees Twenty Three Lakhs and Thirty Thousand only)** to **The Registrar, Tripura University, Suryamaninagar, Tripura** for the implementation of a network project under 'DBT's NER-Banana Program for the NE' titled "*Genome Characterization of Banana/Plantain Genetic Resources of North-eastern Region and their Utilization in Multicenter Planning for Commercial Improvement*" by Prof. Anath Bandhu Das, Utkal University, Bhubaneswar, Odisha; Prof. Rabindra Kumar Sinha, Tripura University, Suryamaninagar, Tripura and Dr. Satya Narayan Jena, National Botanical Research Institute, Lucknow, as per the details given below:

		(₹ in lakhs)
	Heads	1 st Year
I	Non-Recurring (Equipments and accessories)	15.00
Sub Total- I		15.00
II	Recurring	
1	Manpower	3.30
2	Consumables	3.00
3	Travel	0.50
4	Contingency	0.50
5	Overhead charges	1.00
Sub Total- II (1-5)		8.30
GRAND TOTAL (I+II)		23.30

(Rupees Twenty Three Lakhs and Thirty Thousand only)

2. The other terms and conditions governing the financial sanction will remain unaltered.
3. The Non-recurring items must be procured and installed within 6 month period from the date of sanction.
4. "As per Rule 236 (1) of GFR 2017, the accounts of all Grantee Institutions or Organisations shall be open to inspection by the sanctioning authority and audit, both by the Comptroller and Auditor General of India under the provision of CAG(DPC) Act 1971 and internal audit by the Principal Accounts Office of the Ministry or Department, whenever the Institution or Organisation is called upon to do so "

David del Álamo | EMBO | Meyerhofstr. 1 | 69117 Heidelberg | Germany

Dr. Pratap Chandra Acharya
Department of Pharmacy
Tripura University
Suryamaninagar-799022
Tripura (West)
Agartala 799022
India

FELLOWSHIP PROGRAMME

Dr. David del Álamo
Programme Manager

phone +49-6221-8891-122
fax +49-6221-8891-215

fellowships@embo.org

16 May 2018

EMBO Short-Term Fellowship 7702

Dear Dr. Acharya,

I am happy to inform you that EMBO has awarded you a short-term fellowship to support your visit of the lab of Alexandra Paulo in Lisbon.

(1) Please confirm your acceptance of this award within 30 days of the date of this letter; the offer of the fellowship is only valid for that period.

(2) We will also need the details of your bank account including (a) name and address of the bank, (b) the account number and name of the account holder, and (c) the SWIFT/BIC code and IBAN code if available from your bank. Please use the form attached to the email to complete this information. We will arrange your payment one or two weeks before you leave.

(3) As a recipient of an EMBO Short-Term Fellowship, you are obliged to inform our office immediately of any delays or changes in your plans. The dates of your visit on your original application are 9 June 2018 to 5 July 2018. Please let us know if these dates are still valid. Note that you are required to make an appropriate refund to EMBO in case your proposed visit is cancelled or shortened.

(4) We also need to receive a written confirmation from you at this point that you are going to immediately return to your home institute following your research visit, for a minimum of 6 consecutive months.

(5) You are also obliged to advise our office if you will be receiving any other funding from another organisation for the same research visit.

Please remember that EMBO requires a final scientific report on the work carried out during your fellowship; this should be succinct but is a condition of the award. The report should be returned to the EMBO Fellowship Office (fellowships@embo.org) within 6 months of completion of the fellowship, together with a letter by your home institute confirming your return for a duration of at least 6 months.

The EMBO Council has asked me to inform you that the present award is financially sponsored by the 33 governments which contribute to the General Programme of the EMBC.

Yours sincerely,



David del Álamo



मुंबई केन्द्र
Mumbai Centre

विश्वविद्यालय अनुदान आयोग - परमाणु ऊर्जा विभाग वैज्ञानिक अनुसंधान संकुल UGC-DAE Consortium For Scientific Research

(विश्वविद्यालय अनुदान आयोग - नई दिल्ली द्वारा स्थापित स्वशासी संस्थान)

(An autonomous institution of UGC, New Delhi)

Ref: UDCSR/MUM/AO/CRS-M-277/2017/574

Date: 18 DEC 2017

To,
Dr.Ratan Das
Assistant Professor
Department of Physics
Tripura University (A Central University)
Suryamaninagar, Agartala, Tripura (West) – 799 022.

Sub: Sanction of Collaborative research Scheme titled "*Study of the magnetic structure in a few synthesized metal doped spinel ferrite nanocrystals using neutron scattering method*" (CRS-M-277)

Dear Dr. Das,

We are happy to inform you that following the Project Review Meeting held on 22nd August, 2017 at Mumbai, your above Collaborative Research Scheme (CRS) project has been sanctioned. Presently the project is sanctioned for one year w.e.f 1st January, 2018, but it may be extended after a review every year, subject to a total period of three years. The financial sanctions for the year 2018 are as follows:

Sl. No.	Head	Amount sanctioned for current year (01.01.2018 – 31.12.2018)(*)
1	Scholarship / Fellowship(#)	(**)
2	Chemicals/Consumables	30,000.00
3	Contingency	15,000.00
	Total	45,000.00
Note:	No overheads are available under this scheme	

(*) Funds under scholarship will be transferred after appointment of student as per the Guidelines of UGC DAE CSR.

(**) Grants under scholarship will be transferred after appointment of student as per the guidelines of UGC-DAE CSR. If the student has already been appointed in your project and is continuing in the project, PI may please provide the appointment extension letter for release of Scholarship / Fellowship.

(#) Point no. 2.4 of guideline is to be invariably mentioned in the appointment letter issued to the student.

Guidelines regarding implementation of the CRS- Review, Appointment of Project fellow, Travel support to the PI or Student to visit BARC for performing experiments, etc. are enclosed herewith.

Dr.S.M.Yusuf (Email: debasis@barc.gov.in), Dr Debasis Sen (Email: debasis@barc.gov.in) and Dr.V.K.Aswal (Email: vkaswal@barc.gov.in), Solid State Physics Division, BARC, will be your Principal Collaborator (PC) for the above scheme. You may contact him for implementation of the scheme.

Please send us your acceptance letter by 15.01.2018. On receipt of your acceptance letter, financial grant for CRS will be sent through NEFT/ RTGS (kindly provide details in the enclosed format along with the acceptance letter) to the Registrar/Financial Authority of your Institute.

Thanking you,

Yours sincerely


Administrative Officer

Encl : As stated

Copy to,

- 1 Registrar/Director, Tripura University, Tripura West – 799 022.
- 2 Dr S.M.Yusuf, Head, Solid State Physics Division, BARC, Trombay, Mumbai-400 085.
- 3 Director, UGC-DAE CSR, Univ. Campus, Khandwa Road, Indore-452 017.



4 October 2020

International Collaboration with Dr. Anirban Guha

I am writing this letter to describe the international collaboration between Dr. Anirban Guha and my team at Tel Aviv University in Israel. I have known Dr. Guha for about 7 years after meeting him at an international conference on Atmospheric Electricity. We were both presenting papers at the conference, and since we both work in similar fields, we had a lot to talk about. We have remained in close contact since, and today we are working closely together on topics related to lightning, thunderstorms, atmospheric electricity and climate change.

In recent years Dr. Guha and myself applied for a joint research grant to study the link between thunderstorms and upper tropospheric water vapor. This joint research has involved mutual visits in Israel and India, and our students have also started collaborating together. The main field of our interest is related to the Schumann resonances, and Dr. Guha has become one of the world experts in this field, with additional international collaborations with scientists in the US, Europe and Japan on this topic. He has visited many countries for work and research, and has attended many research workshops and international conference around the globe, including one in Israel that I organized a few years ago.

Due to Dr. Guha's pleasant manner, and readiness to always help and collaborate, he has earned himself additional international recognition, as shown by the co-authors on some of his recent papers. Dr. Guha is also promoting a South Asian Lightning Network of research dealing with lightning safety issues to help protect the public from lightning risks. I attended a workshop in Tripura on this topics, and was impressed with the international turnout from neighboring regions (Nepal, Bangladesh, Sri Lanka, Zambia, South Africa, Malaysia, Indonesia, etc.). Hence, Dr. Guha has significant international cooperation, which appears to be expanding all the time.

If you would like any additional information, please feel free to contact me.

Sincerely,

Prof. Colin Price
Head of the Environmental Studies Department
Porter School of the Environment and Earth Sciences
Tel Aviv University

2. MOA between DBT and Tripura University for the project “Establishment of a culture collection centre in North East Region of India Phase II”



त्रिपुरा TRIPURA

365979

MEMORANDUM OF AGREEMENT

This MEMORANDUM OF AGREEMENT is made on this 8th day of June, Two thousand and Eighteen BY AND BETWEEN President of India, acting through Department of Biotechnology, Ministry of Science and Technology, Government of India, New Delhi, hereinafter referred to as the “DBT” (which expression unless excluded by or repugnant to the subject shall mean and include its successor-in-office and assigns) of the ONE PART;

AND

Tripura University (Tripura University Act 2006), a society under the Societies Registration Act – 1860, having its registered office in/at Tripura University, Permanent Campus Suryamaninagar – 799 022, Agartala, Tripura, India, hereinafter referred to as Tripura University (which expression shall where the context so admits include its successors and permitted assigns) of the OTHER PART;

Sham Ray Chaudhuri

(Sanit Debroy) 23.6.18

WHEREAS DBT being desirous of promotion of Biotechnology in NE region of India decided to support a project submitted by Dr Shaon Ray Chaudhuri, Tripura University for the attainment of the objectives, hereinafter described in the Annexure I annexed hereto; This Memorandum of Agreement (MoA) defines the role and responsibilities of the participating agencies, monitoring and other matters related to the “Establishment of a Culture Collection Centre in North East Region of India Phase II.”

NOW THE PARTIES HERETO AGREE AS FOLLOWS:-

1.0 ROLE OF DEPARTMENT OF BIOTECHNOLOGY, NEW DELHI

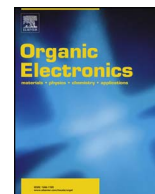
To provide funds to the extent of Rs. 27.104 Lakhs over a period of 3 years from the date of sanction of the project, to Dr Shaon Ray Chaudhuri, Tripura University for undertaking activities as detailed in Annexure I. Details of the funds to be provided are given in Annexure II.

2.0 ROLE OF Tripura University (Institute)

- 2.1. To provide their contribution of Rs. 27.104 Lakhs for 3 years from date of sanction of the project as detailed in Annexure – II (if a jointly supported project).
- 2.2. To provide existing facilities as mentioned in the project document.
- 2.3. To be responsible for accomplishing objectives identified and activities listed.
- 2.4. To allow the Scientists authorized by DBT to work with the Research & Development team of the center in all stages of process development and production.
- 2.5. To recruit all scientific and non-scientific staff as sanctioned by DBT.
- 2.6. To prepare and submit all periodical reports and other documents that would be required by DBT.
- 2.7. To maintain a separate audit head of account for the grants received from DBT for the project.
- 2.8. To submit an annual audited statement of expenditure incurred under the project.
- 2.9. To ensure effective utilization of the grant given by DBT for the purpose for which it was granted and to ensure timely progress of project work.

Sham Ray Chaudhuri

(Sanit Debroy) 24.11.18
Registrar (I/C)
Tripura University



Electrical switching behaviour of a metalloporphyrin in Langmuir-Blodgett film

Bapi Dey^a, Sekhar Chakraborty^a, Santanu Chakraborty^b, Debajyoti Bhattacharjee^a, Inamuddin^{c,d}, Anish Khan^{c,d}, Syed Arshad Hussain^{a,*}

^a Thin Film and Nanoscience Laboratory, Department of Physics, Tripura University, Suryamaninagar, 799022, Tripura, India

^b Department of Physics, NIT Agartala, Jiraniya, 799046, West Tripura, Tripura, India

^c Chemistry Department, Faculty of Science, King Abdulaziz University, Jeddah, 21589, Saudi Arabia

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ARTICLE INFO

Keywords:

Organic electronics
Bipolar switching
Threshold switching
MnTPPS
LB films

ABSTRACT

Here we report the resistive switching behaviour of an water soluble anionic metalloporphyrin 5,10,15,20-Tetrakis(4-sulfonatophenyl)-21H,23H-porphine manganese(III) chloride (MnTPPS) assembled onto spin coated as well as in Langmuir-Blodgett (LB) film. To prepare LB film, water soluble MnTPPS molecules were incorporated into monolayers of two cationic matrix molecules Octadecyltrimethylammonium bromide (OTAB) and N-Cetyl-N,N,N, trimethyl ammonium bromide (CTAB) through electrostatic interaction. Successful incorporation of MnTPPS molecules into the matrix (OTAB/CTAB) monolayers has been confirmed by measuring π – A isotherm, π – t curve and BAM investigations at air-water interface. From I – V characteristic it was found that by adjusting the measurement protocols (compliance current, sweeping direction) all the devices fabricated by using spin coated as well as LB films exhibit outstanding bipolar switching and threshold switching behaviour at room temperature. Presence of electron acceptor groups (SO₃H) and π – electron clouds on the MnTPPS molecules mainly play the crucial role for such observed switching behaviour onto ultrathin films. This type of bipolar memory switching and threshold switching in a single device is technologically very important to use as an active component for the non-volatile information storage and future optoelectronics devices.

1. Introduction

Electronic and optoelectronic devices are the leading tools for the modern society [1–7]. There is a growing interest for the development of nanoscale devices with new functionality and/or greatly enhanced performance. In recent years organic electronics deals with carbon-based conductive organic materials and are extensively studied due to their interesting optical, electrical, photoelectrical conducting, semiconducting, memory, storage and magnetic properties [8–12]. There are numerous potential applications of organic materials in the development of electronic devices such as sensors, solar cells, field-effect transistors (FET), switching devices, optical data storage, organic light emitting diode (OLED) etc [13–19].

Of late molecular electronics has emerged as an important technology which deals with the manipulation of organic materials at the nanoscale level to realize devices that will store and/or process information [20–22]. Here single molecule or an assembly of molecule will be used for the fabrication of electronic components. It has been

observed that several organic molecules show rectification, switching, semiconducting and even metallic properties under certain conditions [23–26]. Therefore molecules that are probably suitable for the applications in molecular-electronic devices have recently been the subject of current interest.

On the other hand Langmuir – Blodgett (LB) technique is one of the few methods for preparing nanoscale organized molecular assemblies which are the pre-requisite for the realization of molecular electronic devices [27,28]. LB technique provides the opportunity to exercise molecular level control over the structure of organic thin layer of molecules [29–31].

Porphyrin derivatives have interesting characteristics such as rigid planar structure, high stability, intense absorption and small HOMO-LUMO energy gap. These characteristics make porphyrins a class of synthetic building blocks for functional nano materials suitable for molecular electronics [32]. Due to their interesting properties and extended π – conjugated structure, porphyrins have potential applications in nonlinear photonic devices [33–35] and for investigations of

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