

LINKAGE FOR ACADEMIC COLLABORATION

SL.NO-- 43

Linkage for Academic Collaboration

This Academic Linkage is made and entered into force this 2nd February 2021

Between

Dr. PRADIP KUMAR SENGUPTA,

Associate Professor

Department of Education

Ramakrishna Mission Sikshasamandira

Belur Math, Howrah- 711202, West Bengal (First Party)

And

Dr. RAJIBA LOCHAN MOHAPATRA

Assistant Professor

Department of Education

The University of Burdwan

Purba Bardhaman, 713104, West Bengal (Second Party)

1. INTRODUCTION

After detailed discussion, the first party and the second party chalked down the areas of cooperation in detail and agreed to provide research consultancy to the students / scholars in the field of Education. Both parties decided that an academic linkage will be of much help in this regard and agreed to establish an academic linkage.

Now both the parties agreed to establish the academic linkage with the following conditions

2. OBJECTIVES OF THE LINKAGE:

The Objectives of this Academic Linkage are as follows:

1. To provide academic support in research work in the field of education.
2. To held discussion, whenever necessary, for the purpose of setting and defining research problem.
3. To provide support in the task of literature review and to identify research gap for the research work.
4. To provide support in tool development and validation for research work.
5. To provide support in arranging data collection from academic institutions.

LINKAGE FOR ACADEMIC COLLABORATION

3. RESPONSIBILITIES OF DR. PRADIP KUMAR SENGUPTA

1. As and when necessary, Dr. Rajiba Lochan Mohapatra will communicate Dr. Pradip Kumar Sengupta for the necessary consultation (as per mentioned areas in the objectives). Dr. Pradip Kumar Sengupta will fix a schedule for the consultation as per convenience of both the parties. Both the parties will meet in the institution and necessary assistance will be given by Dr. Pradip Kumar Sengupta to Dr. Rajiba Lochan Mohapatra or his students/ scholars.
2. In case of review of research literatures, on the intimation regarding library work by Dr. Rajiba Lochan Mohapatra necessary arrangement will be made by Dr. Pradip Kumar Sengupta for the library work in his institution.
3. For tool validation, Dr. Rajiba Lochan Mohapatra will send the tool with a forwarding letter to Dr. Pradip Kumar Sengupta. On receiving the tool, Dr. Pradip Kumar Sengupta will validate the tool and return the validated tool having signed on it within 10-15 days to Dr. Rajiba Lochan Mohapatra.
4. For the purpose of data collection, Dr. Pradip Kumar Sengupta will provide support and arrange condition to collect data from his institution i.e. Ramakrishna Mission Sikshanamandira. He may also give necessary information and introduction to other places where from data can be collected.

4. RESPONSIBILITIES OF DR. RAJIBA LOCHAN MOHAPATRA

1. As and when necessary, Dr. Pradip Kumar Sengupta will communicate Dr. Rajiba Lochan Mohapatra for the necessary consultation (as per mentioned areas in the objectives). Dr. Rajiba Lochan Mohapatra will fix a schedule for the consultation as per convenience of both the parties. Both the parties will meet in the institution and necessary assistance will be given by Dr. Rajiba Lochan Mohapatra to Dr. Pradip Kumar Sengupta or his students/ scholars.
2. In case of review of research literatures, on the intimation regarding library work by Dr. Pradip Kumar Sengupta, necessary arrangement will be made by Dr. Rajiba Lochan Mohapatra for the library work in her institution.
3. For tool validation, Dr. Pradip Kumar Sengupta will send the tool with a forwarding letter to Dr. Rajiba Lochan Mohapatra. On receiving the tool, Dr. Rajiba Lochan Mohapatra will validate the tool and return the validated tool having signed on it within 10-15 days to Dr. Pradip Kumar Sengupta.
4. For the purpose of data collection, Dr. Rajiba Lochan Mohapatra will provide support and arrange condition to collect data from her institution. He may also give necessary information and introduction to other places where from data can be collected.

5. FINANCIAL ARRANGEMENTS

There is no financial obligation under this Linkage.

LINKAGE FOR ACADEMIC COLLABORATION

6. TERMINATION OF LINKAGE

This Linkage may be terminated by either Dr. Pradip Kumar Sengupta or Dr. Rajiba Lochan Mohapatra commits breach of any of the terms hereof and shall have failed to rectify such breach within thirty days of the notice.

In addition to the reasons for termination as set forth above, this Linkage may be terminated forthwith if either of them voluntarily or involuntarily enters into official dilution.

7. DURATION-

This Academic Linkage shall remain valid for a period of 5 years only from the date of signing the Linkage. After this 5 years' time period, this Linkage may be terminated or may be renewed after judging the then situation.

8. SETTLEMENT

Upon termination of the Linkage, all rights granted to and the obligations by Dr. Rajiba Lochan Mohapatra and Dr. Pradip Kumar Sengupta hereto, shall cease to exist forthwith.

9. AMENDMENTS TO THE LINKAGE

No amendment or modification of this Linkage shall be valid unless the same is made in writing by both Dr. Pradip Kumar Sengupta and Dr. Rajiba Lochan Mohapatra; to be an amendment of this Linkage. The modifications/ changes shall be effective, from the date on which they are made/executed; unless otherwise agreed to. In general, the Linkage will be amended on yearly basis, IF AT ALL REQUIRED, on mutually agreed terms.

10. SIGNATURE OF THE PARTIES

This Linkage has been executed in two originals, one of these has been retained by Dr. Pradip Kumar Sengupta and the other has been retained by Dr. Rajiba Lochan Mohapatra.

In witness whereof the parties hereto have signed this Linkage the day, month and year mentioned herein before.

Institute	Ramakrishna Mission Sikshanamandira	The University of Burdwan
Address	Belur Math Campus, Belur Math, Howrah, West Bengal 711202	Golapbag, Purba Bardhaman, 713104
Department	Department Education	Department of Education
Party	First Party	Second Party

LINKAGE FOR ACADEMIC COLLABORATION

Name	Dr. Pradip Kumar Sengupta	Dr. Rajiba Lochan Mohapatra
Designation	Associate Professor	Assistant Professor
Signature with official seal & Date	<p>Pradip Kumar Sengupta</p> <p>02/02/21</p> <p>Dr. Pradip Kumar Sengupta Associate Professor Ramakrishna Mission Sikshanamandira, Belur Math Howrah - 711201</p>	<p>Rajiba Lochan Mohapatra</p> <p>02/02/21</p> <p>Assistant Professor Department of Education Burdwan University Burdwan</p>
Full Signatures of the witnesses	<p>1. <i>Satyajit Kumar</i> 02/02/2021</p>	<p>1. <i>Chitaleshwar Mehera</i> 02.02.2021</p>
	<p>2. <i>Naren Mohan Mandal</i> 02/02/21</p>	<p>2. <i>Jyoti...</i> 02/02/2021</p>



Contents lists available at ScienceDirect

Journal of Molecular Liquids

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

Enhanced optical power limiting and visible luminescence in colloidal dispersion of ultra-small Au nanoclusters synthesized by single-pot chemical technique

Koushik Mondal^a, Subrata Biswas^a, Tara Singha^b, Udit Chatterjee^c, Prasanta K. Datta^b, Pathik Kumbhakar^{a,*}^a Nanoscience Laboratory, Dept. of Physics, National Institute of Technology Durgapur, Durgapur, 713209, West Bengal, India^b Department of Physics, Indian Institute of Technology Kharagpur, Kharagpur 721302, India^c Laser Laboratory, Department of Physics, University of Burdwan, Burdwan 713104, India

ARTICLE INFO

Article history:

Received 18 July 2020

Received in revised form 21 November 2020

Accepted 27 November 2020

Available online 03 December 2020

Keywords:

Gold nanocluster

Two photon absorption

Optical limiting

ABSTRACT

Here, we present a detailed investigation on the synthesis and nonlinear multiphoton absorption properties of the colloidal solution of Au nanoclusters (AuNCs) which contains the atomic clusters, with the number of atoms per cluster (NAC) of only one (Au₁NC) and two (Au₂NC). These AuNCs are synthesized by an easy single step one-pot simple chemical process and by using dimethylformamide (DMF) both as reducer and stabilizer. The presence of both Au₁NC and Au₂NC are found in the sample by their distinct signature in the UV-Vis. absorption spectrum as well as in the high-resolution mass spectrum. The synthesized material has been found to exhibit a strong and stable blue-luminescence with a moderately high quantum yield (QY) of 12.4% when excited with UV light. The nonlinear optical two-photon absorption (2PA) properties of Au₁, Au₂NC solutions are being reported here by Z-scan studies, for the first time, by using both 10 ns and 100 fs pulse laser radiations having wavelength of 532 nm. It is significantly noted here that the synthesized AuNCs are found to exhibit reverse saturable absorption (RSA) when excited either by ns or by fs laser pulses. A high third-order nonlinear susceptibility ($\chi^{(3)}$) of the order of 10^{-13} (esu) of the synthesized materials are obtained under fs laser excitation and it is attributed to the 2PA through electronic band to band transition. In contrast, the variation of the 2PA coefficient (β) with input intensity (I_0) represents the footprint of free carrier involvement in the enhanced nonlinear absorption in the case of ns excitation. Furthermore, through the non-saturable nonlinear multiphoton absorption, the synthesized AuNCs exhibit excellent optical power limiting phenomenon with the limiting threshold (F_{th}) of 9.1 mJ/cm² (fs excitation) and 2.02 J/cm² (ns excitation) owing to their enhanced 2PA coefficient. Therefore, we believe that our synthesized ultra-small colloidal AuNCs can be used as the promising candidate material for advanced photonics application in the future.

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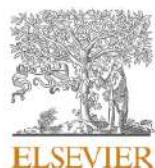
1. Introduction

Thanks to the high polarizability of sub-nanometer AuNCs, having molecular-like electronic structures, due to the appearance of strong quantum size effect. Hence, a high-luminescence along with a very high nonlinear optical (NLO) response can be achieved in AuNCs due to the interaction with the strong electromagnetic field of an incident laser light [1–9]. However, the optical properties of AuNCs can be tuned elegantly by playing with the number of atoms per cluster (NAC). Hence, AuNCs have stimulated considerable interest in the research community having importance not only in fundamental research [1,2] but also for their potential applications in photonics [3], optical

limiting [4], and optical switching [5]. Previously, Thomas et al. have demonstrated the enhancement in NLO response in AuNCs in comparison to that of Au nanoparticles (AuNPs) [4]. Mendez et al. have successfully demonstrated that the polarizability per atom for Au₃₄NC would be 5.59 Å³, whereas it would increase to 7.15 Å³ in case of Au₆NC [6]. In another study, Brevet et al. have reported that the value of the hyperpolarizability for Au₂₅NC is 109×10^{-30} esu, which has been increased to 509×10^{-30} esu for Au₁₅NC [7]. Therefore, one can expect that by reducing the value of NAC in AuNCs stronger NLO response can be achieved. Previously, nonlinear multiphoton absorption in Au and AgNCs with different NAC (=10, 15, 25, 38, 144, etc.) have been reported [8–11]. But till now there is no report on NLO properties of AuNCs with NAC being less than 10. The synthesis of stable AuNCs continues to remain a considerable challenge in compared to the synthesis of gold nanoparticles (AuNPs). Previously, syntheses of PAMAM [1], thiol [2], polyethylenimine [10] stabilized AuNCs have been reported.

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Contents lists available at ScienceDirect

Journal of Hazardous Materials

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

Research Paper

Syntheses of flower and tube-like MoSe₂ nanostructures for ultrafast piezocatalytic degradation of organic dyes on cotton fabricsSrikanta Karmakar^a, Ashim Pramanik^a, Arup Kanti Koley^b, Udit Chatterjee^c, Pathik Kumbhakar^{a,*}^a Nanoscience Laboratory, Department of Physics, National Institute of Technology Durgapur, Durgapur 713209, West Bengal, India^b Department of Physics, Durgapur Women's College, Durgapur 713209, West Bengal, India^c Laser Laboratory, Department of Physics, Burdwan University, Burdwan 713104, West Bengal, India

ARTICLE INFO

Editor: Dr. B. Lee

Keywords:

MoSe₂ nanoflower
Piezocatalyst
Dye degradation
Cotton fabric
Specific capacitance

ABSTRACT

The synthesis of few-layered transition metal dichalcogenides (TMDCs) with abundant exposure of the active site, *vis.*, is an important key to achieve excellent dye degradation performance. Here, we have reported synthesis and ultrafast dye degradation performance of flower-like MoSe₂ nanostructure (FMN) with ~230 nm in diameter and its transformation to tube-like MoSe₂ microstructure (~1 μm in length) by tuning the solvothermal reaction time. The piezoelectric devices are developed using the FMNs delivers the highest open-circuit voltage of ~2.12 V, which is ~21 times higher than that of the developed device with the tube-like MoSe₂ microstructure. The piezoelectric property of the synthesized samples has been judiciously utilized further for ultrafast degradation of organic dyes within 60–120 s only under the low-frequency (40 kHz) ultrasonication vibration in the dark. The estimated dye degradation efficiencies of the FMNs-based piezocatalyst are found to be ~86% and 85% for degradation of Rhodamine B (RhB) and methylene blue (MB) dye within the 60 s, respectively. Also, the FMN has exhibited an excellent piezocatalytic dye degradation capability for RhB-MB dye mixture and dye loaded on a cotton fabric with an efficiency of ~98% (60 s) and 84% (120 s), respectively. The piezocatalytic dye degradation mechanism of FMNs has also been explained theoretically.

1. Introduction

The existing water is being polluted gradually by different toxic dyes coming from the different textiles industries and environmental pollutants. Therefore, the treatment of organic dyes present in wastewater has fascinated significant and long-term consideration (Borgarello et al., 1981; Kabra et al., 2004). The wastewater treatment is also a major problem area in energy research (Borgarello et al., 1981; Kabra et al., 2004). Recently, researchers are extensively utilizing semiconductor nanoparticle-based photocatalysts to degrade organic pollutants by creating strong oxidizing free species under light illumination (Sharma et al., 2009; Xiao et al., 2021). But due to the limitation of the band gap matching of the semiconductor photocatalysts with the illuminated light irradiation, the photocatalytic dye degradation is not applicable at all times. Additionally, for fast degradation, the semiconductor nanomaterial must show a high capability to generate and separate electron-hole (e⁻-h⁺) pairs under optical irradiation. So far, a number of strategies such as doping, use of high reaction temperature, and

designing of heterostructured materials have been tried to enhance photocatalytic dye degradation (Ajmal et al., 2014). However, these materials and methods are also limited due to their low solar energy conversion efficiency (<20%), and low light transmission in intensely dyed toxins (Banin et al., 2021). Therefore, novel environment-friendly, recyclable, highly efficient methods and materials are necessary for forthcoming wastewater purification techniques. Mechanical energy is a sustainable abundant natural energy that can be harvested by employing piezoelectric materials (Wu et al., 2018, 2016, 2017; Mushtaq et al., 2018; Lan et al., 2017; Lin et al., 2017). Piezoelectric materials can produce an electric field in reaction to an external force. A built-in electric field powerfully increases the separation of free carriers (Wu et al., 2018, 2016, 2017; Mushtaq et al., 2018; Lan et al., 2017; Lin et al., 2017). Thus, piezoelectric materials have been widely used in photocatalytic dye degradation. Thus, the innovative studies associated to piezoelectric water treatment are paid significant attention (Wu et al., 2018, 2016, 2017; Mushtaq et al., 2018; Lan et al., 2017; Lin et al., 2017). Recently, researchers have investigated the piezocatalytic

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E-mail address: patihk.kumbhakar@phy.nitdgp.ac.in (P. Kumbhakar).<https://doi.org/10.1016/j.jhazmat.2021.127702>

Received 12 September 2021; Received in revised form 23 October 2021; Accepted 1 November 2021

Available online 5 November 2021

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No.R-Ph.D./Regn./Env. Sc/E-32

Dated: 31.12.2024

To:

Sm Meghla MukherjeeC/O- Prof. Srimanta Gupta,Dept. of Environmental Science , B.U.

**UNDER UGC's
REGULATION 2022**

Sub: Grant of Registration as a candidate for Ph.D. degree in Environmental Science with effect from 25-07-2023

Sir/Madam,

I am to inform you that the Faculty Council for P.G. Studies in Science at its meeting held on **24.10.2024** permitted you to get yourself registered as a candidate for Ph.D. degree, mentioned above, the title of your thesis being , “**ASSESSING THE HYDROGEOCHEMISTRY OF URANIUM IN CONTAMINATED GROUNDWATER OF SOME SELECTED BLOCKS OF BIRBHUM DISTRICT, WEST BENGAL WITH A STRATEGY FOR ITS EFFECTIVE REMOVAL**” Subject to fulfillment of the requirements set forth in the University Ordinances relating to Doctoral Degrees and such terms and conditions as may be laid down by the appropriate authorities of the University from time to time.

You will now be required to deposit the Ph.D. Registration fee of **Rs. 8,000/- (Eight thousand only)** for enrolment of your name in the Register of candidates for Ph.D. degree, **positively within a month from the date of issue of this letter**, failing which your case will not be considered for Registration as a Ph.D. candidate and **the relevant copy of the cash receipt should be submitted to the Ph.D Unit.**

In this connection you are requested to note that ---

a) You have been permitted to do research work under **Prof. Srimanta Gupta ,Dept. of Environmental Science , B.U. & Dr. Pradip Kumar Sukul, Dept. of Chemistry, Amity University,Kolkata (Co-supervisor)** as your Supervisor / Co- Supervisors.

b) You will be **required to get yourself registered as a student of this University** on migration after completing all the necessary formalities prescribed in this behalf, unless you are already a registered student of this University.

c) You will be **required to deliver one seminar talk before submission of the thesis** pertaining to the project of your research you have undertaken within the period of your research work and before submission of the thesis.

d) i) You will have to **publish at least one research paper related to your research work** in a referred journal / peer reviewed journal and ii) Make two presentation in Conference/Seminar before submission of the thesis and produce evidence for the same in the form of acceptance letter / reprint /certificate of presentation as applicable at the time of submission of your thesis.

e) You will have to **submit your thesis within six years from the date of your registration** for Ph.D. degree mentioned above, but **not earlier than 25-07-2026 (three years including course work)** in the prescribed manner along with the fee of **Rs. 8,000/- (Eight thousand only)** or as may be fixed by the Executive Council from time to time towards submission of thesis. A maximum of **an additional two (2) years** can be given through a process of re-registration provided, however, that the total period of completion of a Ph.D programme **should not exceed 8 (eight) years** from date of admission

- f) i) You will be required to appear before **Research Advisory Committee** once in six months to make a presentation of the progress of his/her work for evaluation and further guidance. This six-monthly report shall be submitted by the Research Advisory Committee to the Board of Research Studies with a copy to the research scholar.
- ii) In case the progress of the research scholar is unsatisfactory, the Research Advisory Committee shall record the reasons for the same and suggest corrective measures. If the research scholar fails to implement these corrective measures, the Research Advisory Committee may recommend to the Faculty Council for PG Studies concerned through the Board of Research Studies with specific reasons for cancellation of the registration of the research scholar.
- g) The women candidate & persons with disability (More than 40%) may be allowed **an additional relaxation of 2 (two) years** for Ph.D Programme. However, the total period for completion of a Ph.D in such cases **should not exceed 10 (Ten) years** from date of admission. The women candidates may avail **Maternity Leave/Child care Leave once in the entire duration of Ph.D Programme upto 240 days** with the permission of the Chairman, Doctoral Committee.
- h) In your case, **four/five copies** of the thesis along with a **Pendrive** (containing the Synopsis and the Thesis in PDF Format) be submitted and one copy be retained by you as a reference copy.
- i) At the time of submission of thesis, a certificate in the prescribed form furnished by your Supervisor(s) will have to be pasted on all the copies of the thesis.
- j) **The registration granted under this letter will remain valid for six years from the date of registration.** In the event of failure of submission of the thesis within the stipulated period, re-registration may be sought for and the same may be granted after observing all the formalities required in this behalf and on the receipt of the prescribed fee(s). Application for **re-registration may be sought within the stipulated period i.e. within six years.**
- k) The registration granted herein may be cancelled by the concerned authority/ body of the University in the event of failure of the candidate to fulfill any of the prescribed requirements at any stage.
- l) While submitting for evaluation, the thesis shall contain an undertaking from the research scholar that there is no plagiarism and a certificate from the research Supervisor(s) attesting to the **Originality of the work, vouching that there is no Plagiarism and that the work has not been submitted for the award of any other degree/diploma of the University or to any Higher Educational institution.**
- n) You will be required to submit **six typed copies of Synopsis/Abstract** of the thesis (not exceeding ten pages) along with the certificate mentioned in **Clause(i)** above and a **certificate of delivering Seminar talk(s)** and the **Clearance Certificate** from the Librarian of the Central Library, Burdwan University at the time of submission of thesis.

Yours faithfully,



In Charge
Research Section



Copy forwarded for information to:

- 1) The Head of the Department of **Environmental Science**, B.U.
- 2) Supervisor(s) of the candidate: **Prof. Srimanta Gupta ,Dept. of Environmental Science , B.U. & Dr. Pradip Kumar Sukul, Dept. of Chemistry, Amity University, Kolkata (Co-supervisor)**
- 3) The Senior Secretary, Faculty Council for P.G. Studies in **Science**, B.U.
- 4) The Finance Officer, B.U.



पश्चिम बंगाल पश्चिम बंगाल WEST BENGAL

AN 480022



SL. NO--- 46



Memorandum of Understanding (MoU)
between
CSIR-National Physical Laboratory (CSIR-NPL)
and
The University of Burdwan (BU)

**AGREEMENT between CSIR-National Physical Laboratory, New Delhi, India
and The University of Burdwan,
West Bengal, India, India**

L.1 THE AGREEMENT

**L.1.1 THIS AGREEMENT made and entered into on this 5th day of October
2023 between the COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH
(CSIR), a Society registered under the Societies Registration Act (XXI of 1860),**

[Handwritten signature]

[Handwritten signature]

having its registered office at Anusandhan Bhawan, 2, Rafi Marg, New Delhi – 110001 through its one of the constituent laboratories, **CSIR-NATIONAL PHYSICAL LABORATORY**, Dr. K.S. Krishnan Road, New Delhi (India) (hereinafter called **CSIR-NPL** which expression shall wherever the context so admits include its successors and permitted assigns) of the first Party.

&

L.1.2 THE UNIVERSITY OF BURDWAN, 'Grade A' University accredited by NAAC with its location at Rajbati, Bardhaman, West Bengal - 713104 (hereinafter called the Burdwan University or **BU** which expression shall where the context so admits include its successors and permitted assigns) of the other part.

L.2 PREAMBLE:

L.2.1 WHEREAS, **CSIR-NPL** is mandated to be India's "National Measurement Institute" (NMI) by the act of Parliament and its associated rules for legal metrology. **CSIR-NPL** is the custodian of "National Standards" with a responsibility of realization, establishment, upgradation, maintenance, and dissemination of standards at par to international level. **CSIR-NPL** is serving the Indian industry, academia, and strategic sectors to excel in their endeavours by providing APEX level testing and calibration facilities.

L.2.2 WHEREAS, The University of Burdwan is engaged in R&D activities on GNSS basically focused on study of NavIC, exploring cost-effective and compact GNSS modules, development of low-cost GNSS Modules for positioning, timing, and ionospheric probing.

AND WHEREAS, **CSIR-NPL** being the NMI of India has capability to provide traceability to SI units. **CSIR-NPL** intends to collaborate with The University of Burdwan for joint work under which exchange of students will be selected by mutual agreement between the home institution and the host institution. Furthermore, information sharing on research and educational programs, sharing of teaching/learning materials and other literature and scientific equipment relevant to their educational and research programs would be made on mutual agreement during the tenure of MoU.

L.3 SCOPE OF AGREEMENT

L.3.1 Short and Long-term Scientists / Faculty Exchange

L.3.2 Training of all students and faculty will be as per the HRD norms of the respective institutes.

L.3.3 Collaborative research will be carried out under the outreach programme of the respective institutes.

- L.3.4** Current proposal for the mutual collaboration includes Global Navigation Satellite System (GNSS) and NavIC based Positioning & Timing applications.
- L.3.5** Other mutually agreed educational or research or field programs (rural development programs, material science research, Metrology of various physical parameters etc.,) will be formulated by a joint committee from either party.
- L.3.5** Joint project proposals to R&D funding agencies will be with clear mention of separate budget distribution.

L.4 FINANCIAL ARRANGEMENTS

L.4.1 Activity Agreements should make financial costs and obligations explicit. Collaborating units are encouraged to work together to identify and secure any outside funding which may be needed. Projects requiring funding must be approved by both institutions.

i) Lumpsum

- a. Training charges as per HRD.

ii) Royalty: The royalty will be on case-to-case basis if required for Technology transfer.

L.5 MODALITIES

L.5.1 In consideration of financial arrangements as provided in clause L.4, CSIR-NPL hereby agrees to provide continuous services to **The University of Burdwan** for SI traceability and for the period of this agreement.

L.5.2 The AGREEMENT shall come into force from date of the signing of the AGREEMENT (herein after called the effective date) and shall remain valid till further joint meeting.

L.6 MUTUAL RESPONSIBILITIES

L.6.1 Short and Long-term Scientists/Faculty Exchange.

L.6.2 Training of all students and faculty will be as per the HRD norms of the respective institutes.

L.6.3 Collaborative research will be carried out under the outreach programme of the respective institutes.

L.6.4 Other mutually agreed educational or research or field programs (popularization of metrology, rural development programs, scientific social responsibility etc.,) will be formulated by a joint committee from either party.

L.6.5 Joint project proposals to R&D funding agencies will clear mention of separate budget distribution.



(Before implementing these activities, the parties will discuss the opportunities and challenges presented and will thereafter enter into specific activity agreements based on the mutually agreed objectives and outcomes.)

CSIR NPL Responsibility

CSIR-NPL reserves the right to perform a separate risk assessment on the legal, tax and other liabilities that may arise under each Activity Agreement and to structure its deliverables under the Activity Agreement in a way that maximizes the cost and liability efficiencies for CSIR-NPL.

We at CSIR-NPL will define what is Activity Agreement: Like for example, for people called in and out for very specific purpose (talks, committee meetings, assessment reports, etc etc) will be completely hosted by the hosting Univ./Instt etc

L.7 CALENDAR OF EVENTS: At the start of every year, for which the MoU is valid, a clear active plan may be defined for whole year.

L.8 GENERAL PROVISIONS

L.8.1 This AGREEMENT shall be the sole repository of the terms and conditions agreed to herein by the between CSIR-NPL and The University of Burdwan.

L.8.2 Either Party to this AGREEMENT shall be entitled to request an amendment or modification to this AGREEMENT by submitting its request in writing to the other Party. If the other Party agrees to amend this AGREEMENT, the amendment shall take effect after it is signed by both Parties.

L.8.3 Prior to the effectiveness of any such amendment, original terms and conditions of this AGREEMENT shall remain in full force and shall only be superseded after the signature of the amendment by both the Parties and then only to the extent specifically provided in such amendment.

L.8.4 The Parties may cancel the AGREEMENT either wholly or in part by giving three (3) months written notice due to a breach of material conditions that were not cured or were impossible to cure.

L.8.5 If necessary, AGREEMENT review process can be done yearly or as per 6.2 the frequency mutually decided.

L.8.6 The University of Burdwan will not use the name or logo of CSIR or CSIR-NPL, nor of any member of CSIR or CSIR-NPL's program staff, in any publicity, advertising, or news release without the prior written approval of an authorized representative of CSIR-NPL will not use the name or logo of The University of Burdwan, or of its any employee of, in any publicity, advertising, or news release without the prior written approval of The University of Burdwan.



L.8.7 Prevailing Language - English version of this Memorandum of Understanding represents the understanding of both Parties. Any other language version is provided as a translation. In the event of any conflict between the two versions, the English version will prevail.

L.8.8 Non-Binding - This Agreement is non-binding and solely for the purpose of establishing a basis upon which the two parties will continue discussions. Either of the parties may at its sole discretion terminate discussions for any reason by giving written notice of termination to the other. In the case of a dispute that arises relating to any aspect of cooperation under this Agreement, the parties may attempt to resolve such dispute through friendly negotiation, or either party may elect to terminate the agreement pursuant to the previous provision. Upon termination, the parties will have no further obligations hereunder.

L.9 MANAGEMENT

L.9.1 An apex body with Director, CSIR-NPL, and **Prof. Venugopal Achanta** or its representative and **Registrar, The University of Burdwan** or his representative as members shall monitor the implementation of this AGREEMENT and provide decision on managerial and financial related matters.

L.9.2 A team appointed by Director, CSIR-NPL and **Registrar, The University of Burdwan** shall hold periodic discussions on scientific and technical matters and resolve issues, if any.

L.9.3 Any unresolved issue shall be referred to the apex body.

L.10 FORCE MAJEURE

L.10.1 The purpose of this clause is to establish the consequences of FORCE MAJEURE events preventing either Party from complying with any of its responsibilities under this AGREEMENT.

L.10.2 For the purpose of this Article, the term FORCE MAJEURE shall refer to unforeseen and irresistible events extrinsic to this AGREEMENT and which are beyond the reasonable control of the party such as wars, riots, serious floods typhoons and earthquake leading to the damage or destruction of the facilities required for the services. The term shall not include strikes or other events caused by labour disputes, unless such strikes or other events are part of national or regional disputes.

L.10.3 The party affected by FORCE MAJEURE event shall send notification of this to the other party without undue delay and shall send to the other Party by registered / speed post mail within fourteen (14) days, a confirmation certificate issued by the authorities or departments concerned along with a detailed explanation.

L.10.4 During the period of effect of the FORCE MAJEURE event, the execution of any services requirement agreed between the Parties under this AGREEMENT shall be suspended without damages for the Party affected by such a FORCE MAJEURE event.

L.10.5 In case of a FORCE MAJEURE event, the parties agree to do their utmost to minimize the negative impact on the other party of the suspension, and each Party shall do its best to execute the service requirements already initiated.

L.10.6 Should the FORCE MAJEURE event last for more than two (2) consecutive months, each Party shall have the option of terminating the AGREEMENT; the Party wishing to terminate this AGREEMENT shall notify the other Party of its intention in writing.

L.11 ARBITRATION

In case of any disputes or differences arising between the Parties in relation to this AGREEMENT, such disputes or differences shall be amicably settled by mutual discussions between the Parties at the level of their respective Executive Directors or such officials so authorized by the parties. Except as hereinbefore provided, all disputes arising out of or in connection with the AGREEMENT shall be referred to Delhi International Arbitration Centre, Delhi High Court, New Delhi. Arbitration proceedings shall be conducted in the English Language.

L.12 CONFIDENTIALITY

L.12.1 Each Party shall have the responsibility to keep confidentiality of the techniques, technical documents and information obtained from the other Party. Both Parties shall not disclose any of them to any third party unless otherwise explicitly agreed by the Parties.

L.12.2 Neither of the two Parties shall disclose the content of this AGREEMENT to any third party without the written permission of the other Party.



L.13 ASSIGNMENT

L.13.1 The rights and/or liabilities arising to any Party of this AGREEMENT shall not be assigned except with the written consent of the other Party and subject to such terms and conditions as may be mutually agreed upon.

L.13.2 This AGREEMENT executed between CSIR-NPL and ~~Registrar~~, The University of Burdwan, at New Delhi on **5th October 2023**. IN WITNESS WHERE OF, the Parties hereto have entered and agreed to this AGREEMENT effective at as of the day and year first above written.

SEAL OF PARTIES

In witness whereof the Parties hereto have signed this agreement on the day, month and year mentioned herein before:

Signature : 	Signature:  REGISTRAR THE UNIVERSITY OF BURDWAN BURDWAN - 713104
Name: Dr Jiji T J Pulikkotil Date : 05 October 2023 Position: Head, HRD, CSIR-NPL, New Delhi Affiliation & Seal: CSIR-NPL	Name: Dr Sujit Kumar Chowdhury Date : 05 October 2023 Position: Registrar, The University of Burdwan Affiliation & Seal:  The University of Burdwan
Signature (Witness 1) 	Signature (Witness 1)  Professor & Head Department of Physics The University of Burdwan Burdwan-713104
Name: Dr Ashish Agarwal Date: 05 October 2023 Position: Sr. Pr. Scientist, CSIR-NPL	Name: Prof Atis Chandra Mondal Date: 05 October 2023 Position: Head, Department of Physics, BU
Signature (Witness 2) 	Signature (Witness 2) 
Name: Ms Preeti Kandpal Date: 05 October 2023 Position: Scientist, CSIR-NPL	Name: Dr Anindya Bose Date: 05 October 2023 Position: Senior Scientific Officer, BU



Key Contacts at CSIR-NPL New Delhi:

Name	Organisation	Role	Telephone	Email
Dr. Venugopal Achanta	CSIR-NPL	Director	45609301/ 45609302	dnpl@nplindia.org
Dr. Ashish Agarwal	CSIR-NPL	Sr. Pr. Scientist	45608384, 45608525	ashish@nplindia.org

Key Contacts at The University of Burdwan:

Name	Organisation	Role	Telephone	Email
Prof S Karforma	BU, West Bengal	Dean, Faculty of Science University of Burdwan	9474553590/ 7384456418	dean_science@buruniv.ac.in
Prof A C Maudal	BU, West Bengal	HoD, Physics Department University of Burdwan	7001399026	hod@phys.buruniv.ac.in



Project Number: DST/INT/POL/P-41/2020

INDO-POLAND BILATERAL PROJECT

entitled

**“DEVELOPMENT OF A SMART SCAFFOLD FOR
ASSISTING EFFICIENT BONE REPAIR”**

Sanctioned Date: 01.03.2021

INDIA

Project Investigator: Dr. K. Ravichandran

Co-Investigator: Dr. Suvro Chatterjee

POLAND

Project Investigator: Professor dr hab. inż. Elżbieta Pamuła

Financed by

Ministry of Science and Technology

Department of Science and Technology (DST)

Government of India



Article

Characterization and In Vitro Evaluation of Porous Polymer-Blended Scaffolds Functionalized with Tricalcium Phosphate

Iwona Pudelko-Prażuch ¹, Mareeswari Balasubramanian ², Sundara Moorthi Ganesan ², Stanisław Marecik ¹, Kamila Walczak ¹, Kinga Pielichowska ¹, Suvro Chatterjee ³, Ravichandran Kandaswamy ^{2,*} and Elżbieta Pamuła ^{1,*}

¹ Department of Biomaterials and Composites, Faculty of Materials Science and Ceramics, AGH University of Krakow, Al. Mickiewicza 30, 30-059 Krakow, Poland; ipudelko@agh.edu.pl (I.P.-P.); smarecik@agh.edu.pl (S.M.); kamwalczak@agh.edu.pl (K.W.); kingapie@agh.edu.pl (K.P.)

² Department of Rubber and Plastics Technology, Madras Institute of Technology Campus, Anna University, Chromepet, Chennai 600 044, Tamil Nadu, India; venibala18@gmail.com (M.B.); sundaramoorthi1997@gmail.com (S.M.G.)

³ Department of Biotechnology, Golapbag Campus, University of Burdwan, Burdwan 713 104, West Bengal, India; soovro@yahoo.ca

* Correspondence: ravi@mitindia.edu (R.K.); epamula@agh.edu.pl (E.P.)

Abstract: Bone tissue is one of the most transplanted tissues. The ageing population and bone diseases are the main causes of the growing need for novel treatments offered by bone tissue engineering. Three-dimensional (3D) scaffolds, as artificial structures that fulfil certain characteristics, can be used as a temporary matrix for bone regeneration. In this study, we aimed to fabricate 3D porous polymer scaffolds functionalized with tricalcium phosphate (TCP) particles for applications in bone tissue regeneration. Different combinations of poly(lactic acid) (PLA), poly(ethylene glycol) (PEG with molecular weight of 600 or 2000 Da) and poly(ϵ -caprolactone) (PCL) with TCP were blended by a gel-casting method combined with rapid heating. Porous composite scaffolds with pore sizes from 100 to 1500 μ m were obtained. ATR-FTIR, DSC, and wettability tests were performed to study scaffold composition, thermal properties, and hydrophilicity, respectively. The samples were observed with the use of optical and scanning electron microscopes. The addition of PCL to PLA increased the hydrophobicity of the composite scaffolds and reduced their susceptibility to degradation, whereas the addition of PEG increased the hydrophilicity and degradation rates but concomitantly resulted in enhanced creation of rounded mineral deposits. The scaffolds were not cytotoxic according to an indirect test in L929 fibroblasts, and they supported adhesion and growth of MG-63 cells when cultured in direct contact.

Keywords: PLA; polymer scaffolds; porous scaffolds; polymer blends; TCP; polymer functionalization



Citation: Pudelko-Prażuch, I.; Balasubramanian, M.; Ganesan, S.M.; Marecik, S.; Walczak, K.; Pielichowska, K.; Chatterjee, S.; Kandaswamy, R.; Pamuła, E. Characterization and In Vitro Evaluation of Porous Polymer-Blended Scaffolds Functionalized with Tricalcium Phosphate. *J. Funct. Biomater.* **2024**, *15*, 57. <https://doi.org/10.3390/jfb15030057>

Academic Editor: Silvia Panzavolta

Received: 24 January 2024

Revised: 16 February 2024

Accepted: 22 February 2024

Published: 26 February 2024



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1. Introduction

In recent years, bone tissue was the second most transplanted tissue after blood [1,2]. This growing demand for new solutions provided by bone tissue engineering is caused by common trauma or pathologies, different diseases, and the ageing population [3]. The aim of bone tissue engineering is to design biomaterials that temporarily mimic the three-dimensional structure and functions of bone to promote cell adhesion, proliferation, and differentiation [4].

Bone tissue has a very complex and highly organized structure. When it comes to its chemical composition, it consists of from 50% to 70% inorganic constituents (mainly hydroxyapatite), 20% to 30% organic constituents (type I collagen), 5% to 10% water, and 3% lipids. While if its architecture is taken into account, bone tissue can be classified as hard cortical bone (with a porosity of 10–30%) or spongy cancellous bone (with a



पश्चिमबङ्ग पश्चिम बंगाल WEST BENGAL

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MEMORANDUM OF UNDERSTANDING

BETWEEN

STESALIT SYSTEMS LTD, KOLKATA

AND

THE UNIVERSITY OF BURDWAN, BURDWAN

This Agreement made and entered into on this 02 day of Feb 2015 between Stesalit Systems Ltd, Kolkata, India (hereinafter called STESALIT) situated at Stesalit Towers, Salt Lake Electronics Complex, Kolkata 700 091, India and The University of Burdwan, Burdwan, India (hereinafter called Burdwan University which expression shall include its successors and permitted assignees) with its having administrative office at Rajbati, Burdwan 713 104, West Bengal

1. OBJECTIVES OF THE MOU

The objective of this Memorandum of Understanding is:

- To form a technical collaboration in the field of Global Navigation Satellite Systems (GNSS)
- To provide a formal basis for initiating interaction between STESALIT and Burdwan University.



2. PROPOSED MODES OF COLLABORATION

STESALIT and Burdwan University propose to collaborate through

- a. Development of algorithms and applications using joint competency of STESALIT & Burdwan University in the field of GNSS and mobility solutions for GPS/ GNSS Devices in different sectors and verticals.
- b. STESALIT would bring in the competencies in higher accuracy GNSS segment with details of software and hardware suites, including the other mobility devices from STESALIT.
- c. Burdwan University would bring in the competencies of developing algorithms and solutions for improved accuracy to be integrated with STESALIT solution frameworks.
- d. It is decided that STESALIT and Burdwan University would work together in the GNSS and related markets where Burdwan University would offer its expertise for enhancing user Experience on STESALIT devices
- e. It is decided that STESALIT and Burdwan University would form collaboration through a MOU by which STESALIT would officially declare Burdwan University, Burdwan as a Solution Development Partner.
- f. Burdwan University and STESALIT teams will jointly work to ensure that ^{they agree} will actively participate in ensuring their developed applications and compliers will get integrated into STESALIT GNSS/ GPS devices
- g. Burdwan University and STESALIT will jointly work to add features to the developed application to make the product offering more attractive to existing and future customers of STESALIT devices.

3. TECHNICAL AREAS OF COLLABORATION

The principal technical areas of collaboration between STESALIT and Burdwan University will be in the points of Algorithms/ Solutions development and testing to enhance Features and Functionalities of STESALIT GNSS Devices.

4. CONFIDENTIALITY

- a. During and for a period of three years from the date of disclosure, each party agrees to consider as confidential all information disclosed by the other party in written or tangible form or, if orally disclosed confirmed in writing within thirty days of disclosure and identified as confidential by the disclosing party.
- b. The obligations above shall not extend to any confidential information for which the receiving party can prove that, this information:
 - is in the public domain at the time of disclosure or comes within the public domain without fault of the receiving party.
 - is already known or become known to the receiving party
 - is received from a third party having no obligations of confidentiality to the disclosing party,
 - is independently developed by the receiving party or
 - is required to be disclosed by law or court order.



5. NON-EXCLUSIVITY

The relationship of the parties under this MOU shall be nonexclusive and both parties, including their affiliates, subsidiaries and divisions, are free to pursue other agreements or collaborations of any kind. However, when entering into a particular business, partnership, or dealership agreement, the participants may agree to limit each party's right to collaborate with others on that subject.

6. TERMS AND TERMINATION

This MOU, unless extended by mutual written agreement of the parties, shall expire 3 years after the effective date specified in the opening paragraph and can be renewed through mutual interest. This MOU may be amended or terminated earlier by mutual written agreement of the parties at any time. Either party shall have the right to unilaterally terminate this MOU upon 90 days prior written notice to the other party. However, no such early termination of this MOU, whether mutual or unilateral, shall affect the obligations of the participants under any Business Agreement, Confidentiality clause as referenced in clause 4 above, or any other agreement entered into pursuant to this MOU, which obligations shall survive any such termination.

7. BRANDING

The STESALIT Devices and its Installed Software Applications shall continue to be sold under STESALIT's existing brands Sxtreo or any others and STESALIT would give due credit to Burdwan University for the solutions provided. For certain products, developed jointly by both the Parties, Co-branding may be done by signing a separate agreement on a mutually agreed basis for such an instance and terms of the same would NOT be guided through this MOU.

8. RELATIONSHIP

Nothing in this MOU shall be construed to make either party a partner, an agent or legal representative of the other for any purpose. Now onwards, till the validity of this agreement, both the parties may mention the name and LOGO of the other in their brochures/ flyers/ websites/ documents as "TECHNICAL COLLABORATOR" for purposes as may be required. But, such an instance should be communicated by the user to the other party in writing beforehand.

9. INTELLECTUAL PROPERTY RIGHTS (IP)

Intellectual property rights of both the parties will continue to be maintained as is and no party will have rights to any IP already existing with each party. In case of any IP developed jointly, both parties would sign a separate agreement on a mutually agreed basis for such an instance and terms of the same would NOT be guided through this MOU.

10. ASSIGNMENT

It is understood by the Parties herein this MOU is based on the professional competence and expertise of each party and hence neither Party shall transfer or assign this Agreement, or rights or obligations arising hereunder, either wholly or in part, to any third party.



11. AMENDMENTS

Amendments or changes to this agreement or MoU shall be made in writing and signed by the duly authorized Representatives

12. FUNDING

The initial stage of this agreement would not be funded by any of the parties, however, each party would be responsible for the cost of their travel and living expenses.

After the inception, when the collaboration matures, the funding may be realized on application to various funding agencies of relevance. The Parties can submit joint project proposals to relevant funding agencies and the funding applications should be made by the participating parties with their mutual consent and discussions regarding the scope and extent of such funded program and its goals.

STESALIT, may, at its discretion extend financial support in the form of "Consultancy Charges" to The University of Burdwan for supporting research in a particular technical area of GNSS. Both the parties sign a separate agreement on a mutually agreed basis for such an instance and terms of the same would NOT be guided through this MOU.

13. COSTS OF THE MOU

Each Party shall bear the respective costs of carrying out the obligations under this MOU

14. POINT OF CONTACTS

Each Party will nominate its own representatives who would be responsible for all measures to be undertaken under this agreement and they would be called point of contact (PoC). The point of contact for each of the parties are mentioned below:

FOR STESALIT:

Mr. Pratyush Talukdar

Asst Technical Lead

Software Department

Stesalit Limited, Kolkata

Email: pratyush.talukdar@stesalit-inc.com

Mobile No.: +91 98308 80591

FOR THE UNIVERSITY OF BURDWAN

Dr Anindya BOSE,

Scientific Officer

Department of Physics, The University of Burdwan

Golapbag, Burdwan 713 104

Email: abose@phys.buruniv.ac.in

Mobile No: +91 94340 04478



[Handwritten signature]

The Industry Institute Partnership Cell (IIPC), The University of Burdwan will support the communications and implementation of the program.


15. SIGNED IN DUPLICATE

This MOU is executed in duplicate with each copy being an official version of the Agreement and having equal legal validity.

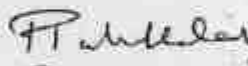
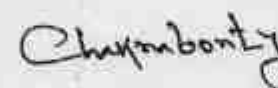
BY SIGNING BELOW, the parties, acting by their duly authorized officers, have caused this Memorandum of Understanding to be executed, effective as of the day and year first above written.

On behalf of

STESALIT SYSTEMS LTD, Kolkata

By : 
Name : JAYANTA SOM
Title : Zonal Manager
Date : 2/2/2015

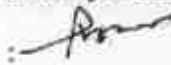
Witness :

1. 
PRATYUSH TALUKDAR
2. 
Sibayan Chakraborty

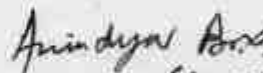
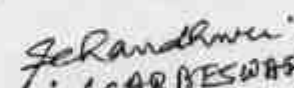


On behalf of

The University of Burdwan, Burdwan

By : 
Name : RAJAT BHATTACHARY
REGISTRAR
THE UNIVERSITY OF BURDWAN
Title : BURDWAN-713104
Date : 02/2/15

Witness :

1. 
(ANINDYA BOSE)
2. 
(SARVESWAR CHAUDHURI)



**Memorandum of Understanding
Between
The University of Burdwan, West Bengal, India
and
the University of Dhaka, Bangladesh**

The University of Burdwan (hereinafter called B.U.) and the University of Dhaka (hereinafter called D.U.) establish hereby a formal understanding of co-operation and friendship which is intended to further the academic objectives of each Institution and to further develop academic co-operation, strengthen cultural ties between the two countries and thereby improve mutual understanding and relationships. Under this MOU the two Institutions will proceed to implement the following endeavours and exchanges of materials and personnel.

Areas of Co-operation

Co-operation shall be carried out subject to availability of funds and the approval of the competent authority of Burdwan University and Dhaka University, through such activities or programmes as:

- (1) Exchange of Faculty Members and scholars
- (2) Inter-disciplinary and result oriented joint research activities and field studies
- (3) Participation in Seminar and academic meetings
- (4) Exchange of Academic materials and other information
- (5) Short term Academic Programmes

The terms of such mutual co-operation shall be mutually discussed and agreed upon in writing by both the Institutions. Both the Burdwan University and the Dhaka University agree to waive all regular fees for the exchange programme under this MOU. Both the Institutions agree to provide rent free accommodation at their respective Guest House for the participants of the exchange programme under this MOU.

The present MOU will be effective from the date of its signature and will in force for a period of three years. It shall be automatically extended for an additional period of three years unless either Institutions notify its intention to terminate the MOU, at least six months before the date of expiry

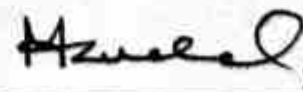
Signed in Dhaka University, Bangladesh

Signed for the University of Burdwan

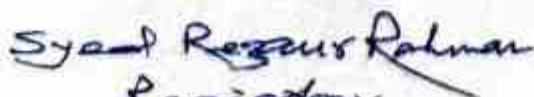
Signed for the University of Dhaka

 22.10.14

Dr. Shorosimohan Dan
Pro-Vice-Chancellor
University of Burdwan
West Bengal, India

 22/10/2014

Professor Dr. Md. Kamal Uddin
Treasurer
University of Dhaka
Bangladesh.


Registrar
Dhaka University