

## New Methods for the Production and Chemical Manipulation of 2D Nanomaterials and Carbon Nanotubes



### Overview:

2D materials like graphene or transition metal dichalcogenides (TMDCs), and carbon nanotubes are some of the most promising nanomaterials due to their extraordinary physical properties. Foreseen applications for these nanomaterials include next-generation electronics, photovoltaics, chemical sensors, etc. However, the implementation of these nanomaterials in real-life applications depends on a precise control over their production and/or chemical modification, so that we can fully benefit from their native properties or fine-tune them to serve our purposes. In this course we will present the latest advances in methodologies for their production and chemical manipulation. In particular, we will focus on: (i) liquid phase exfoliation techniques to produce graphene and TMDCs, (ii) selective production of high chiral angle metallic nanotubes, (iii) covalent modification of 2D materials, (iv) on-device supramolecular modification of 2D materials, and (v) synthesis of mechanically interlocked derivatives of carbon nanotubes.

### Objectives:

The objectives of this course are:

- To acquire adequate background information on nanoscience;
- To learn the fundamentals of the structure, reactivity and physical properties of graphene, TMDCs and carbon nanotubes;
- To identify and learn how to overcome the challenges in their production;
- To identify and learn how to overcome the challenges in their chemical modification;
- To get familiar with state-of-the art techniques for the characterization of nanomaterials.

To achieve these objectives, the course will focus on practical examples described in high-impact research reports from our group in the field.

<b>Modules/ Brief Syllabus</b>	<b>A: Duration</b> :	20-30 <sup>th</sup> March, 2017
	<b>B: Venue</b> :	Centre for Nanoscience and Nanotechnology, Jamia Millia Islamia, New Delhi-110025.
<b>No. of Participants for the course will be limited to fifty.</b>		

**Module A:** Structure and production of graphene, carbon nanotubes and transition metal dichalcogenides

**Monday, 20 March 2017**

**Inaugural Ceremony: 10:00 AM to 11:00 AM**

**Lecture 1: 11:15 AM to 12:30 PM**

**Nanoscience and nanotechnology, the 5<sup>th</sup> innovation wave**

**Lecture 2: 2:30 PM to 4 PM**

**Nanotechnology in today's technologies**

**Tuesday, 21 March 2017**

**Lecture 3: 10:00 AM to 11:30 AM**

**Graphene, the wonder material**

**Lecture 4: 11:45 AM to 01:15 PM**

**Carbon nanotubes structure and electronic properties**

**Tutorial 1: 2:30 to 4:00 PM**

**Problem solving session: Characterization of graphene and carbon nanotubes with examples**

**Wednesday, 22 March 2017**

**Lecture 5: 10:00 AM to 11:30 AM**

**2D Materials beyond graphene, TMDCs**

**Lecture 6: 11:45 AM to 01:15 PM**

**Synthesis of 2D materials**

**Tutorial 2: 2:30 to 4:00 PM**

**Problem solving session: Characterization of TMDCs with examples**

**Thursday, 23 March 2017**

**Lecture 7: 10:00 AM to 11:30 AM**

**Synthesis of carbon nanotubes**

**Lecture 8: 11:45 AM to 01:15 AM**

**Selective synthesis of continuous fibres of carbon nanotubes**

**Tutorial 3: 2:30 to 4:00 PM**

**Brain storming session: Addressing problems in the synthesis of graphene, TMDCs and carbon nanotubes**

**Friday, 24 March 2017**

**Lecture 9: 10:00 AM to 11:30 AM**

**Liquid phase exfoliation for the production of 2D materials**

**Lecture 10: 11:45 AM to 01:15 PM**

**Producing ultrathin luminescent MoS<sub>2</sub> and WS<sub>2</sub> nanosheets through mild LPE**

**Tutorial 4: 2:30 to 4:00 PM**

**Laboratory session: Hands-on demonstration of LPE of 2D materials**

**Module B:** Chemical modification of graphene, carbon nanotubes and TMDCs

**Monday, 27 March 2017**

**Lecture 11: 10:00 AM to 11:30 AM**

**Covalent modification of 2D materials and carbon nanotubes**

**Lecture 12: 11:45 AM to 01:15 PM**

**Covalent nanopatterning of graphene with atomic selectivity**

	<p><b>Tutorial 5: 2:30 to 4:00 PM</b>  <b>Brain storming session: Design of chemically modified 2D materials and carbon nanotubes for specific applications</b></p> <p><b>Tuesday, 28 March 2017</b>  <b>Lecture 13: 10:00 AM to 11:30 AM</b>  <b>Noncovalent modification of graphene, carbon nanotubes and TMDCs</b>  <b>Lecture 14: 11:45 AM to 01:15 PM</b>  <b>On-device modification of 2D materials</b>  <b>Tutorial 6: 2:30 to 4:00 PM</b>  <b>Problem solving session: Determination of thermodynamic parameters in the noncovalent association of nanomaterials</b></p> <p><b>Wednesday, 29 March 2017</b>  <b>Lecture 15: 10:00 AM to 11:30 AM</b>  <b>Mechanically interlocked molecules and molecular machines</b>  <b>Lecture 16: 11:45 AM to 01:15 PM</b>  <b>Synthesis of mechanically interlocked derivatives of carbon nanotubes</b>  <b>Tutorial: 2:30 to 4:00 PM Brain storming session: Applications and research directions in MINTs</b></p> <p><b>Thursday, 30 March 2017</b>  <b>Examination of students: 2:00 PM to 4:00 PM</b>  <b>Valedictory Ceremony 4:00 PM to 5:00 PM</b></p>
<p><b>You should attend If</b></p>	<ul style="list-style-type: none"> <li>• Executives, engineers and researchers from manufacturing, service and government organizations including R&amp;D laboratories.</li> <li>• Student students at all levels (BTech/MSc/M.Tech/PhD) or Faculty from reputed academic institutions and technical institutions.</li> </ul>
<p><b>Fees</b></p>	<p>The participation fees for taking the course is as follows:</p> <p><b>Participants from abroad:</b> US \$300  <b>Industry/Research Organisations:</b> 10,000/-  <b>Academic Institutions:</b>  Faculty members: Rs. 3000/-  Masters/PhD Students: Rs. 1500/-</p> <p>Course Fees Payment: The DD should be prepared in favour of “<b>Registrar, JamiaMilliaIslamia</b>”, payable at New Delhi and submit to the Centre for Nanoscience and Nanotechnology, JamiaMilliaIslamia, New delhi</p>
<p><b>Registration</b></p>	<p>The participants should register on the following link:  <a href="http://www.gian.iitkgp.ac.in/GREGN/index">http://www.gian.iitkgp.ac.in/GREGN/index</a></p>

## Teaching Faculty:



**Dr. Emilio M. Pérez (EMP)** obtained his BSc (2000, top 10%) and MSc (2001) from the Universidad de Salamanca. He then joined the group of Prof. David A. Leigh at the University of Edinburgh (UK) where he obtained his PhD in 2005. He joined the group of Prof. Nazario Martín at the Universidad Complutense de Madrid in 2005 holding a Juan de la Cierva postdoctoral fellowship (selected as n°3 in Chemistry). In December 2008 he moved to IMDEA Nanoscience as a Ramón y Cajal researcher (selected as n°1 in Chemistry). He was promoted to Senior Researcher in 2014, and to his current position as Distinguished Researcher and Executive Director for Science Communication and Outreach in 2015.

In 2012 he was awarded the prestigious ERC Starting Independent Research Grant to establish his own research group at IMDEA. His main research interests concern the development of unconventional methods for the modification of carbon nanotubes and 2D materials, and fundamental supramolecular chemistry. EMP is currently the PI of a group consisting of four postdoctoral fellows, six PhD students and a senior technician.

EMP is the author of >60 peer-reviewed publications, including 10 *Angew. Chem.*, 8 *JACS*, 6 *ChemComm*, 4 *ChemSci*, *NanoLett*, *ACS Nano*, *Nature Comms*, and *Nature Mater*. He has received a total of **2690 citations** (>40 citations/article), with **h = 24** (Google Scholar, December 2016).

EMP has been distinguished with: **Early Excellence in Physical Organic Chemistry Profile**, (*J. Phys. Org. Chem.* 2015, 28, 445). **Miguel Catalán Award**, 20 January 2014. Award for best scientist in the Comunidad Autónoma de Madrid under the age of 40. **ERC Starting Independent Research Grant**, January 2012, 1.49 M€. **UCM Foundation Prize for Science and Technology**, 25 November 2010. A prestigious nation-wide award for early career achievements of scientists of all fields below the age of 35. **RSEQ Prize for Novel Researchers**, May 2009. One of four winners of the prize, awarded to the best chemists in Spain under the age of 35. **IUPAC Prize for Young Chemists** 2006, 28 April 2006. One of five winners of the prize, awarded to the most outstanding PhD thesis in the world of Chemical Sciences

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**Prof. S. S. Islam** is Director in the Centre for Nanoscience and Nanotechnology, Jamia Millia Islamia, Delhi. He did his Masters in physics from Burdwan Univ. West Bengal, India. In 1984 he was awarded with French Govt. Fellowship for pursuing Ph.D. from University of Paris. He was awarded Post-Doctoral Fellowship for research at Max Planck Institute, Stuttgart, Germany. His current research area includes material science, nanoscience and nanotechnology. Prof. S. S. Islam is keenly interested in developing advanced nanomaterial for sensing and energy applications. He has 2 U.S. Patent, filed 4 Indian patent and 2 patent are under consideration. He has supervised many Ph.D. students among them 11 are awarded and 5 students are presently pursuing their Ph.D. under his supervision. Prof. S. S. Islam has received several research grants. Prof. S. S. Islam has published 154 research articles among them 76 research papers in peer-reviewed journals of high repute, 78 research papers in conference and workshop proceedings. Prof. S. S. Islam has also authored a book on “Semiconductor Physics and Devices, published by Oxford University Press, India, 2006. Prof. S. S. Islam has been the active member of Semiconductor Society of India and Electron Microscope Society of India (EMSI).

Homepage: <http://jmi.ac.in/upload/employeeresume/sislam.pdf>

## **Course Coordinator:**

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