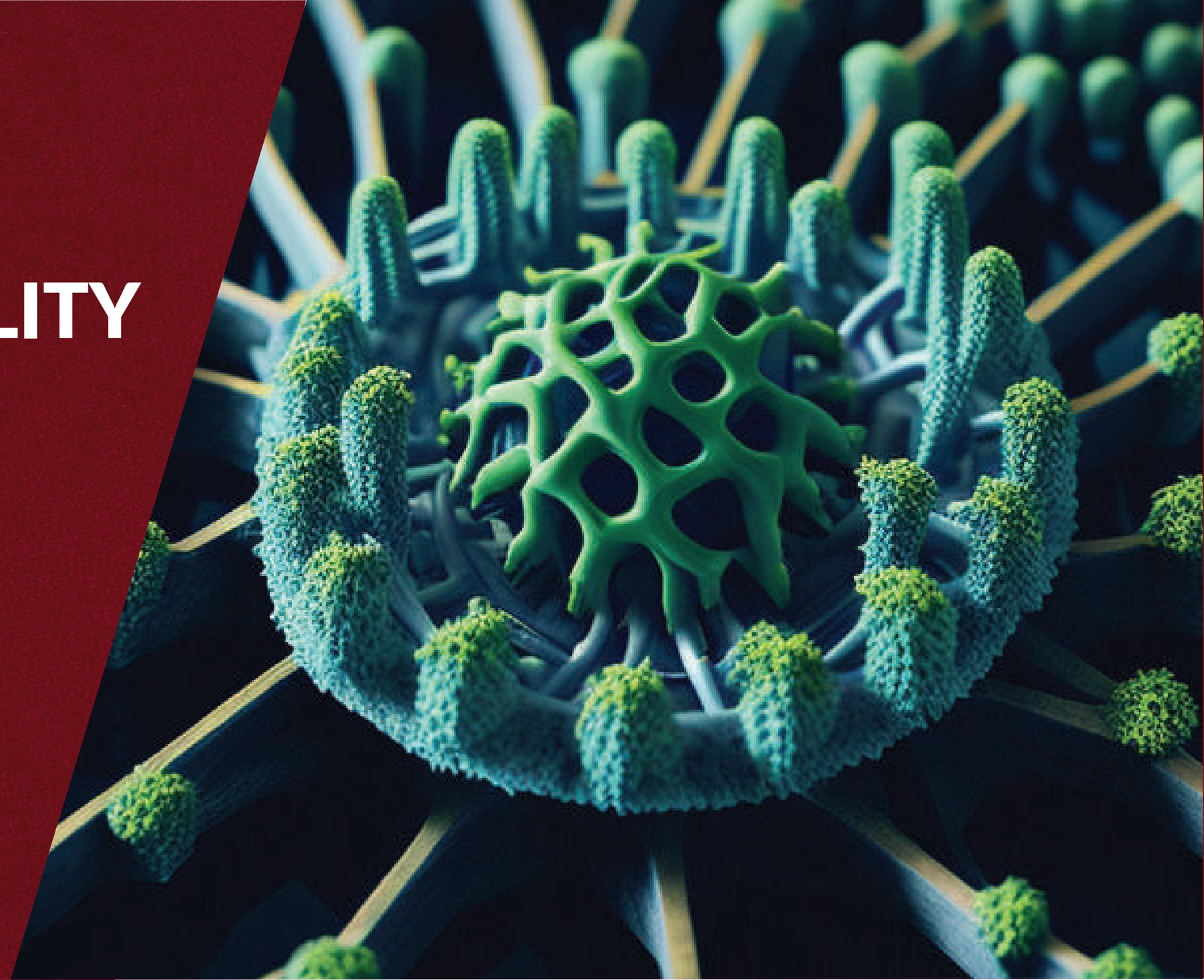
SHIV NADAR
INSTITUTION OF EMINENCE DEEMED TO BE
UNIVERSITY
DELHI NCR

SUSTAINABILITY INITIATIVES

IMPACT STORY 3



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Our third Sustainability impact story highlights the research work of Dr. Subahbrata Sen.

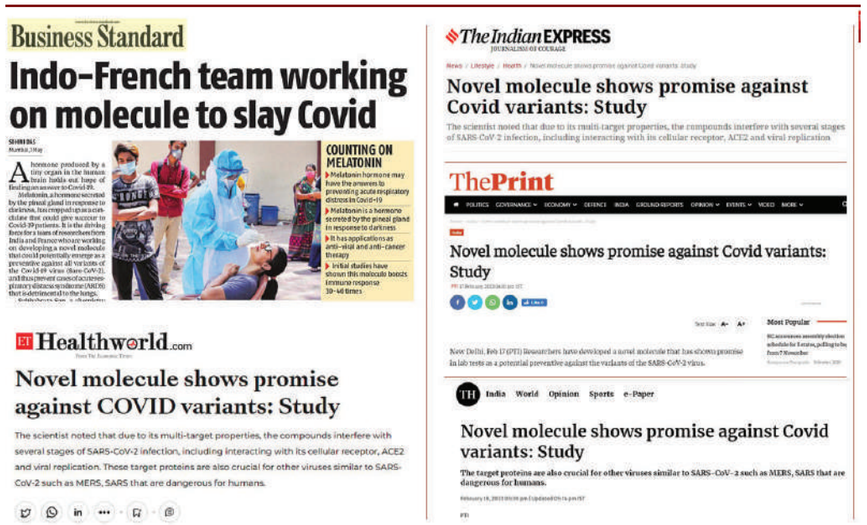
Dr. Sen is a Professor at the Department of Chemistry at Shiv Nadar University. It was a delight for all of us at the university when Dr. Sen and his team's project was shortlisted for the Research Project of the Year in the STEM category for the Times Higher Education (THE) Asia Awards 2024.

Dr. Sen and his research group focus on fundamental and applied research in synthetic organic chemistry, which involves the discovery of biologically active molecules through organic chemistry-driven approaches. His research also includes metal and organo-catalyzed synthesis of novel heterocyclic molecules, library design and synthesis, and target-based projects in breast cancer, diabetes, and malaria.

Today, we are in conversation with Dr. Subhabrata Sen to bring you many of his and his students' exciting research projects. He also talks about how his teaching, research, patents, collaborations, and students' research is creating a difference and contributing to the UN Sustainable Development Goals (SDGs).

Your research covers a vast ground around medicinal chemistry, natural product synthesis, small molecule synthesis, combinatorial library design, etc. What has been the motivation behind your work?

My Ph.D. training in the U.S. and my industrial career spanning a decade before I moved to Shiv Nadar provided me with ground realities about pharmaceutical and chemical research. This inspired me to work on human health. I focused on discovering bioactive small molecules with therapeutic properties through combinatorial and molecular library design and their biological screening. Last year, we found a novel library of indoles that are modulators of melatonin receptors and exhibited therapeutic properties against SARS-CoV 2, the pathogen that wreaked havoc through COVID-19. My research focused a lot on sustainable organic synthesis. Although organic chemistry is essential to generate molecules for numerous applications, conventional organic synthesis uses reaction conditions and reagents that are not sustainable and detrimental to the environment. My motivation is to make organic synthesis sustainable and eco-friendly.



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Your research contributes to more than one sustainable development goal, such as SDGs 3, 6, and 7, addressing good health, clean water, and energy. What are some of the critical elements of your research since 2023 in sustainability?

We use alternate energies such as blue LED (photolysis), mechanochemical energy (Ball-mill), and photo-electricity to perform organic reactions and generate intelligent heterocycles for therapeutic use or as photoprobes. Blue LED possesses 450 nm wavelength with a mild intensity, which makes it energetically sustainable. Solvent-free mechanochemistry under the ball-milling technique replaces complex glass paraphernalia with simple bill mills for performing organic reactions, and a novel catalyst-free photo-electrochemistry leverages mild blue LED and electric current to perform organic reactions. We prefer not to use any metal catalysts, acids, or bases, or for that matter, organic solvents, which are volatile in nature and evaporate and pollute the atmosphere. The reactions require minimum or no thermal energy.

How have you been able to include sustainability in your teaching in the undergraduate and graduate programs?

In the present world, “green” organic chemistry is a concept and a consciousness. We must be aware of our environment and how we damage it through our actions, and science plays a critical role in this. I have included the importance of Sustainable Development Goals (SDGs) and sustainability in teaching undergraduate and graduate students. In addition, the students who pursue research with me are exposed to the different sustainable organic synthetic techniques, which provide them with hands-on experience in green chemistry research.

Please highlight some of your students’ key research projects in Opportunities for Undergraduate Research (OUR) and Ph.D.

During my tenure at Shiv Nadar for the last 11 years, my students have published nearly 100 research articles and patents. All these research articles, culminating in exciting projects, are very close to my heart. I am proud of my OUR and other undergraduate research students. I have also supervised thirteen Ph.D. theses. With my 13th Ph.D. student, Dr. Debajit Maiti, we have devised a strategy to clean water from toxic contaminants such as 1 and 4-dioxane, which is predominant in the effluents of the paint industry; we have designed and patented a state-of-the-art instrument to perform photo-electric organic reactions and many more.

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Another brilliant Ph.D. was Dr. Jyoti Chauhan, presently at Harvard Med-School, performing her postdoc with Prof. Shiladitya Sengupta. She has designed and synthesized novel anti-covid molecules. Her project was selected among the top 8 projects in the Times Higher Education Asia Awards 2024.

My OUR student, who continued her final year of research, **Ms. Sanjana Maheshwari,** is now pursuing her Ph.D. in atmospheric chemistry at the University of Maryland, College Park. She was brilliant, garnering two top-notch publications in *Chemistry, an Asian Journal and Organic and Biomolecular Chemistry*, during her B.Sc. Both projects involved blue LED-induced carbene generation and their application in cycloaddition reactions. Ritwik Bhattacharya, another undergraduate student who continued in our M.Sc. program, has been performing very productive research on photo and mechanochemistry and drug discovery research on Leishmania with one of my external collaborators, DNDi (Switzerland).

Please share some of your partnerships and collaborations with Industry and Academia.

I have been fortunate with my research collaborations in both academia and industry. One of my present academic partners is Prof. Gremaud Ludovic, Haute école d'ingénierie et d'architecture de Fribourg, Switzerland. Ludo and I are working closely on devising novel photolytic and mechanochemical methods to perform organic reactions. We also work with WAB, a Basel-based Swiss company focusing on mixing and milling instruments. **I am happy to share that I recently received the Research Exchange Award from the Swiss National Science Foundation, sponsoring my two-month travel to Fribourg in Ludo's lab.**

Another significant collaboration is with Prof. Ralf Jockers, CNRS Director in Institut Cochin, University of Paris, Cite, for our COVID-19 medicine project.

We actively collaborate with colleagues within and outside the School of Engineering. And have begun a synergistic collaboration about water cleaning using microfluidics under photolysis.

Some recent publications

1. Suchismita Rath and Subhabrata Sen*, Protocol for the aqueous synthesis of bioactive quaternary ammonium betaine derivatives under blue *LED. STAR PROTOCOLS*, 2024, DOI: 10.1016/j.xpro.2024.102890.

2. Dhiraj Barman,§ Suchismita Rath,§ Mahesh Ravva, Jesni Jacob, and Subhabrata Sen*, Oxidative Aminopyridylation of Maleimides and 1, 4-quinones with N-Aminopyridinium Ylides at room temperature in the absence of any external reagents. *Adv. Synth. Catal.*, 2023, https://doi.org/10.1002/adsc.202300909.

3. A. Saha, C. Sen, S. Guin, C. Das, D. Maiti, D. Maiti,* S. Sen Photoinduced [3+2] Cycloaddition of Carbenes and Nitriles: A Versatile Approach to Oxazole Synthesis. *Angewandte Chemie International Edition*., 2023, e202308916 (DOI: https://doi.org/10.1002/anie.202308916).

4. Tejas Prabakar,§ Subhankar Bera,§ Shagun Singh,§ Anubhuti Srivastava, Manasi Chandrachood, Debajit Maiti, Naiwrit Karmodak* and Subhabrata Sen* Theoretical studies to predict the utility of diazo esters in their reactions with 1, 4-quinones: Experimental validation via visible light driven metal-free process. *Organic Chemistry Frontiers*, 2023, 10.1039/D3QO01275A.

5. Alicja Urbaniak, Chandramohan Bathula, Jyoti Chauhan, Prateek Rai, Joshua Thammathong, Christopher Clark, Billie Heflin, Annick De Loose, Nathan Avaritt, Analiz Rodriguez, Alan J. Tackett, Subhabrata Sen,* Souvik Banerjee,* Synthesis and Anti-Melanoma Activity of Acryloyl Pyridinone Analogues. *Chem. Biodiversity*, 2023, DOI: 10.1002/cbdv.202301550

6. Shweta Singh, Ludovic Gremaud, Subhabrata Sen*, Debajit Maiti* A combination of computational and experimental studies to correlate electronic structure and reactivity of donor-acceptor singlet carbenes. *SYNLETT, 2023*, DOI: 10.1055/a-2153-6819

7. Souvik Guha, Sanjana Maheshwari, Dr. Mahesh K. Ravva, Jesni M. Jacob, Shalini Yadav, and Prof. Dr. Subhabrata Sen*, Mechanochemical metal free N-sulfonyl transfer reaction: Expedient synthesis of N-1 sulfonyl amidines. *Asian J Org. Chem.* 2023, http://dx.doi.org/10.1002/ajoc.202300348

8. Debajit Maiti and Subhabrata Sen, PHOTO ELECTROCHEMICAL REACTION DEVICE AND METHOD THEREOF. Application No.202311031791 A. 16/06/2023

9. Suchismita Rath, Debajit Maiti, Malvika Modi, Parul Pal, Subrata Munan, Biswajit Mohanty, Anjani Bhatia, Rohit Bhowal, Richa Priyadarshini, Animesh Samanta, Parthapratim Munshi,* and Subhabrata Sen*, Metal-free synthesis and study of glycine betaine derivatives in water for antimicrobial and anticancer applications. *iScience.*, (2023), DOI: 10.1016/j.isci.2023.107285.

10. S. Guha, R. Bhattacharya, J. M. Jacob, M. K. Ravva and S. Sen, Metal-free synthesis of N-sulfonyl imines from benzyl alcohol derivatives and iminoiodinanes via mechanochemistry. *Org. Biomol. Chem.*, (2023), DOI: 10.1039/D3OB00791J

11. Haya Khan,§ Souvik Guha,§ Mousumi Baruah,§ Shalini Yadav, Sanjana Maheshwari, Sara Sainani, Debajit Maiti and Subhabrata Sen*, Blue LED induced three-component reactions for the generation of 4, 6-dioxo-hexahydro-1H-furo[3, 4-c] pyrrole: Their evaluation as anticancer agents through PARP-1 inhibition. *Chem. Asian J.*, (2023), DOI: 10.1002/asia.202300420

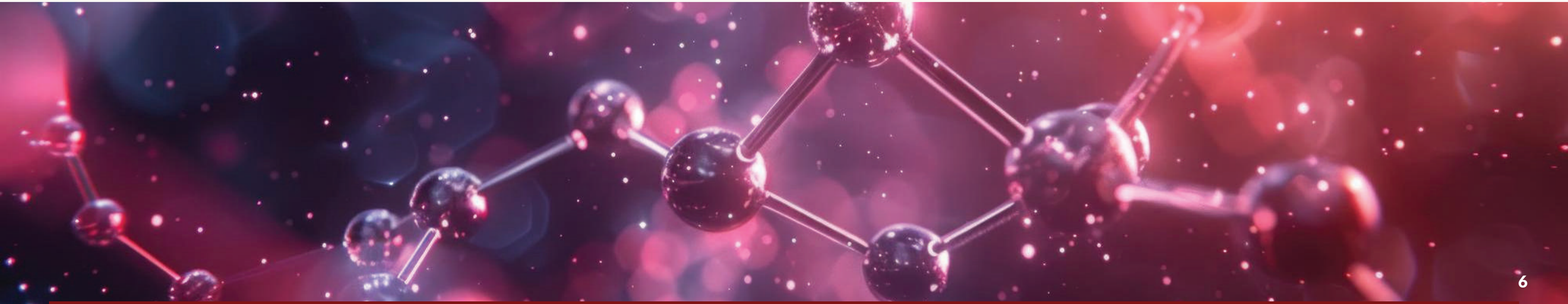
12. Debajit Maiti, Argha Saha, Srimanta Guin, Debabrata Maiti and Subhabrata Sen*, Unveiling catalyst-free electro-photochemical reactivity of aryl diazo esters and facile synthesis of oxazoles, imide-fused pyrroles, and tetrahydro-epoxy-pyridines via carbene radical anion. *Chem. Sci.*, (2023), DOI: 10.1039/D3SC00089C.

13. Debajit Maiti§, Subrata Munan§, Shweta Singh, Ranajit Das, Animesh Samanta*, Subhabrata Sen*, Light-induced diversity-oriented synthesis (DOS) library of annulated indolizine fluorophores for imaging non-lysosomal lipid droplets (LDs). *J. Mater. Chem. B*, (2023), DOI: 10.1039/D2TB02656B.

14. Jyoti Chauhan,§ Erika Cecon,§ Nedjma Labani, Florence Gbahou, Fernando Real, Morgane Bomsel, Kshatresh Dutta Dubey, Ranajit Das, Julie Dam, Ralf Jockers,* and Subhabrata Sen*. Development of indolealkylamine derivatives as potential multi-target agents for COVID-19 treatment. *Eur. J. Med, Chem.*, (2023), DOI: 10.1016/j.ejmech.2023.115152.

How do you think your work is creating a long-term impact on sustainability?

My work on photo and electrochemistry will have a deep and long-term effect on the environment. We have high hopes that this research will bring a paradigm shift in how organic reactions are performed. It could address sustainability and optimize the energy resources vis a vis product output. This is the primary focus of our lab.



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Shiv Nadar Institution of Eminence is fully committed to the UN Sustainable Development Goals (SDGs). We have embraced a four-pronged strategy for SDGs through **teaching, research, our core institutional practices, and partnerships.**

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