INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: **Chemically Twisted Superlattices of Two-dimensional Assemblies of Copper Nanoclusters**

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Thesis Submitted to the Department/ Center	:	Chemistry
Date of completion of Thesis Viva-Voce Exam	:	03.05.24
Key words for description of Thesis Work	:	Physical Chemistry, Materials Chemistry, 2D Materials, Moiré Superlattices

SHORT ABSTRACT

The organization of molecules or atoms in a hierarchical manner leads to the formation of complex superstructures with enhanced properties and functionalities, resulting in superior performance when compared to mono-morphological units. Researchers have been motivated by the impact of these achievements to explore the design and fabrication of materials with hierarchical assembly at the nanoscale level. In this regard, research on the hierarchical assembly of two-dimensional (2D) nanomaterials has led to several exciting discoveries in various fields such as energy storage, optoelectronic devices, chemical sensors, catalytic performance, membranes, and solar cells.

Recently, the angular-dependent arrangement of 2D layers has become popular in the scientific community due to the discovery of exciting new phenomena that are greatly influenced by the twist angle between consecutive layers. However, the conventional physical methods to design these superlattices limit their application owing to the weak coupling between the layers. Here, we have proposed a chemical bonding-based approach for stacking 2D nanosheets that holds significant potential for creating numerous fascinating and tunable properties. Chapter 1 describes the introduction highlighting the significance of hierarchical superstructures in nanoscale science and technology. Chapter 2 presents the formation of 2D crystalline nanosheets with exceptional delayed photoluminescence quantum yield from small-ligand-stabilized luminescent copper nanoclusters (CuNCs), followed by surface modification with organic ligand to create a single-component dual-emitting nanocompound with near-white-light emission. Chapter 3 describes the achievement for the first time of the chemical bonding mediated stacking

of 2D hexagonal crystalline assembly of CuNCs at a specific relative angle of 30° providing regional dodecagonal quasicrystalline lattice. The soformed quasiperiodic nanosheets exhibited superior delayed photoluminescence properties and enhanced chemical stability compared to individual nanosheets. Chapter 4 reports the successful formation of chemical-guided moiré superlattices on low twist angle stacking of 2D hexagonal crystalline assembly of CuNCs in a liquid medium. The resulting superlattices generated an additional quantum emissive state in the blue region due to the inter-nanocluster coprophilic interactions. This state can be tuned based on the density of the moiré superlattices, leading to white light emission with a chromaticity index value of (0.32, 0.39). Finally, chapter 5 concludes the thesis by summarizing the findings and discussing the plausible future prospects.