INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

This thesis focuses on the design and development of homo- and hetero-junction–based two-dimensional (2D) materials for high-performance supercapacitor applications. Supercapacitors are attractive energy storage devices due to their fast charge–discharge ability, long cycle life, and high power density; however, their practical use is limited by low energy density. To overcome this limitation, this work explores interface engineering and electronic modulation in advanced 2D electrode materials. Several strategies were employed, including high-valent vanadium-assisted redox activation, integration of redox-active metal oxides with conductive MXene sheets, and the development of a metal-free supercapacitor electrode, such as Borophene and boron- and oxygen-doped heterostructures. The formation of homo- and hetero-junctions enhances charge transfer, increases electroactive sites, improves ion transport, and suppresses material restacking. The developed electrodes exhibit high capacitance, improved energy density, excellent rate performance, and long-term cycling stability, demonstrating their potential for next-generation supercapacitor applications.