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Plasma-derived Few-Layer Graphene for Hydrogen Storage and Water Remediation

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Graphene and other carbon-based nanomaterials have attracted significant interest in energy storage and environmental remediation due to their high surface area, tunable surface chemistry, and exceptional electrical and mechanical properties. In this study, plasma-derived few-layer graphene (FLG), featuring surface defect engineering and a specific surface area of 614 m²/g, was systematically investigated with respect to its structural, morphological, and adsorption properties. The material was characterized using X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), X-ray photoelectron spectroscopy (XPS), gas sorption analysis, scanning electron microscopy (SEM), and transmission electron microscopy (TEM). Structural analyses confirmed the high crystallinity and few-layer morphology of FLG, while surface chemical analysis revealed the presence of oxygen-containing functional groups favorable for dye adsorption. The adsorption behavior of crystal violet (CV) on FLG was evaluated under various physicochemical conditions, including different pH values (4, 7, and 9), contact times and temperatures (45 °C and 55 °C). Steady-state adsorption experiments demonstrated that temperature influenced CV uptake, while comparable removal efficiencies exceeding 95 % were observed across all pH values. Kinetic studies indicated a rapid adsorption process, highlighting the high affinity of FLG towards CV molecules. In addition, preliminary H_2 adsorption measurements revealed a promising candidate for H_2 storage applications, underlining the multifunctional character of the plasma-treated FLG material. Overall, this study highlights the dual potential of FLG as an efficient adsorbent for dye removal and as a promising candidate for hydrogen storage, emphasizing the versatility of graphene-based materials for combined environmental and green energy applications.