Novel Method for producing Transparent Graphene-Based Films

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Transparent films with high optical clarity and mechanical strength are essential for applications in optoelectronics, flexible substrates, and coatings. Traditional materials like ITO and PET offer transparency but suffer from high cost, brittleness, or limited sustainability[1–4]. As a result, there is increasing demand for alternative materials that address these limitations without compromising performance.

Graphene and its derivatives, particularly graphene oxide (GO) and reduced graphene oxide (rGO), have emerged as promising candidates due to their exceptional optical, electrical, and mechanical properties[5]. GO's hydrophilic nature, conferred by oxygen-containing functional groups, allows for easy dispersion but compromises transparency. Upon thermal or chemical reduction, GO regains partial conductivity and transparency through restoration of its sp^2 carbon network[6]. However, the resulting rGO often suffers from aggregation and optical losses due to residual defects and strong inter-sheet interactions[7–8].

To address this, controlled reduction techniques have been explored, achieving high transmittance while balancing conductivity and structure integrity[9–11]. In composite systems, integrating rGO with polymers or nanoparticles can enhance mechanical or thermal performance, yet often at the cost of optical clarity due to increased scattering and phase separation[12–16]. The dispersion quality and choice of matrix become pivotal in defining the optical performance of such composites[17].

In this work, we present a novel approach for synthesizing transparent GO-based composites using laponite as the host matrix. Laponite, a synthetic smectite clay ($Na^+_{0.7}[(Si_8Mg_{5.5}Li_{0.3})O_{20}(OH)_4]^-_{0.7}$), is selected for its optical transparency, colloidal stability, and chemical compatibility with GO[18]. Initially, GO is dispersed in a laponite sol to ensure uniform distribution and minimize aggregation. The resulting GO–laponite film is then thermally reduced under controlled conditions, facilitating in-situ conversion to rGO. This strategy enhances the interaction between the matrix and rGO sheets, yielding a homogeneous, defect-minimized composite film with enhanced light transmittance and mechanical stability.

Our results demonstrate that this process achieves superior optical performance compared to composites formed with pre-reduced rGO. By leveraging the synergistic properties of GO, rGO, and laponite, the developed films exhibit excellent transparency and structural integrity, making them ideal candidates for next-generation flexible optoelectronic devices and coatings.

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Figures

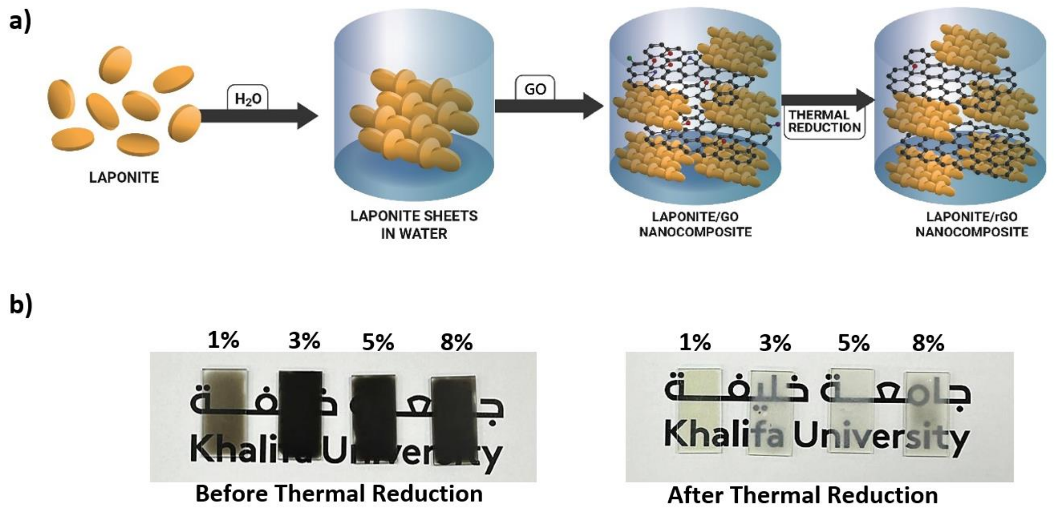

Figure 1: Schematic illustration of the preparation of Laponite-rGO nanocomposites with thermal treatment, and b) picture of the films before and after thermal treatment at different concentrations of GO.

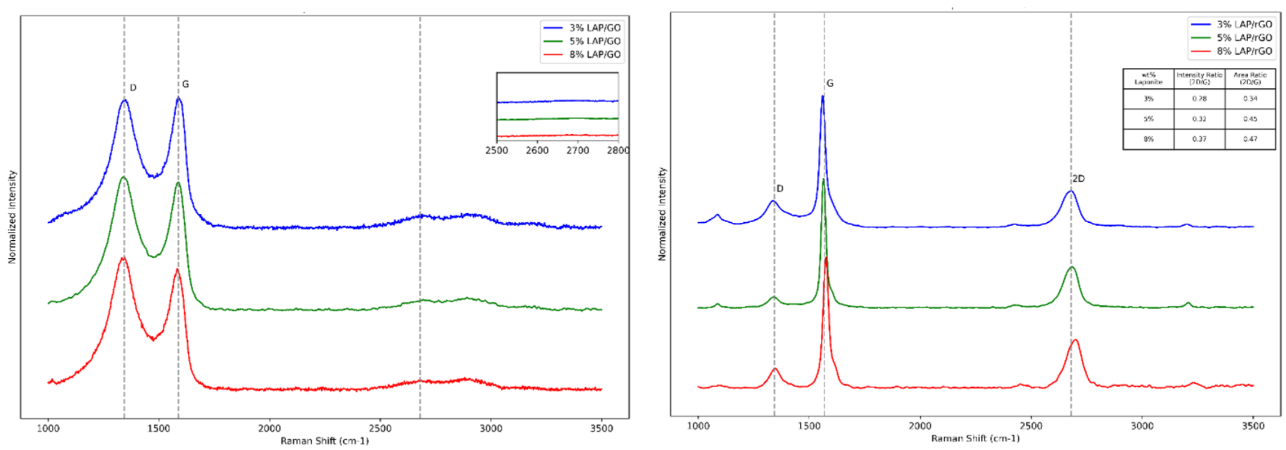

Figure 2: Raman Spectrum of a) LAP-GO and b) LAP-rGO films at different GO concentrations of GO.