Pristine Graphene from Sugar Industry Waste: A Sustainable Nanotech Breakthrough

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Abstract

The sugar industry, a cornerstone of agricultural economies worldwide, generates significant amounts of carbon dioxide (CO_2) as a by-product during the fermentation process. With over 40 billion tons of CO_2 produced annually, this by-product represents both an environmental challenge and a potential resource for value-added applications. The selective conversion of CO_2 into advanced materials like graphene offers a transformative solution for a sustainable, low-carbon future.

Graphene, a revolutionary material with unparalleled applications in electronics, energy storage, and composites, requires scalable and eco-friendly synthesis methods. Traditional methods, such as chemical vapor deposition (CVD) and exfoliation, often face limitations in cost, complexity, and scalability. Here, we introduce a novel magnesiothermic reduction process to synthesize pristine graphene directly from CO_2 derived from the sugar industry.

By reacting sugar industry-derived CO_2 with magnesium turnings at 700-800 °C (**Figure 1**) under an inert argon atmosphere, we produce high-quality, few-layered graphene nano sheets. Characterization techniques confirm the exceptional quality of the graphene: Raman spectroscopy reveals a low D/G band ratio (~0.1), indicating minimal defects. Transmission electron microscopy (TEM) and scanning electron microscopy (SEM) show uniform, single-to-few layered sheets with a lateral size of 1–5 µm. Fourier-transform infrared spectroscopy (FTIR) confirms the absence of residual impurities, validating the "pristine" nature of the graphene.

This innovative approach offers multiple benefits:

Environmental Sustainability: Converts a major greenhouse gas (CO_2) from the sugar industry into a valuable material.

Scalability: Utilizes the abundant CO_2 byproduct from sugar production for large-scale graphene synthesis.

Industry Innovation: Positions the sugar industry as a feedstock for advanced nanomaterials, aligning with global efforts for sustainable resource utilization.

Our work bridges agricultural byproduct valorization and cutting-edge materials science, demonstrating that CO_2 from the sugar industry can be a key driver in the future of nanotechnology.

Keywords:
Graphene synthesis, Sugar industry-derived CO_2, Magnesiothermic reduction, Sustainable nanotechnology, Agricultural waste valorization, Carbon capture utilization (CCU), Industry innovation

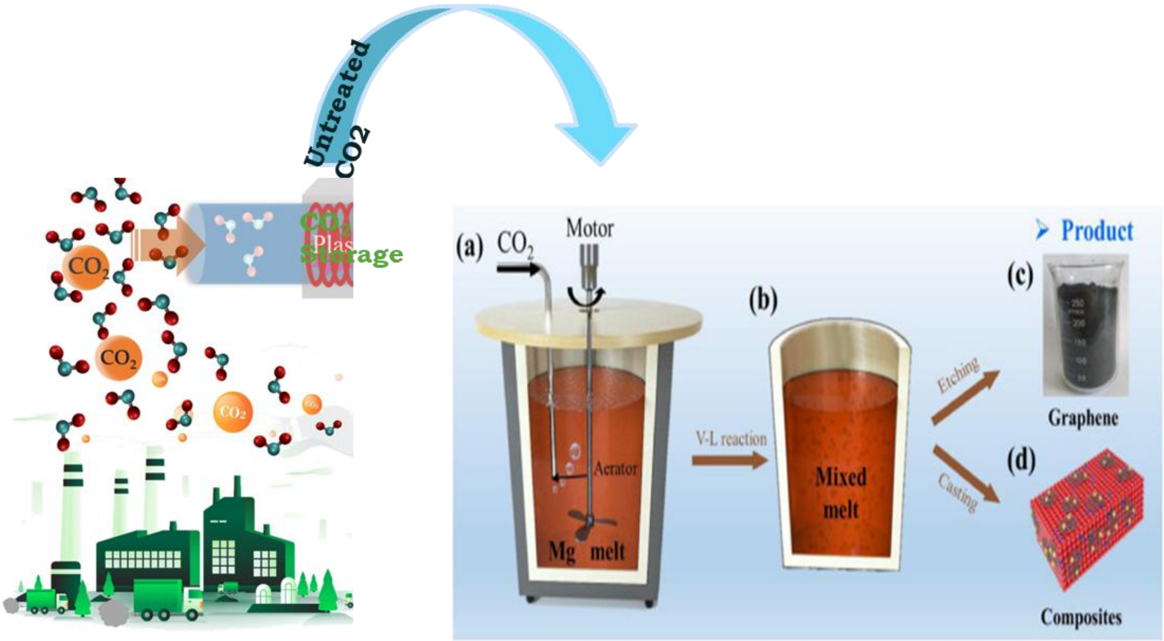

Figure 1: Catalytic – thermal degradation: breaking the Carbon Dioxide (CO2) waste for coal industry apart at high temperature in presence of reducing catalyst