CSIR-NIIST's Technology on Graphene Production from Indian Mineral Resources

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Abstract

Scalable production of few-layer graphene from natural resources remains a key challenge for its widespread industrial application. In this study, a sustainable and scalable route for preparing graphene directly from low-grade graphite ore is demonstrated using mechanochemical ball milling. A run-of-mine graphite ore from Jharkhand, India, containing ~9% fixed carbon, was initially upgraded by froth flotation using a newly developed eco-friendly collector derived from natural sources, yielding a graphite concentrate with more than 90% fixed carbon. Further purification was achieved through alkali roasting followed by acid leaching using hydrochloric and sulphuric acids under mild conditions, producing high-purity graphite with a maximum fixed carbon content of 98.16%. Sulphuric acid exhibited superior leaching efficiency. The purified graphite was subsequently converted into few-layer graphene via dual-drive horizontal planetary ball milling under optimized critical speed conditions using oxalic acid as a milling aid. Structural and morphological characterization by XRD, SEM, TEM, Raman spectroscopy, and XPS confirmed effective exfoliation, reduction in crystallite size, and formation of single- to few-layer graphene sheets with minimal structural defects. The intensity reduction of the (002) XRD peak and the evolution of characteristic Raman bands corroborated progressive layer thinning with increased milling time. The process enables bulk graphene production (up to 200 g per batch) with low energy consumption and without the use of hazardous reagents or extreme processing conditions. This integrated beneficiation–exfoliation strategy offers a cost-effective and environmentally benign pathway for large-scale graphene synthesis from low-grade graphite resources.

References

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Figures

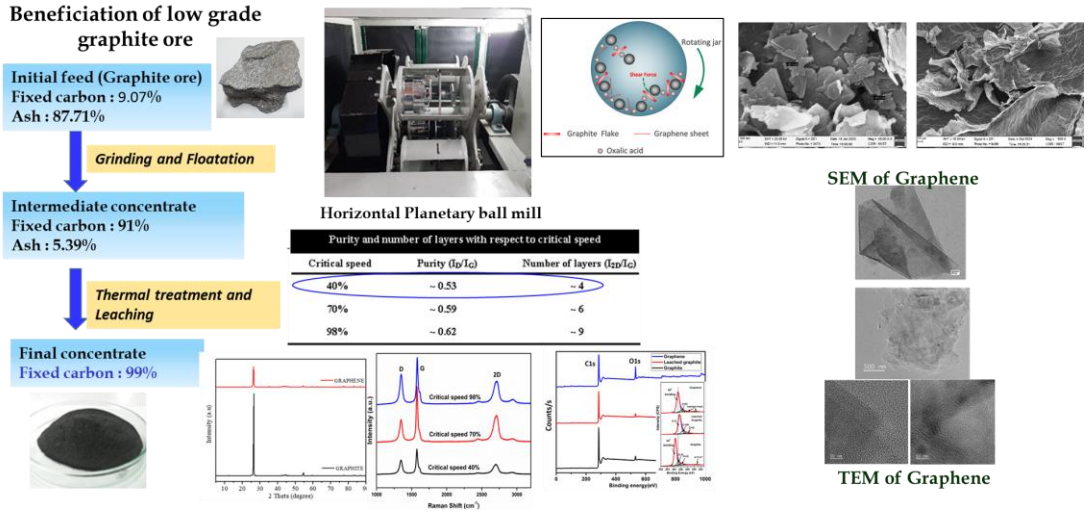

Figure 1: Process Flow Sheet and mechanical exfoliation of graphite for Graphene production