Chapter 5
Plant-Derived Nanocomposites for Sustainable Desulfurization With a Focus on Materials, Applications, and Environmental Impact

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ABSTRACT

The removal of sulfur from fossil fuels is crucial for achieving clean energy and complying with stringent environmental regulations. Although traditional desulfurisation methods are effective, they are often energy-intensive, costly, and inefficient for addressing recalcitrant sulfur compounds. Plant-based nanocomposites present a promising alternative owing to their tunable structures, high porosity, and unique surface properties that facilitate sulfur removal. This review examines the utilisation of agricultural and forestry wastes, such as rice husks, coconut shells, sugarcane bagasse, and fruit peels, in the synthesis of these materials. Eco-friendly techniques, including pyrolysis, hydrothermal carbonisation, and steam activation, can be used to produce materials with high surface areas and advantageous properties. Additionally, it discusses the necessity of balancing the hydrophobic and hydrophilic properties for effective application with hydrocarbons.

INTRODUCTION

For a long time, sulfur in fossil fuels has plagued the energy and environmental sectors. When burned, they produce sulfur oxides, pollutants that are the main cause of acid rain, which destroys trees, soils, and aquatic life, and is also a major contributor to respiratory diseases affecting humans. Although progress may be made in emission control technology regarding the removal of sulfur from exhaust technologies, the most preferable solution to avoid such adverse implications is the removal of sulfur at the fuel treatment level (Sedyaaw et al., 2024). However, desulfurisation techniques, such as hydrodesulfurization, require high temperature, high pressure, and expensive catalysts, use non-renewable resources, and are unsustainable. Thus, the need for highly innovative and environmentally friendly alternatives to synthetic polymers of mineral oil origin is becoming increasingly urgent, and the global trend in the construction industry's dedication to green energy and environmental protection is increasing (Dembaremba et al., 2022).

The transition to green alternatives is clearly related to focusing on materials and processes based on the circular economy approach. In contrast to finite or costly feedstocks, the utilisation of renewable and naturally abundant feedstocks is becoming increasingly popular. Among the potential alternative feedstocks, plant-based materials, particularly agriculture and forestry residues, are the most widely studied (Le et al., 2024). As sources of carbon, these resources are environmentally sound and renewable materials with intrinsic carbon content that can be easily developed into functional materials with interesting physicochemical properties(He et al., 2023). The utilisation of nanocomposites based on these adsorbents for desulfurisation is