Biomass-Derived Carbon-Supported Catalysts for Sustainable Emission Control and Energy Applications

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Abstract. The escalating challenges of pollutant emissions from combustion systems and the growing demand for clean energy necessitate the development of sustainable, low-cost catalytic materials. This presentation explores the valorization of abundant agricultural waste, such as palm kernel and coconut shells, into highly porous activated carbon supports for Earth-abundant transition metal catalysts, including copper, iron, manganese, and nickel. Our core research demonstrates the efficacy of these biomass-derived carbon-supported bimetallic catalysts in critical environmental and energy applications. Specifically, we highlight their high performance in the low-temperature selective catalytic reduction (SCR) of NO_x emissions, utilizing renewable reductants like hydrogen or intrinsic exhaust gases. Furthermore, the application of these materials extends to liquid waste remediation, such as the photocatalytic degradation of ammoniacal nitrogen from landfill leachate. In the realm of clean energy, we examine the aqueous-phase reforming of biodiesel-derived waste glycerol into value-added chemicals and in-situ hydrogen using carbon-supported bimetallic catalysts. The presentation also outlines emerging research frontiers, illustrating the versatility of biomass-derived materials. This includes the development of graphene oxide composites for advanced environmental monitoring, such as highly selective Ag+ colorimetric sensors. Ultimately, this work presents a comprehensive blueprint for a circular economy, converging waste-to-materials and catalysis-to-clean-energy paradigms. We conclude by outlining future opportunities including the integration of AI in catalyst design, the advancement of the hydrogen economy, and the transformative potential of circular carbon materials in global air and water pollution control.

Keywords: Biomass, carbon, catalyst, emission control, energy application