ABSTRACT:

Exploring Nanocatalyst Design and Reactivity in Sustainable Biomass Conversion

M. Manzoli

Drug Science and Technology Department, University of Turin, Turin, Via Pietro Giuria 9, 10125, Italy.

The transition from a fossil-based to a sustainable chemical industry requires the development of efficient and sustainable strategies for the conversion of renewable carbon resources into fuels, chemicals, and materials. Lignocellulosic biomass composed of cellulose, hemicellulose, and lignin, represents one of the most abundant and versatile renewable feedstocks, yet its structural complexity and chemical heterogeneity pose significant challenges to selective and energy-efficient valorisation [1]. In this context, nanocatalysis has emerged as a powerful platform to enable controlled biomass conversion through tailored active sites, tunable interfaces, and enhanced reaction pathways [2,3]. Recent progress in the design and application of nanostructured catalysts for lignocellulosic biomass valorisation, in combination with enabling technologies such as microwave or ultrasound, will be presented. Special attention will be given to how tailored nanomaterials provide precise control over catalytic activity, selectivity, and stability within biorefinery schemes. The role of catalyst structure–performance relationships, reaction environment, and insights gained from advanced characterization in guiding rational catalyst development will also be discussed. By integrating nanomaterials synthesis, catalytic testing, and mechanistic understanding, this contribution aims to demonstrate how nanocatalysis serves as a key enabling technology for biomass valorisation, bridging fundamental nanoscience with sustainable chemical applications.

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