Abstract

Innovative Lignin-TiO_2 Nanocomposites: Advancing Redox Materials and sustainable wastewater decontamination

Combining and recycling biowaste offers significant environmental and technological benefits. An urgent goal is to enhance the value of biowaste through innovative techniques. Lignin, an abundant plant polymer, shows great potential for developing sustainable multifunctional materials. Despite its advantages, lignin valorization faces challenges due to its chemical complexity and tendency to aggregate in water. By using a versatile in situ hydrothermal approach alongside a ceramic templating method, lignin and TiO_2 can be combined to produce hybrid nanostructures with customizable properties. Detailed physicochemical analyses reveal correlations between structure, properties, and functions. Incorporating 20% lignin into the nanostructures (TiO_2_DL200) results in improved antibacterial and antifungal properties, a 90% radical scavenging activity within 2 minutes, and nearly complete removal of dyes within 5 minutes. At lower lignin content, the nanostructures exhibit efficient pollutant adsorption and photocatalytic degradation, while higher lignin content enhances antioxidant and UV-blocking properties. These outcomes highlight the potential applications of hybrid nanoparticles as antioxidants, antibacterial and antifungal agents, and for dye decontamination in water remediation. This approach emphasizes the environmental impact of reusing biowaste with tailored functional properties.