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Elucidation of enhanced cellulase immobilization onto synthetic magnetic nickel nanomaterials for lignocellulosic biomass hydrolysis

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ABSTRACT

The immobilization of cellulase enzymes for the conversion of lignocellulosic biomass into sustainable biochemical products is essential for the stability and recovery of the enzymes. In this study, nickel nanoparticles (NiNPs) were synthesized and coated with 3-aminopropyl triethoxysilane (APTES) to serve as cellulase enzyme carriers. Cellulase enzyme immobilization on the prepared NiNPs was achieved using glutaraldehyde as a cross-linker. The physicochemical properties of the carrier were determined before and after enzyme immobilization using X-ray Powder Diffraction (XRD), Transmission Electron Microscopy (TEM), Fourier transform infrared spectroscopy (FTIR), Vibrating-Sample Magnetometer (VSM), and Field Emission Scanning Electron Microscopy (FESEM). The impacts of different experimental factors on the performance of the cellulase enzymes immobilized on the synthesized NiNPs and commercial nickel nanoparticles were compared. The results showed comparable optimal cellulase enzyme immobilization conditions on both substrates in terms of the immobilization time, pH, and cellulase enzyme concentration. However, the recommended temperatures for cellulase enzyme immobilization on the synthesized and commercial NiNPs were 50 °C and 40 °C, respectively. Under these optimum conditions, the immobilized cellulase enzyme on the synthesized NiNPs had an activity of about 99.1% (in comparison to the activity of free cellulase enzyme), while the activity of the enzyme upon immobilization on commercial NiNPs was about 93%. The particle size of the NiNPs was found to be crucial for enzyme immobilization efficiency and its magnetic strength. Therefore, cellulase enzyme immobilization on tunable NiNPs could be a sustainable and eco-friendly approach towards high recovery of cellulose from lignocellulosic materials.

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