Operational stability, regenerability, and thermodynamics studies on biogenic silica/magnetite/graphene oxide nanocomposite-activated Candida Rugosa lipase

ABSTRACT

Inorganic biopolymer-based nanocomposites are useful for stabilizing lipases for enhanced catalytic performance and easy separation. Herein, we report the operational stability, regenerability, and thermodynamics studies of the ternary biogenic silica/magnetite/graphene oxide nanocomposite (SiO2 /Fe3 O4 /GO) as a support for Candida rugosa lipase (CRL). The X-ray photo-electron spectroscopy (XPS), X-ray diffraction (XRD), field-electron scanning electron microscopy (FESEM), vibrating sample magnetometry (VSM), and nitrogen adsorption/desorption data on the support and biocatalyst corroborated their successful fabrication. XPS revealed the Fe3 O4 adopted Fe2+ and Fe3+ oxidation states, while XRD data of GO yielded a peak at 2θ = 11.67◦, with the SiO2 /Fe3 O4 /GO revealing a high surface area (≈261 m2 /g). The fourier transform infrared (FTIR) spectra affirmed the successful fabricated supports and catalyst. The half-life and thermodynamic parameters of the superparamagnetic immobilized CRL (CRL/SiO2 /Fe3 O4 /GO) improved over the free CRL. The microwave-regenerated CRL/SiO2 /Fe3 O4 /GO (≈82%) exhibited higher catalytic activity than ultrasonic-regenerated (≈71%) ones. Lower activation (Ea) and higher deactivation energies (Ed) were also noted for the CRL/SiO2 /Fe3 O4 /GO (13.87 kJ/mol, 32.32 kJ/mol) than free CRL (15.26 kJ/mol, 27.60 kJ/mol). A peak at 4.28 min in the gas chromatograph-flame ionization detection (GC-FID) chromatogram of the purified ethyl valerate supported the unique six types of 14 hydrogen atoms of the ester (CAS: 539-82-2) in the proton nuclear magnetic resonance (1 H-NMR) data. The results collectively demonstrated the suitability of SiO2 /Fe3 O4 /GO in stabilizing CRL for improved operational stability and thermodynamics and permitted biocatalyst regenerability.