

Nanobiocatalyst advancements and bioprocessing applications

Abstract

The nanobiocatalyst (NBC) is an emerging innovation that synergistically integrates advanced nanotechnology with biotechnology and promises exciting advantages for improving enzyme activity, stability, capability and engineering performances in bioprocessing applications. NBCs are fabricated by immobilizing enzymes with functional nanomaterials as enzyme carriers or containers. In this paper, we review the recent developments of novel nanocarriers/nanocontainers with advanced hierarchical porous structures for retaining enzymes, such as nanofibres (NFs), mesoporous nanocarriers and nanocages. Strategies for immobilizing enzymes onto nanocarriers made from polymers, silicas, carbons and metals by physical adsorption, covalent binding, cross-linking or specific ligand spacers are discussed. The resulting NBCs are critically evaluated in terms of their bioprocessing performances. Excellent performances are demonstrated through enhanced NBC catalytic activity and stability due to conformational changes upon immobilization and localized nanoenvironments, and NBC reutilization by assembling magnetic nanoparticles into NBCs to defray the high operational costs associated with enzyme production and nanocarrier synthesis. We also highlight several challenges associated with the NBC-driven bioprocess applications, including the maturation of large-scale nanocarrier synthesis, design and development of bioreactors to accommodate NBCs, and long-term operations of NBCs. We suggest these challenges are to be addressed through joint collaboration of chemists, engineers and material scientists. Finally, we have demonstrated the great potential of NBCs in manufacturing bioprocesses in the near future through successful laboratory trials of NBCs in carbohydrate hydrolysis, biofuel production and biotransformation. © 2014 The Author(s) Published by the Royal Society. All rights reserved.