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Nanobiotechnology: A Tool for improving Efficiency of Biofuel Production

Madan L. Verma[1,3]*, Munish Puri[1,2]
[1]*Centre for Chemistry and Biotechnology, Deakin University Australia*
[2]*Centre for Marine Bioproducts Development, Flinders University, Australia*
[3]*Dr Y. S. Parmar University of Horticulture and Forestry, Himachal Pradesh- 177001, India*
**Email:* madanverma@gmail.com

ABSTRACT: Nanobiotechnology is emerging as a new frontier to advance biofuel production. Robust advanced nanocarrier support has surpassed the conventional bulk support for immobilizing enzyme due to inherent features associated to nanoscale dimension like higher surface area, greater enzyme loading, higher mass transfer rate, selective, nonchemical separation from the reaction mixture and cost effectiveness. To economise the biofuel production, fragile enzyme targeted for either biodiesel or bioethanol application need to protect from the harsh environmental condition and made recyclable with the aid of nanocarrier. It is opined that such nanocarrier immobilized enzymes, callednanobiocatalyst, improve thermostability, cost-effective recyclability and quick recovery.

Keywords: Nanotechnology; enzyme; immobilization; biodiesel; bioethanol

INTRODUCTION

Nanotechnology is a fast-growing domain involving the fabrication and use of nanomaterials[1]. Nanomaterials are the advanced materials that have at least one dimension between 1 and 100 nanometers. Nanomaterials can be synthesised by physio-chemical and biological methods. Although nanomaterials production by physicochemical methods have employed harsh chemical and environmental conditions; thus, green method of nanomaterials production by biological methods is highly preferred[2]. Synthesis of nanomaterials are done by either 'bottom-up' or 'top-down' processes[3]. The properties of nanomaterials differ significantly from those of other materials because of their increased surface area and quantum effects. Recent advances in nanofabrication techniques has made many tailormade nanomaterials with unique properties such as optical, electrical, chemical and mechanical etc [4]. Nanobiotechnology, a combination of two technologies namely biotechnology and nanotechnology, has hold a great growth in multidisciplinary fields that have potential applications in food, pharmaceutical and bioenergy sectors. Various forms of nanomaterials such as nanoparticles, nanotubes and nanocomposites etc have recently employed enzyme for bioenergy production as a robust nanocarrier[5-7].

BENEFITS OF NANOCARRIER FOR ENZYME IMMOBILIZATION

Recently many research papers have appeared in many journals of repute that clearly demonstrate the importance of nanomaterial-based enzyme immobilization for potential applications in different sectors ranging from biomedical to industrial applications [2, 8-10]. Nanomaterial possesses unique extra properties that differ from bulk materials including micromaterial and micromaterial [11]. For example, nanomaterial shows exceptional property beneficial to as an enzyme carrier such as: higher surface area to volume ratios; high amenability of surface modification; high mass transfer rate; low steric hinderance; and quick enzyme separation from product [3].

NANOBIOTECHNOLOGY FOR BIODIESEL PRODUCTION

Microbial lipase has been playing a crucial role in biodiesel production [12-15]. Efficiency of enzyme has further improved with the intervention of nanotechnology. Magnetic nanoparticle was functionalized with lipase from Candida antarctica*[16]*. Magnetic nanoparticle was modified with silica coating followed by functionalization with silanization agent. Robust nanobiocatalyst showed 100% efficient transesterification process. Nanobiocatalyst showed high recyclability without loss of biocatalytic potential. Magnetic nanocomposite was synthesized by encapsulating magnetic nanoparticle into the graphene oxides [17]. Lipase sourced from Candida rugosa was immobilized on the nanobiocomposite by hydrophobic interaction via interfacial activation of the enzyme. Nanobiocatalysts showed excellent transesterification process by high yield of biodiesel production. Nanobiocatalysts showed excellent recyclability without the loss of catalytic potential of enzyme.

Robust magnetic nanocarrier was developed by using surface modification of magnetic nanoparticle with the functionalizing agents such 2,3-epoxypropyltrimethylammonium chloride [18]. Functionalized aminated magnetic nanoparticle was treated with glutaraldehyde. The lipase sourced from

Burkholderiacepacia was immobilized on the surface of the functionalized nanoparticle by anion exchange and covalent binding methods. The immobilized biocatalyst was employed for biodiesel production by using substrates of soybean oil and methanol. Nanobiocatalyst showed excellent transesterification process for biodiesel production at 12 h; It was approximately two-fold to free enzyme. Nanobiocatalysts showed excellent performance in terms of high yield of transesterification process. The immobilized biocatalysts demonstrated high operational stability and recyclability. Thangaraj et al. [19] developed nanobiocatalyst for biodiesel production by using modified magnetic nanoparticle. Magnetic nanoparticle core was coated by silica shell. It was functionalized by silanization process. Lipase was covalently bound to functionalized nanoparticle by using a glutaraldehyde crosslinker. Nanobiocatalyst showed a maximum yield of biodiesel production using methanol and oil.

The magnetic barium ferrite nanoparticle was employed for immobilizing lipase sourced from Aspergillus niger [20]. Nanobiocatalyst was used for biodiesel production using waste cooking oil and methyl alcohol. Nanobiocatalyst exhibited excellent performance by retaining approximately 90% activity even after the many recyclability studies. The biodiesel showed properties fit as per the standard parameters. For example, the measured flash point, calorific value and cetane number of biodiesel were 188 °C, 43.1 MJ/Kg and 59.5, respectively.

NANOBIOTECHNOLOGY FOR BIOETHANOL PRODUCTION

Magnetic nanoparticle was surface modified and immobilized β-glucosidase using a glutaraldehyde with different molecular weights of polyethylene glycol space-linkers [1]. Nanobiocatalyst demonstrated improved thermal activity and retained high biocatalytic activity even after ten cycles. Nanobiocatalyst was developed by entrapment of magnetic nanoparticle into the cross-linked ionic liquid and epoxy polymer [21]. Cellulase was covalently immobilised onto the surface via activation of epoxy group. Higher amount of enzyme was loaded on the surface of the nanocomposite. Nanobiocatalyst retained higher activity and improved thermal stability.

Nanobiocatalyst was developed by covalently immobilizing cellulase from Trichoderma reesei onto the chitosan modified magnetic nanoparticle [22]. Nanobiocatalyst showed higher biocatalytic activity using carboxymethylcellulose and retained higher activity. Nanobiocatalyst showed high activity towards hydrolysis of real biomass i.e., Agave atrovirens leaves. Nanobiocatalyst was developed by using two nanoparticles namely magnetic nanoparticle and silica nanoparticle [23]. The cellulase immobilized on magnetic nanoparticle showed higher catalytic activity as compared to silica nanoparticle. Magnetic nanoparticle was further employed for saccharification of ionic liquid pre-treated sugarcane bagasse and wheat straw. Magnetic nanoparticles demonstrated high hydrolysis yield. Nanobiocatalyst was developed by immobilizing cellulase from Aspergillus fumigatus onto MnO_2 nanoparticles [24]. Nanobiocatalyst showed improved stability and reusability. Robust nanobiocatalyst was developed by covalent binding of cellulase onto the surface of superparamagnetic nanoparticle [25]. Nanobiocatalyst showed high hydrolysis of microcrystalline cellulose and hemp hurds (natural cellulosic substrate). Robust nanobiocatalyst showed better storage stability, recyclability and improved thermal stability.

Nanobiocatalyst was developed by covalent immobilization ofβ-glucosidase onto the surface modified magnetic nanoparticle [6]. Robust showed improved catalytic activity towards synthetic substrate and the same studies was compared with microparticle immobilized enzyme [26]. Robust magnetic nanoparticle demonstrated high stability and fast recovery as compared to microparticle.

CONCLUSIONS

The present article critically discusses the recent technological advances made in the biofuels production through nanobiotechnology intervention. Robust nanobiocatalyst was successfully developed and employed for plethora of applications ranging from biomedical to bioenergy sector. Nanobiocatalyst was fully characterized by spectroscopy and microscopy techniques to understand the structure-function relationship at the interface of enzyme and nanomaterial. Recyclable robust nanobiocatalyst can be reused thus economising the process of biofuel production. The results of the various studies encompassing use of various novel nanomaterials for immobilizing enzymes involved in oil transesterification/biomass hydrolysis is very promising that demonstrate a sustainable biofuel production.

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