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The catalytic activity enhancement and biodegradation potential of free laccase and novel sol–gel laccase in non-conventional solvents

Nur Atikah Mohidem [a], Hanapi Bin Mat [a,b,*]

[a] Advanced Materials and Process Engineering (AMPEN) Laboratory, Faculty of Chemical Engineering, Universiti Teknologi Malaysia, 81310 UTM Skudai, Johor, Malaysia
[b] Novel Materials Research Group, Nanotechnology Research Alliance, Universiti Teknologi Malaysia, 81310 UTM Skudai, Johor, Malaysia

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ABSTRACT

The catalytic activity of free laccase and a novel sol–gel laccase (SOLAC) in ionic liquids and organic solvents was demonstrated by using 2,6-dimethoxyphenol (2,6-DMP) as a substrate. The enhancement of the catalytic activity of the SOLAC was observed and compared to the free laccase in both media. The oxidative biodegradation of *o*-chlorophenol as a model of phenolic environmental pollutants in organic media shows that the degradation was observed only when using water pre-saturated organic solvents or reverse micelle system. The SOLAC gave higher biodegradation rate in either aqueous or organic solvents, in which the optimum temperature was observed at 40 °C for the reverse micelle system as a reaction medium. All results demonstrated the potential use of the SOLAC for biodegradation of phenolic environmental pollutants in non-conventional media.

1. Introduction

Oxidoreductase biocatalysts are much sought after particularly in view of certain unsolved problems of oxidation reactions in conventional chemical process. Among oxidoreductases, laccases have attracted considerable interests due to their potential applications in many industrial and technological importances such as textile or strain bleaching, decolourisation, bio-bleaching of pulp, detoxification of xenobiotics, synthesis of polymers and biopolymers modification, chemical synthesis, bioremediation and biosensor applications (Majeau et al., 2010).

Nevertheless, the usefulness of the free laccase may often be hampered by their instability in non-conventional solvents and under other harsh conditions. In order to increase the potential use of enzymes in industrial process, immobilization is absolutely necessary for biochemical stability and reusability (Peralta-Zamora et al., 2003). The laccases stability and reusability could be achieved through immobilization which have been investigated by researchers ranging from method of adsorption (Salis et al., 2009), covalent attachment on various supports (Rekuc et al., 2010), cross-linking (Matijosyte et al., 2010), and encapsulation in reverse micelles and emulsions (Michizoe et al., 2005), organic polymers such as chitosan (Vasquez-Duhalt et al., 2001), and inorganic polymers such as sol–gel silicas (Zawisza et al., 2006).

Nowadays, biodegradation in non-conventional solvents such as organic solvents and ionic liquids has gained considerable interest as an efficient preparative approach, as the use of enzymes in non-aqueous media has numerous advantages compared to their use in conventional aqueous media (Moniruzzaman et al., 2009). Michizoe et al. (2005) demonstrated that the biodegradation rate of phenolic environmental pollutants such as bisphenol A and chlorophenols was enhanced by the surfactant-laccase complex (reverse micelle) in isooctane by appropriately adjusting the water content of the reaction medium. Singh et al. (2010) demonstrated that *Pseudomonas aeruginosa* lipase catalyzed the enantioselective transesterification of racemic phenyl ethanol and its derivative in organic solvent and ionic liquid. The use of ionic liquids offers many advantages over conventional organic solvents, such as non-flammability, low volatility, high thermal stability, broad liquid temperature ranges, good electrical conductivity, and wide electrochemical potential windows (Moriel et al., 2010). The ionic liquids (ILs) composed of organic cations and anions are molten salts at or below room temperature and thus are usually considered as "green" solvents. The use of ILs, especially hydrophobic ILs as media for enzymatic catalysis has gained increased interest in recent years (Moniruzzaman et al., 2010). Yang et al. (2010) demonstrated that both hydrolytic and transesterification activities of *Penicillium expansum* lipase were significantly enhanced in ionic liquid [BMIm][PF_6]. Besides, Khan et al. (2010) reported that various ionic liquid based on *N*-methyl *N′*-alkyl imidazolium salts

* Corresponding author at: Advanced Materials and Process Engineering (AMPEN) Laboratory, Faculty of Chemical Engineering, Universiti Teknologi Malaysia, 81310 UTM Skudai, Johor, Malaysia. Tel.: +60 75581463.
E-mail address: hbmat@cheme.utm.my (H.B. Mat).

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