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Oil-in-water microemulsions enhance the biodegradation of DDT by *Phanerochaete chrysosporium*

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ABSTRACT

A novel approach was developed using oil-in-water (O/W) microemulsions formed with non-ionic surfactant, cosurfactant (1-pentanol) and linseed oil, at the cosurfactant to surfactant ratio (C/S ratio, w/w) of 1:3 and oil to surfactant ratio (O/S ratio, w/w) of 1:10, to enhance the biodegradation of DDT by the white rot fungus *Phanerochaete chrysosporium*. Results showed that microemulsions formed with Tween 80 effectively enhanced the biodegradation of DDT by *P. chrysosporium* and the enhancement was about two times that of Tween 80 solution, while microemulsion formed with Triton X-100 exhibited negative effect. Further studies revealed that microemulsion formed with Tween 80 enhanced the biodegradation of DDT through transporting DDT from crystalline phase to mycelium as well as their positive effect on the growth of *P. chrysosporium*; of these, the former is likely the most important and pre-requisite for the biodegradation of DDT by *P. chrysosporium*.

1. Introduction

Bioremediation is considered as a major technique to decontaminate hydrophobic organic compounds (HOCs) from contaminated soils or waters because of its environmental and economic advantages over other physical–chemical remediation methods, such as low temperature thermal desorption (Percin, 1995), incineration, photodegradation (Chu, 1999) and phytoremediation (Lunney et al., 2004; Cheng and Wong, 2006; White et al., 2007). In this process, the pollutants are mainly degraded by microorganisms or some specific enzymes present in solutions, where the contaminants are available for microbial action (Harms and Bosma, 1997; Zhu and Aitken, 2010; Zhao et al., 2011). However, the hydrophobicity and low aqueous solubility of most HOCs usually result in only very slow and frequently unsatisfactory biodegradation. Therefore, overcoming the limited accessibility of these hydrophobic pollutants for the microbes or enzymes is a pivotal issue for bioremediation processes.

To date, the main approach to increase the bioavailability of HOCs is using different kinds of surfactants including synthetic surfactants (Walters and Aitken, 2001; Kim and Weber, 2003; Zhu and Aitken, 2010), natural surfactants (Kommalapati et al., 1997) and biosurfactants (Mulligan, 2005; Zhao et al., 2011) to promote their solubility and thus improve the biodegradation processes. Although many researchers have demonstrated that surfactants can stimulate the biodegradation of HOCs by increasing HOCs aqueous solubility (Guha et al., 1998; Zheng and Obbard, 2001; Zhou et al., 2007; Zhu and Aitken, 2010), the solubilizing capacity of a specific surfactant at a certain temperature is determined only by its intrinsic micelles property and thus enhancing its solubilizing capacity is usually very difficult. Therefore, continuing efforts have been made to search for new surfactants or biosurfactants with much higher solubilizing efficacy, lower cost and low microbial toxicity instead of tailored changing the micelles of a specific surfactant to enhance its solubilizing capacity.

However, our previous study has revealed that oil-in-water (O/W) microemulsions formed with non-ionic surfactants including Tween 80 and Triotn X-100, cosurfactant 1-pentanol and plant oils possess much higher solubilizing capacities for organochlorine pesticides (OCPs), e.g. 1,1,1-trichoro-2,2-bis(*p*-chlorophenyl)-ethane (DDT) and γ-hexachlorocyclohexane (γ-HCH), than their counterpart surfactant solution (Zheng et al., 2011). Compared to conventional micelles, microemulsions have much more hydrophobic and larger cores due to the incorporation of plant oil, and the cosurfactant/surfactant interfacial layer could provide additional space for the solubilization of hydrophobic solutes (Testard and Zemb, 1998). Thus, the solubilizing capacities of non-ionic surfactants including Tween 80 and Triotn X-100 can be successfully enhanced through changing their micelles to form O/W microemulsions (Zheng et al., 2011; Testard and Zemb, 1998). To date, although microemulsions have been used in soil washing and exhibit high efficiency in enhancing the solubility of some hydrophobic organic pollutants including polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) (Dierkes et al.,

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