Efficient asymmetric hydrolysis of styrene oxide catalyzed by Mung bean epoxide hydrolases in ionic liquid-based biphasic systems

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1. Introduction

Enantiopure chiral epoxides and ortho-diols play a crucial role in the synthesis of medicines, pesticides and fine chemicals (Gong and Xu, 2005), and have been employed for production of β-3-adrenergic receptor agonists, anti-obesity drugs, anticancer agents, N-methyl-o-aspartate receptor antagonists with neuroprotective properties and nematocides (Archelas and Furstoff, 2001). Among them, (S)- or (R)-1-phenyl-1,2-ethanediol (PED) is a valuable and versatile chiral building block for the synthesis of pharmaceuticals, agrochemicals, pheromones, and liquid crystals, and so on. (S)-PED can also be used as the precursor for the production of chiral biphosphines and chiral initiator for stereoselective polymerization (Nie et al., 2004). Enantiopure epoxides and ortho-diols can be prepared by chemical or biological approaches. Recently, much attention has been paid to epoxide hydrolases (EHs) capable of readily catalyzing asymmetric hydrolysis of epoxides to ortho-diols (Kumar et al., 2011; Sheng et al., 2011). Pedragosamoreau et al. (1993) first reported the asymmetric hydrolysis of styrene oxide (SO) to (R)-PED using EHs-producing Aspergillus niger LCP 521 cells, but the product e.e. was only 51%. Subsequently, EHs from various microorganisms, plants and animal tissues have been widely adopted for the biocatalytic resolution of chiral epoxides (Chiappe et al., 2007; Sheng et al., 2011). In many cases, the non-enzymatic hydrolysis of some epoxides and the relatively poor solubility of the substrates in aqueous phase resulted in a significant drop in the product e.e. and yield, thus limiting the application of the biocatalytic process in aqueous phase.

Recently, two novel EHs, capable of effectively catalyzing enantioconvergent hydrolysis of racemic p-nitrostyrene oxide to (R)-p-nitrophenyl glycol, were discovered from Mung bean and these two EHs could also catalyze (S)-SO to (R)-PED (Xu et al., 2006). Owing to its cheapness and availability, Mung bean is regarded as a very attractive source of EHs for synthetic purposes. However, due to the poor solubility of SO and its obvious non-enzymatic hydrolysis in aqueous monophasic system, both the product yield and the product e.e. of Mung bean EHs-mediated asymmetric hydrolysis of SO were quite low. In order to overcome these limitations, a biphasic system has been examined (Chen et al., 2011), where an aqueous phase contains Mung bean EHs and a water-immiscible organic phase acts as a reservoir for substrate. Despite the fact that an organic solvent-based biphasic system can partially inhibit the non-enzymatic hydrolysis of SO and thus enhance the product e.e., the use of conventional organic solvents in such processes may be problematic because they are generally toxic to biocatalysts (Gong and Xu, 2005; Baldascini and Janssen, 2005). Also, they may be explosive and are usually environmentally harmful. Hydrophobic ionic liquids (ILs) are a promising new class of alternative ‘green’ solvents that are obvious candidates for a great variety of biocatalytic transformations (Lou et al., 2009; van Rantwijk and Sheldon, 2007). However, to date...