NanoBioCat: Developing biopolymer-based and protein friendly ionic liquids assisted enzyme nano-constructs with improved efficacy for tandem biocatalysis under multiple stresses.

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INTRODUCTION

Biocatalysis has been renowned as an important industrial process applied in diverse fields such as synthesis of valuable medicinal intermediates and biofuels from renewable resources. Thus, in fine chemical, pharmaceutical industries and biorefinery for the production of alcohols, ketones, chiral amines, fermentable sugars and renewable chemicals, there is a need to use enzymes which are catalytically active as well as structurally stable. However, enzymes have evolved to work in cellular environments and are therefore usually unstable to severe reaction conditions such as high temperature, pH, oxidative stress, osmotic stress, protease digestion, chemical denaturant and use of organic solvents, which are the major obstacles to use the enzymes in industrial biotechnology. There are many research groups working on biocatalysis, wherein the enzyme used is either isolated to work under extreme conditions or via enzyme surface engineering approach. Enzyme encapsulation within nano-construct could manipulate the activity and stability of different enzymes by preserving the unfolding tendency. But, sometimes irreversible damage in the structural integrity and catalytic activity during drying and long-term storage of such materials limit their broader utility as biocatalyst. Cholinium-based ionic liquids (ILs) have been found to be a promising alternative of organic solvent in biocatalysis owing to both protein friendly nature and long-range solubility of different substrates. Therefore, combining both (enzyme surface modification and solvent manipulation), a new strategy for improving the catalytic activity and structural stability against multiple-stresses for long term storage of enzymes envisaging facile biocatalysis are presented in the NanoBioCat project (Fig. 1).

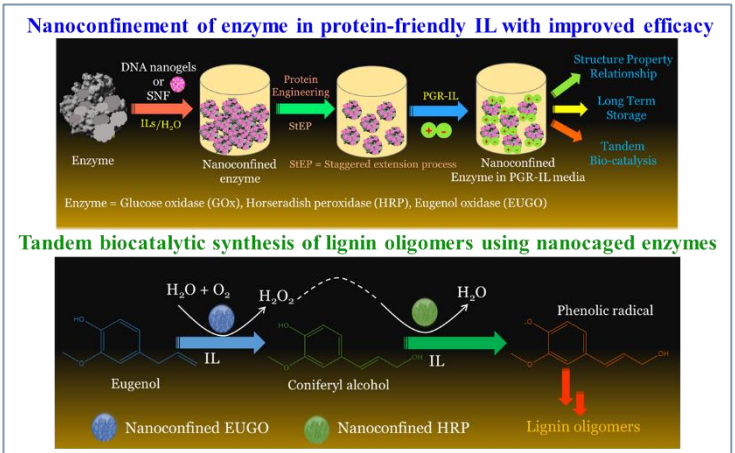

Fig. 1: Showing biopolymer-assisted nanoconfinement of enzymes in presence of ILs and tandem biocatalysis for lignin oligomer synthesis using nanoconfined enzymes in IL media.

AIM OF THE PROJECT AND APPROACH

To improve our understanding in manipulation of enzymes structure with improved catalytic activity and enhanced stability against various harsh reaction conditions, this innovative research project (NanoBioCat) aims at the creation of enzyme nano-construct based catalytically active nanobiocatalyst with improved stability in presence of plant growth regulators-based biocompatible and nontoxic ionic liquids (PRG-ILs) for tandem biocatalytic synthesis of lignin oligomers (Fig. 1).

The detailed research approach to achieve general goal of this project is divided into four research task (T). T-1: Encapsulation of enzyme in biopolymer based nanocontainers in presence of protein friendly ILs (Fig. 1); T-2: Dispersion of such enzyme nano-construct in PGR-ILs and study of long-term storage of the nano-caged enzymes at ambient condition (Fig. 1); T-3: Explore structure-property relationship, thermodynamic, kinetic, biological stabilities and catalytic activity of enzyme nano-constructs against multiple stresses; T-4: Validation of efficacy of enzyme nano-constructs in tandem biocatalytic synthesis of lignin oligomers in presence of PGR-ILs (Fig. 1).

SIGNIFICANCE OF THE PROJECT RESULTS

The field of designing robust biocatalytic process in IL is in an early stage of development. Thus, the practical demonstration of NanoBioCat project will open up a wide research area towards low-cost industrial biocatalysis in the context of green chemistry, sustainable development, environment and human wellbeing. Besides chemical science and material chemistry, the project results will also attract researchers from various scientific discipline such as nanotechnology, biotechnology, and plant science. Overall, the pioneering knowledge that will be gained from NanoBioCat project will improve our understanding to manipulate in vitro tandem biocatalysis.