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Letter to Editor Open Access

Designer Enzymes: Present and Future

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Letter to Editor

Enzymes as biocatalysts are the most challenging tools which apart from their indispensable role in maintaining metabolic and physiological homeostasis within living entities, share asignificant contribution in various industries like: pulp and paper, petroleum, leather, detergent, oil, food, feed, energy and pharmaceutical industries etc., along with their undebatable role in environmental clean-up. Application of enzymes in waste management is well established, and hence form the integral core in emerging "Green" and "White" Technologies.

The need for designer enzymes gradually emerged when the existing enzymes were found either uncompetitive or inadequate in terms of compatibility under different environmental conditions in identified applications. This led to the development of contemporary approach in the field of Enzyme technology i.e., creation of designer enzymes - the enzymes created through amalgamation of genetic and protein engineering techniques with or without opting for protein tailoring methods which may confer chemical modifications upon both existing enzymes and enzymes produced de novo. Thus, the catalytic properties of an enzyme can be tailored to a specific catalytic requirement. The designer enzyme technology may reach to successful accomplishments only through a critical aid of state of art computational chemistry and bioinformatics prior to release for evaluation under pilot, industrial or field trials.

Improvement in the catalytic abilities of existing enzymes or designing new enzymes for those reactions which are not catalyzed normally under natural conditions is a tough job. Researchers use computational methods to design the arrangement of different catalytic and functional groups inside a protein to accomplish occurrence of a desired reaction.

Yi Lu, a professor in the University of Illinois rightly said that although oxygen present in air is abundant and cheap but its conversion to useful energy requires catalysts with high efficiency and stability. The heme-copper oxidase (HCO) performs efficient four-electron reduction of oxygen to water without any release of toxic, reactive oxygen species (ROS) such as superoxide and peroxide, hence, finding importance in biogenetics, and potential applications in fuel cells. The in vitro production of HCO in bioprocess industry is a big challenge owing to huge production cost and the instability of enzyme under specific production conditions. By introducing one tyrosine and two hystidine residues into myoglobin, Lu and his colleagues were able to design an enzyme which could catalyze the reduction of oxygen to water with minimal release of reactive oxygen species (ROS) and more than thousand turnovers. The enzyme was not only smaller and cheaper, but more stable than the native enzyme. ROS not only decrease the efficiency of energy conversion reactions but are known to damage the components of the fuel cells.

The Houk and Baker group (University of Washington) collaboratively designed a Theozyme (Theoretical enzyme) in which the design of an active site with functional catalysis was achieved following inside–out approach, using quantam mechanical calculations. The computational method was advantageous in the sense that protein functionality could be optimized to bind and stabilize the transition state. Use of microbial enzymes in bioremediation has become an emerging area of research interest during the last few years. Oxidoreductases are an emerging class of enzymes known for selective oxygenation of aromatic compounds. This includes an array of monooxygenases, dioxygenases apart from three major lignolytic enzymes: LiP (Lignin peroxidise), MnP (Manganese peroxidase) and Lac (Laccase). These lignin degrading enzymes have widely been shown to play significant role in catalyizing one-electron oxidation of phenols which result in the production of cation-radical intermediates extrapolating their further use in oxidation of non-phenolic substrates. Because most of the high redox potential laccases isolated from microorganisms are recalcitrant to engineering, attempts have been made to create designer Laccase with improved catalytic activity and stability. Directed evolution to improvise the activity and level of expression of Laccases followed by rational designing has been amalgamated for the protein function engineering to achieve the desired properties in enzyme. Dioxygenases have also been engineered to improve their potential in degradation of environmental pollutants through in vitro shuffling of DNA along with exchange of domains or subunits between dioxygenase of different microbial origin. Such evolved enzymes confer enhanced degradation capacity for xenobiotic compounds of diverse origin. The upcoming revolution in the field of designer enzyme technology may foresee an intelligent employment of techniques like nanotechnology which is already toddling to stand high in the row, followed by other methods like gene shuffling and high throughput screening etc. The biggest challenge faced by the designer enzyme technology at large is their low efficiency and turnover which make their applications difficult to use under real life.

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