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Biodegradation: Enzymes Evolution

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It is well known that the vast capacities of microorganism enzymes are considered to be faultless. However, even though several enzymes of microorganisms in Nature are naturally adapted to various compounds, the evolution rate is relatively slow. The genetic biotechnology and bioengineering can accelerate and control this evolution rate. Generally, microorganism enzymes involved in degrading contaminants in the environment are highly specific for each substrate. However, when microorganisms are exposed to new substrates or growth conditions, they are able to synthesize new enzymes to yield energy and nutrients from different substrates or under new growth conditions after an acclimation period. This is because microorganism enzymes can be directly modified, modified by site-specific mutagenesis or modified in the development of biocataclytic (new enzymes) processes. For example, *Rhodococcus* sp. m15-3 can evolve a modified haloalkane dehalogenase to degrade 1,2,3-trichloropropane. In addition, microorganisms can synthesize several intermediate enzymes (e.g., tetrachloroquinone dehalogenase, adenosine deaminase and atrazine chlorohydrolase, respectively) to degrade new contaminants.

Because microorganism enzymes evolution naturally occurs in Nature and its rate is relatively slow, it is essential to control its process to use it for bioremediation. There are several techniques to control microorganism enzymes evolution such as the explosion of whole-genome sequence information, the designed pathways for precluding any biodegradation limitation, and the construction of new pathways by availability of genomic resources.

Optimization of biological remediation was often limited to only make environmental conditions for target microorganisms. Given that the environment is heterogeneous, currently released contaminants are synthesized (more persistent), and the capacity of microorganisms enzymes is infallible, it need to focus how to simultaneously control enzymes of microorganisms and habitats. The principle of bioremediation is to detoxify contaminants from a given environment using microorganisms. Most commercial bioremediation trains keep their eyes on the toxicity of end-products because that of contaminants maybe increase caused by intermediates. Several investigators showed the excellent performance for the toxicity reduction of contaminants using physicochemical, thermal and Advanced Oxidation Processes (AOPs) including ozone, ozone/UV, ozone/H_2O_2 and electron beam/gamma irradiation. AOPs have attracted great interest of scientific and engineering because they were recognized as a feasible option for detoxifying process of many refractory wastes because this processes usually use hydroxyl radicals to oxidize contaminants or reduced organic matter in soil/aqueous phase.

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