Chapter 15

Microbial Bioreactor Systems for Dehalogenation of Organic Pollutants

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ABSTRACT

Halogenated organic compounds having many beneficial applications, both in industries and agriculture sectors. Basically, the uses are as pesticides, solvents, surfactants, and plastics. However, their large, widespread uses throughout the world have resulted the negative impact on the environment. Considering their treatment process are widely accepted by using the bioreactor systems. The large variety of microorganisms present in the bioreactor and their interaction is the key to the effective treatment and removal of these compounds. Usually the microbes produce the enzymes known as dehalogenase to remove the halogen form the compounds to make it non-toxic. Many of the different steps and about the microbial groups in degradation process of halogenated compounds are well understood, but more details concerning the microbial community are yet to be discovered. This chapter describes about the different dehalogenation systems available in microbes and their ultimate application in different bioreactor systems for the degradation analysis of several harmful halogenated compounds.

INTRODUCTION

Halogenated organic compounds are the product from the industries and agriculture sectors and extensively used in many ways (Gribble, 1994; Song et al., 2000). Due to massive nature and continuous entry into the environment, the probability for the accumulation of these compounds in the habitats indicates a global threatening. For example, some of these compounds like dichloro-diphenyl trichloroethane (DDT), polychlorinated biphenyl (PCB), dioxins and halogenated flame retardants have a destructive impact on human health also these are persistent in nature (Perocco et al., 1983; Muir et al., 2006; Rees et al., 2007). An important step in the degradation of harmful organohalide compounds is the cleavage of the carbon-halogen bond and the process is known as dehalogenation. This process is mediated by a diverse

The basis of microbial dehalogenation is the induction of an enzyme of dehalogenases that basically catalyzes the cleavage of carbon–halogen (C-X) bonds (Janssen et al., 1994; Chaudhry & Chapalamadugu 2001; Van Pee & Unversucht, 2003). Microbiological dehalogenation reactions have immense particular practical interests because of their potential biotechnological applications in the bioremediation of halogenated environmental pollutants (Fishbein, 1979). Many types of dehalogenase enzymes have been discovered in the microorganisms and that corresponds to the types of the halogenated pollutant to which the microorganism is exposed. The global halogen metabolism that occurs in the environment consists of both biotic and abiotic modes of halo-dehalogenation mechanism. For the last few years the number of natural organo-halogen compounds have been discovered more than 4000 today (Gribble, 2003; Velazquez et al., 2011). Examples of the halogenated hydrocarbons which are produced from biological sources are basically chlorinated phenols and phenolic ethers, halogenated terpenes, chlorinated amino acids and peptides, halogenated alkaloids, bromo- and chloro- substituted pyrroles, chlorinated insole, halogenated thiophenes, chlorinated prostaglandins, and various antibiotics (Gribble, 2004). However the toxic effect exhibited by different organohalidic compounds and their capacity for bioaccumulation in the food chain, food web and the creation of environmental contamination is a greater concern now (Table 1). So the major efforts have been taken to degrade the halogenated substances by using the microorganisms that play a major role the major mediators for the re-cycling of these halogenated organic compounds. Therefore, it is essential to study and understand the diverse microbial effect on the biodegradation and biotransformation processes (Hardman, 1991).

**Mechanism of Microbial Dehalogenation Reaction**

This mechanism by which the toxic organic compound is converted to non-toxic metabolite by a biological organism is referred to as bioremediation. One amongst the potential bioremediation technique is dehalogenation, where the microbe has the ability to degrade halogenated toxic organic compounds (Satpathy et al., 2015). The organo-halide compounds are among the largest group of environmental chemicals and also important intermediate substances of the global halogen cycle occurring in nature. The degradation mechanisms for the halogenated substances are available in databases. Many attempts are made to replace halogenated chemicals by using microorganisms that play a major role as mediators for recycling of halogenated compounds. Thus, it is all important to study and understand the diverse microbial impact on the biodegradation and biotransformation processes (Hardman, 1991).

The study of halogenated substances in the environment and their presence in life forms open the door to understanding the carbon–halogen bond formation and cleaving process. The interdisciplinary methodology is truly essential to determine the basic nature, metabolic potential of these biochemical reactions takes place in different microbiological systems (Erable et al., 2006; Krupp et al., 2006). Different types of dehalogenase enzymes are evolved in the microorganisms to catalyze different types of the halogenated pollutant to which the microorganism is exposed. The dehalogenase enzymes from diverse microbial sources have been classified as many categories, depending upon the type of halogenated substances it degrades (Hamid et al., 2013). The eight categories of dehalogenase enzyme and the reaction mechanism of the substrate also has been described by Janssen (Janssen et al., 1994) and tabulated on the Table 2.
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