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Effect of process intensifying parameters on the hydrodynamic cavitation based degradation of commercial pesticide (methomyl) in the aqueous solution

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ABSTRACT

Methomyl, a carbamate pesticide, is classified as a pesticide of category-1 toxicity and hence shows harmful effects on both human and aquatic life. In the present work, the degradation of methomyl has been studied by using hydrodynamic cavitation reactor (HC) and its combination with intensifying agents such as H_2O_2, fenton reagent and ozone (hybrid processes). Initially, the optimization of operating parameters such pH and inlet pressure to the cavitating device (circular venturi) has been carried out for maximizing the efficacy of hydrodynamic cavitation. Further degradation study of methomyl by the application of hybrid processes was carried out at an optimal pH of 2.5 and the optimal inlet pressure of 5 bar. Significant synergetic effect has been observed in case of all the hybrid processes studied. Synergetic coefficient of 5.8, 13.41 and 47.6 has been obtained by combining hydrodynamic cavitation with H_2O_2, fenton process and ozone respectively. Efficacy of individual and hybrid processes has also been obtained in terms of energy efficiency and extent of mineralization. HC + Ozone process has proved to be the most effective process having highest synergetic coefficient, energy efficiency and the extent of mineralization. The study has also encompassed the identification of intermediate by-products generated during the degradation and has proposed the probable degradation pathway. It has been conclusively established that hydrodynamic cavitation in the presence of intensifying agents can effectively be used for complete degradation of methomyl.

1. Introduction

Large amounts of pesticides have been used across the globe for the purpose of increased cultivation; however their residues have posed serious threats to the environment and mankind [1]. Methomyl, $C_5H_{10}O_2N_2S$, is a broad spectrum insecticide which belongs to the family of oxime carbamate pesticides. It has been classified as a very toxic and hazardous pesticide by many agencies such as World Health Organization (WHO), Environment Protection Agency (EPA), European Chemical Classification (ECC), etc. It can easily cause contamination of both ground and surface water resources, due to its high solubility in water (57.9 g/L, 20 °C) and a low-sorption affinity to soils [2].

Application of Advanced Oxidation Processes (AOPs) has found to be a promising technology for the degradation of various insecticides and pesticides. AOPs are based primarily on the formation and subsequent attack of the highly reactive hydroxyl radicals, leading to the destruction/oxidation of the target pesticide compound [3]. Cavitation is an emerging AOP and not many studies have been reported for its application in the degradation of pesticides. It is the phenomena of formation, growth and collapse of large number of cavities in the liquid medium [4]. Two most important ways of generating cavitating conditions are acoustic cavitation (US) and hydrodynamic cavitation (HC). If the cavitation occurs by a passage of high frequency sound wave it is called as an acoustic cavitation and if it occurs by pressure variation in the flowing liquid due to the presence of throttling devices such as venturi, orifice etc., it is called as hydrodynamic cavitation [5]. It

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