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Recirculation Type Photocatalytic Reactor for Degradation of Monocrotophos Using TiO_2 and W-TiO_2 Coated Immobilized Clay Beads

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Abstract : Monocrotophos (MCP) is a widely used pesticide in India, which belong to an extremely toxic organophosphorus family, is persistent in nature and its toxicity is widely reported in all environmental segments in the country. Advanced Oxidation Process (AOP) is a promising solution to the problem of water pollution. TiO_2 is being widely used as a photocatalyst because of its many advantages, but it has a large band gap, due to which it is modified using metal and nonmetal dopant to make it active under sunlight and visible light. The use of nanosized powdered catalysts makes the recovery process extremely complicated. Hence the aim is to use low cost, easily available, eco-friendly clay material in form of bead as the support for the immobilization of catalyst, to solve the problem of post-separation of suspended catalyst from treated water. A recirculation type photocatalytic reactor (RTPR), using ultraviolet light emitting source (blue black lamp) was designed which work effectively for both suspended catalysts and catalyst coated clay beads. The bare, TiO_2 and W-TiO_2 coated clay beads were characterized by scanning electron microscopy (SEM), electron dispersive spectroscopy (EDS) and N_2 adsorption–desorption measurements techniques (BET) for their structural, textural and electronic properties. The study involved variation of different parameters like light conditions, recirculation rate, light intensity and initial MCP concentration under UV and sunlight for the degradation of MCP. The degradation and mineralization studies of the insecticide solution were performed using UV-Visible spectrophotometer, and COD vario-photometer and GC-MS analysis respectively. The main focus of the work lies in checking the recyclability of the immobilized TiO_2 over clay beads in the developed RTPR up to 30 continuous cycles without reactivation of catalyst. The results demonstrated the economic feasibility of the utilization of developed RTPR for the efficient purification of pesticide polluted water. The prepared TiO_2 clay beads delivered 75.78% degradation of MCP under UV light with negligible catalyst loss. Application of W-TiO_2 coated clay beads filled RTPR for the degradation of MCP under sunlight, however, shows 32% higher degradation of MCP than the same system based on undoped TiO_2. The COD measurements of TiO_2 coated beads led to 73.75% COD reduction while W-TiO_2 resulted in 87.89% COD reduction. The GC-MS analysis confirms the efficient breakdown of complex MCP molecules into simpler hydrocarbons. This supports the promising application of clay beads as a support for the photocatalyst and proves its eco-friendly nature, excellent recyclability, catalyst holding capacity, and economic viability.

Keywords : immobilized clay beads, monocrotophos, recirculation type photocatalytic reactor, TiO_2
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