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Performance evaluation of a continuous flow Photo-Impinging Streams Cyclone Reactor for phenol degradation

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ABSTRACT

In this study, an impinging streams cyclone reactor has been utilized as a novel apparatus in photocatalytic degradation of phenol. Degussa P25 TiO_2 nano particles have been applied as the photocatalyst under UV radiation. The operating parameters including catalyst loading, pH, initial phenol concentration and light Intensity have been found to affect the efficiency of the photocatalytic degradation process within this photoreactor. Photocatalytic degradation of phenol has been also investigated in a continuous flow impinging streams system. The results have shown a higher efficiency and an increased performance capability of the present reactor in comparison with the conventional processes.

Keywords: Phenol; Photo-impinging; Cyclone reactor; Degradation; TiO_2

1. Introduction

Effective removal of water pollution is an essential issue in the water treatment process. The pollution removal mechanisms can be classified as chemical oxidation technique, biochemical treatment, activated carbon adsorption and Advanced Oxidation Processes (AOPs). Photo catalytic technique is classified under AOPs. Such a process has attracted considerable attention within the last few years due to its ability to decompose a wide range of organic and inorganic pollutants at ambient temperature and pressure, without generation of harmful byproducts (Ray et al., 2007, 2009). In photocatalytic degradation processes, the catalyst suspension method excels over the immobilized or supported catalyst techniques due to the higher efficiency of the former method (Gumy et al., 2006), however, requirement of the catalyst separation after the photocatalytic treatment may be regarded as a disadvantage.

Several attempts have been made to develop suitable reactors for the treatment of organic pollutants in water. These include fluidized bed reactor, tubular reactor, batch reactor, PET bottle and rotating disk reactor (RDPR) (Vega et al., 2011; Suryaman et al., 2009; Carpio et al., 2005; Zhang et al., 2011). However, there are two essential issues in the case of liquid phase reactions: photon transfer limitations and mass transfer limitations. An ideally intensified reactor, however, should be able to integrate both maximized light efficiency and mass transfer process within a single piece of equipment.

By application of impinging streams cyclone reactors both limitations may be overcome simultaneously due to the following reasons (Royaee and Sohrabi, 2010):

(a) Increase in relative velocities between the phases.
(b) Increase in the residence time of particles due to oscillatory motion within the impingement zone.
(c) Due to excellent mixing within the impingement region the effective area for mass and heat transfer are enhanced, leading to the increase in overall heat and mass transfer rates.

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