CHAPTER 1

Introduction

1.1 Research introduction

Wastewater treatment is an increasing issue because of rapid industrial growth, global warming, environmental pollution and climate change. The available surface waters on earth (in lakes and rivers) are just 1% of the total freshwater and most of them are polluted. The development of industrial technology is becoming a factor that threatens human health and the environment. Pollutants are changing the quality of human. Photocatalysis is a well-known advanced oxidation process (AOP) for the degradation of volatile organic pollutants at mild conditions. Industrial wastewater usually contains highly toxic pollutants such as chlorophenols (CP). UV radiation from sunlight decomposes organic compounds by the oxidation process. However, the oxidation process is less effective due to the presence of the too much toxic pollutant. AOP is more effective using photodegradation by TiO_2 photocatalyst and TiO_2 was prepared by the hydrothermal method.

The semiconductor photocatalysis with a primary focus on TiO_2 as a durable photocatalyst has been applied to a variety of problems of environmental interest in addition to water and air purification (Rafique et al., 2013). TiO_2 has been proven to be the most suitable catalyst for widespread environmental applications. It has the ability to mineralize organic contaminants in wastewater to carbon dioxide and water. The reasons why TiO_2 has received addressed high attentions are due to its stable nature towards photo corrosion, ease of preparation, non-toxicity, high ultraviolet absorptivity and strong oxidizing power towards great photochemical activity (D’Auria, 2011). The physical and chemical properties of the TiO_2 powder are dependent on the synthesis methods, selection of chemicals and addition of dopants among others.

Variations in these factors lead to significant changes in TiO_2 structure, surface area phase composition, optical and electronic properties and most importantly the photocatalytic (Zainullina et al., 2015). Titanium dioxide is the most widely used photocatalyst in water treatment systems research. The reason being that is because it has a good spectral overlap with near UV radiation and high quantum efficiencies. Titanium dioxide (TiO_2) has band gap energy of 3.2 eV, equivalent to about 400 nm spectral energy. Thus, photocatalyst excited of TiO_2 is near UV radiation (300–400 nm range). A wide variety of organic contaminants, including chlorinated substances such as chlorophenols (CP) are high efficiently in aqueous suspensions or in immobilized catalytic systems on exposure to near-ultraviolet radiation.

Photocatalysis of titanium dioxide with dopants can be made by several methods, such as hydrothermal method, precipitation nutrient compliance, sol–gel and impregnation. This study utilized the hydrothermal method. Hydrothermal synthesis includes the various techniques of crystallizing substances from high-temperature aqueous solutions at high vapour pressures. Hydrothermal synthesis can be defined as a method of synthesis of single crystals that depends on the solubility of minerals in hot water under high pressure. The crystal growth was performed on an apparatus consisting of a steel pressure vessel called an autoclave, in which a nutrient was supplied along with water. Doping of TiO_2 by a hydrothermal process can enhance interfacial charge-transfer reactions of TiO_2 and it has been shown to increase the efficiency of the photocatalysis and inhibition of electron-hole recombination. The hydrothermal method is regarded as a convenient, inexpensive and environmentally innocuous method for producing high-quality TiO_2 nanotubes (Yu et al., 2003). Hydrothermal synthesis is a promising method because of the mild experimental conditions simple preparation process and lower cost (Yu et al., 2005).

Among the various organic wastes, chlorophenols are significantly harmful environmental pollutant due to their high toxicity, recalcitrance, bioaccumulation, and persistence in the environment (Dixit et al., 2011).

Chlorophenols have been widely used as bactericides, insecticides, herbicides, fungicides and wood preservative as well as intermediates of dyes (Czaplicka and Kaczmarczyk, 2006). In wastewater, 2-chlorophenol represents an important water pollutant and has been named as the priority pollutant by the USEPA citation. The stability of the C-Cl bond in halo-hydrocarbons are responsible for their toxicity and persistence in the biological environment.

The photocatalytic degradation of 2 -chlorophenol in aqueous solution using TiO_2 synthesized by hydrothermal method and determination of the effects of synthesis parameters including amount of dopant, amount of acid added during synthesis, and calcination temperature by 2^k factorial design were the main focuses of this study. The photocatalytic degradation of 2-chlorophonol were determined by different parameters.

1.2 Research objectives

1. To synthesize and characterize titanium dioxide nanoparticles by hydrothermal method for chlorophenols degradation.

2. To determine the efficiency of photocatalytic system on treating chlorophenols.

1.3 Hypothesis

Doping cerium treatment by hydrothermal method can expand the photocatalytic activity of TiO_2 down to the LED blue light visible region.

1.4 Scopes of the study

1. Hydrothermal method was adapted to prepare photocatalyst doping with cerium on TiO_2 photocatalyst in the range of 0.07 to 0.35 %mol.

2. All experiments were investigated by a batch reactor consisting of control parameters as follows;

   2.1. Light source HR 16 blue light emitting diode (LED).

   2.2. Reactor Volume: 1,000 ml.

   2.3. Catalyst semiconductor such as TiO_2 with dopants.

   2.4. The treatment time 4 – 7 hours.

3. The experiments were designed by a statistical tool called 2^k Full-Factorial Design. Variable parameters including type of photocatalyst, amount of photocatalyst, pollutant concentration, calcination temperature and amount of nitric acid were varied in order to determine the performance of the optimized photocatalyst relative to the degradation rate of chlorophenols in which were varied in the range of 0.07-0.35 %mol, 1-3 g/L, 10-50 ppm, 200-600°C and 0.05-0.15 vol HNO_3 / $Ti(OBu)_4$, respectively. The main effect factors were determined.

4. Main factors were varied delicately to find degradation effect and model.

1.5 Research contribution

1. The maximum condition were found and used as the operational condition for degradation of 2-chlorophenols, by synthesized titanium dioxide nanoparticles.

2 . The photocatalysts (synthesized titanium dioxide nanoparticles) can be workable operated under the sunlight without UV lamps.

3. The photocatalytic efficiency and economic in this research could be compared to another titanium dioxide nanoparticles researchs.