CHAPTER I

INTRODUCTION

1.1 Research motivation

During this decade, the photocatalytic process has been widely promoted by the use of TiO_2 as a catalyst to eliminate several hazardous substances in polluted air and wastewater (Linsebigler et al., 1995; Ollis, 2000). Moreover, hazardous organic substances from dyes can be dislodged to transform them into non-hazardous substances by this process (Venkata Subba Rao et al., 2003). Titanium dioxide is a semiconductor used as a non-toxic catalyst (Hoffmann et al., 1995), high stability and inexpensive (Yu et al., 1998). Regarding the TiO_2 configuration, two performing modes for photocatalysis can be recognized with the catalyst suspended or with the catalyst immobilized on materials (Dijkstra et al., 2001 (a)). When these two are compared, the suspended system has been readily used without any preparation practices could be arrogated to the absence of mass transfer limitation and the large specific surface area of the particles (Dijkstra et al., 2001 (b)). Meanwhile, the need for a separation step to recover the catalyst after treatment in the suspended system is a chief fatal flaw of this process compared to the immobilized system (Chenthamarakshan et al., 1999). Also, the other limitation is the penetration depth of the light into the slurry (Chan et al., 2000). The novel technique can help to avoid these problems by using the immobilized catalyst on carriers (Negishi et al., 1995).

In order to overcome these disadvantages, the preparation of a TiO_2 thin film has been generated by some different technical practices; for example, chemical vapor deposition, chemical spraying, electrodepositing and the sol-gel method (Parsons, 2004). The sol-gel process is simple and easy to operate and apply to complex surfaces or huge surface areas (Sonawane, 2002). A thin film catalyst is basically prepared using a sol-gel technique (Kim and Anderson, 1994). Several researchers have focused on the sol-gel method coating on carrier materials such as web-net stainless steel (Shang et al., 2003), glass plate (Nogueira and Jardim, 1996), stainless steel plate (Kajitvichyanukul et al., 2005), and alumina (Sonawane, 2002), etc.

A fixed bed reactor can be designed in which all the catalyst can be illuminated (Nogueira and Jardim, 1996). This type of the reactor has been selected for use as a developed prototype photocatalytic reactor for this research. The fixed bed photocatalytic reactor was used to study the applications and area where a solar catalytic treatment or recycling of wastewater (Freudenhammer et al., 1998). However, this research used the fixed bed photoreactor with irradiation from ultraviolet light to find the optimum synthesis conditions which were suitable for this kind of the reactor for chromium (VI) removal due to the addition of acetyl acetone used as an additive, the number of coating cycles, the calcination temperatures and the appropriate wavelength. In this case, the advantages of this photoreactor are: (1) sufficient mass transfer rates between the liquid phase and the photocatalyst surface; (2) adequate light distribution throughout the photoreactor volume; (3) cheap and easy to fabricate and operate (Mehrvar et al., 2002).

As the research in the photocatalysis progresses, it was putting more focus on the effect of the TiO_2 thin film characteristics on the photocatalytic reduction of chromium (VI) using a fixed bed photocatalytic reactor.

1.2 Research objectives

The main objective of this work was to identify the optimum synthesis conditions of the TiO_2 thin film derived from the sol-gel method using in a fixed bed photocatalytic reactor (FBPR) for chromium (VI) removal by the photocatalytic reduction.

The specific objectives were as follows:

1. To study the effect of the addition of acetyl acetone used as an additive on thin film properties and photocatalytic reduction of Cr (VI),

2. To find the optimum calcination temperatures on the film properties and the photocatalytic activities of chromium (IV) removal,
3. To investigate the effect of the dipping cycle of the sol-gel method on thin film properties and photocatalytic reduction of Cr (VI) ,
4. To discover the effect of UV-irradiation wavelengths on photocatalytic reduction of Cr (VI).

1.3 Hypothesis

The fixed bed photocatalytic photocatalytic reactor (FBPR) placed with thin films of TiO_2 on stainless steel plates derived from the sol-gel method could be used to remove chromium (VI) from wastewater via the photocatalytic reduction due to their characteristics obtaining from preparation conditions which were the addition of acetyl acetone, the number of coating cycles, the calcination temperatures and the appropriate wavelengths.

1.4 Scope of work

All of the experimental practices in this work were conducted on a laboratory scale. The scopes of this work were as follows:

1. TiO_2 thin films were prepared by the sol-gel dip-coating method.
2. Factors affecting the performance of a fixed bed photocatalytic reactor were the addition of acetyl acetone used as an additive, the number of coating cycles, the calcination temperature and the appropriate wavelength.
3. Synthetic chromium (VI) wastewater was used as the polluted water.
4. The fixed bed photocatalytic reactor was normally used as a reactor underneath the UV-irradiation.
5. The TiO_2 thin film characteristics were specifically tested for the photocatalytic intention. They did not include the optical and electrochemical aspects.

6. The kinetic study of the photocatalytic reduction was calculated; however the mechanism of the photocatalytic process for Cr (VI) removal was not included in this work.

1.5 The advantage of this work

The results attained from this work can be applied to prepare the TiO_2 thin film which is used in the photocatalytic reduction process for industrial works. In addition, this pilot scale can be sized up to be a large scale for chromium (VI) wastewater treatment plants in the future.