# CHAPTER I

# INTRODUCTION

## 1.1 Research background and motivation

In the recent years, the emission of hazardous pollutants has become very serious problem and cause different degrees of hazard to human health and environment. In order to eliminate their presence in the environment, much attention has been paid to finding practical ways to introduce efficient remediation technologies.

Photocatalysis process using titanium dioxide, $TiO_2$, as a catalyst is emerging as one of the more promising candidates for the elimination of hazardous substances in polluted air and wastewater (Linsebigler *et al.*, 1995; Ollis, 2000). Under favorable conditions, a wide range of organic and inorganic compounds can be mineralized to mineral acids, carbon dioxide and water or transformed into harmless species (Huang *et al.*, 1993; Litter, 1999). $TiO_2$ as used in the photocatalysis process always exists in two forms, one is the suspended form of fine particles dispersed in a liquid medium, and the other is the immobilized form as thin films. Although the suspended $TiO_2$ can be used without any preparation techniques, it is associated with the difficult problem of powder separation and the catalyst recycle after use. For this reason, several techniques have been developed to immobilize $TiO_2$ on different substrates with suitable properties to offer a highly active surface area, photoactivity and effective separation properties (Ding *et al.*, 2001; Srikanth *et al.*, 2001). This research is one of among several works focusing on the study of the preparation $TiO_2$ thin film using the sol-gel technique-which is the most use and appropriate technique to immobilize $TiO_2$ on substrates (Pozzo *et al.*, 1997). In addition, the application of the developed $TiO_2$ thin film to the wastewater treatment is one of the aim of this work.

Regarding to the wastewater treatment, photocatalytic reduction of Cr(VI) was experimented in this study. Cr(VI) has been classified as the most heavy metal

employed in many industrial processes. Consequently, it can be easily found in the improper discharge of effluent streams from chrome plating, electronic, timber and leather tanning industries. These effluents must be treated due to its relatively high toxicity and mobility. (Fu *et al.*, 1998). Several technologies have been used for the treatment of heavy metals, such as chemical precipitation, ion exchange, activated carbon adsorption and membrane processes. Chemical precipitation is considered as an effective treatment technology for the removal of Cr(VI) from waste streams (Ku *et al.*, 2001). However, Cr(III) sludge is remained and presented as hazardous waste that is difficult to dispose of.

In this research, $TiO_2$ thin films were prepared using titanium(IV) butoxide as a precursor, ethanol as a solvent, HCl as a acidic catalyst and acetylacetone as studied additive substance. Acetylacetone was expected to play a major role as a stabilizer in thin film preparation and it can improve the quality of the film (Liu *et al.*, 2003). The soda-lime glass was used as the substrate for the thin films due to the advantage of its properties that are corrosion resistant, commercially available, inexpensive and stable for the reaction. Furthermore, it can be applied to many shapes such as plate, bead and rod.

In this work, variation mole ratios between titanium(IV) butoxide : HCl : ethanol : acetylacetone, calcination temperatures, coating cycles and photocatalytic reduction of Cr(VI) were investigated in order to find role of each parameters and their effects on $TiO_2$ thin film preparation using sol-gel technique.

## 1.2 Research objectives

The main objective of this research was to synthesize $TiO_2$ thin film for chromium removal by photocatalysis process.

The specific objectives are as follows:

1. To investigate role of solvent to alkoxide ratio, calcination temperature and coating cycles in $TiO_2$ thin film preparation on glass plates using sol-gel technique.

2. To investigate the parameters effecting thin film properties that influence the photo-reduction efficiency of Cr(VI).

## 1.3 Hypothesis

$TiO_2$ thin film of optimum condition, prepared by using the sol-gel technique, can be used to efficiently remove Cr(VI) from industrial wastewater. The solvent to titanium alkoxide ratio, calcination temperature and coating cycle are the important factors that control the quality of the $TiO_2$ thin film.

## 1.4 Scopes of work

All experiments in this research were conducted on laboratory scale.
The scope of this work were as follows:

1. $TiO_2$ thin films were prepared by sol-gel dip-coating technique.
2. The thin film characteristics were measured for photocatalytic purposes only. This characteristic study was not involved optical and electrochemical aspects.
3. Synthetic industrial wastewater with a concentration of Cr(VI) corresponding with real wastewater was used as tested pollutant.
4. The photoreduction of Cr(VI) was tested to show the effects of thin film preparation conditions on photocatalytic efficiencies. The mechanism of Cr(VI) photoreduction was not included in this study.

## 1.5 Advantage of this work

The results obtained from this research can be beneficial for the developments of thin film $TiO_2$ preparation that can be applied for the removal of industrial wastewater containing Cr(VI) in full-scale photocatalysis reactor.