



## CHAPTER I

### INTRODUCTION

Nowadays, wastewater problems are commonly found around the world. Several wastewaters have been always produced from the industrial processes. One of the major industrial water pollutions is textile wastewater, which contains high concentrations of un-fixed dyes (about 20%). Dyes are of great concern because of their widespread use, toxic aromatic intermediates, and biorecalcitrance for traditional aerobic wastewater treatment (Chang *et al.*, 2009). A more complex environmental problem associated with the textile industry is that organic dyes are resistant to microbial degradation, and thus they can unavoidably be converted to the toxic or carcinogenic compounds. Especially, an abundant class of synthetically colored organic compounds is azo dye, such as Methyl Orange, Congo Red, and Acid Black, which is characterized by the presence of azo group ( $-N=N-$ ) bound to aromatic rings (Yang *et al.*, 2004 and Liu *et al.*, 2005).

Various methods have been developed for dye removal from wastewaters, such as physical methods (adsorption), chemical method (chlorination and ozonation), biodegradation, reverse osmosis, combined coagulation and flocculation, electrochemical oxidation, and also photocatalysis (Hinda *et al.*, 2002 and Konstantinou and Albanis, 2004). The existing physical/chemical methods have some drawbacks of being economically unfeasible (more energy and chemicals required), being unable to remove the recalcitrant azo dyes and their organic metabolites completely from such effluents, generating a significant amount of sludge that may cause secondary pollution problems, and substantially increasing the cost of these treatment methods and complicated procedures (Saratale *et al.*, 2009). However, photocatalysis is an environmentally friendly process that utilizes solar radiation energy to perform catalytic reactions under ambient conditions. Thus, photocatalysis technology has been widely investigated for pollutant eradication, with an emphasis on the development of effective photocatalysts (Puangpetch *et al.*, 2008).

Among the new oxidation methods called “advanced oxidation processes” (AOPs), heterogeneous photocatalysis appears as an emerging destructive technology due to its several advantages. First, it destroys the pollutants by degrading or transforming into less harmful substances in the presence of UV and near-UV illumination. Second, non-toxic materials can be used as semiconductor photocatalyst, such as titanium dioxide ( $\text{TiO}_2$ ). Third, this process can be operated at room temperature and atmospheric pressure. Fourth, it leads to the total mineralization of most of organic pollutants. Finally, the photocatalytic process is receiving increasing attention because of its low cost due to the use of sunlight as the source of irradiation. One of the interesting photocatalysts is strontium titanate ( $\text{SrTiO}_3$ ) due to its superior physical and chemical properties, such as its excellent thermal stability, photocorrosion resistibility, and good structure stability as the host for metal ion doping (Ohno *et al.*, 2005). Because of these advantages, there are a lot of approaches, such as solid-state reaction technique, sol-gel technique, molten salt technique, polymerized complex technique, and hydrothermal technique, developed to synthesize  $\text{SrTiO}_3$  photocatalysts as advanced materials with specific functions to achieve good photocatalytic activity (Puangpetch *et al.*, 2008). Another promising one is strontium zirconate ( $\text{SrZrO}_3$ ) since it has many important characteristics, which are suitable for high voltage and high reliability capacitor applications. It also has high dielectric constant, high breakdown strength, and low leakage current density. It also has a large optical gap of 5.6 eV (Vali, 2007). The primary photocatalytic processes occur upon irradiation of light with energy greater than or equal to the band gap of the photocatalysts, and the electrons and holes are then generated and trapped on the photocatalysts surface, subsequently producing reactive oxygen species, such as  $\text{OH}^\bullet$  and  $\text{O}_2^{\bullet -}$  radicals, to degrade organic dye pollutants. Therefore, the charge separation in the photocatalysts can be increased, and the energy needed for photoexcitation is reduced, both of which allow the photocatalysts to absorb light efficiently and to initiate the reaction rapidly (Ioannis *et al.*, 2003, and Yang *et al.*, 2004).

In the previous work, Puangpetch *et al.* (2008) studied the photocatalytic degradation of Methyl Orange (MO) monoazo dye as a model contaminant in wastewater, using mesoporous-assembled  $\text{SrTiO}_3$  nanocrystals synthesized by a

sol-gel process with the aid of a structure-directing surfactant. The effects of various synthetic conditions, including types of solvents and surfactants, calcination heating rate, and calcination temperature, with respect to the characteristics of the obtained  $\text{SrTiO}_3$  photocatalyst were studied on the photocatalytic degradation efficiency. From literature reviews, the photocatalytic degradation of azo dye by using nanocrystalline mesoporous-assembled  $\text{SrTi}_x\text{Zr}_{1-x}\text{O}_3$  (i.e.  $\text{SrTiO}_3$ - $\text{SrZrO}_3$  mixed oxide) has not yet been investigated, so this research was focused on this kind of photocatalyst. The experimental investigation was performed on the photocatalytic degradation of Acid Black 1 (AB) diazo dye as a model contaminant in textile wastewater, using mesoporous-assembled  $\text{SrTi}_x\text{Zr}_{1-x}\text{O}_3$  nanocrystals synthesized by a sol-gel process with the aid of a structure-directing surfactant without and with loaded Pt nanoparticles. The effect of Zr incorporation in the  $\text{SrTiO}_3$  photocatalyst was examined on the photocatalytic activity enhancement. Various synthetic parameters, including calcination conditions for the photocatalyst preparation and Pt loading, were mainly studied on the photocatalytic AB degradation performance.