UNIVERSITI TEKNOLOGI MARA

EFFECT OF DISSOLVED OXYGEN IN IMMOBILIZED Ag-TiO_2 AND SOLVENT IMPACT IN PHOTODEGRADATION OF REACTIVE RED 4 DYE

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ABSTRACT

Visible light active silver (Ag) modified titanium dioxide (TiO_2) photocatalysts has been widely studied. However, the presence of Ag_2O during this photocatalyst modification reduces the photocatalytic performance. This study was conducted to determine the optimum percentage of Ag loading and elucidate the effect of dissolved oxygen (DO) in forming metallic Ag (Ag^0) and Ag_2O (Ag^+) in the Ag-TiO_2. $AgNO_3$ and Degussa P25 TiO_2 were used as an Ag precursor and TiO_2 source respectively. Various purging times of nitrogen (N_2) and solvent were conducted to compare the effect of DO and solvent impact on the photocatalyst. The photocatalytic activity was determined by photodegradation of 30 mg L^{-1} RR4 dye under a 55W fluorescent lamp. The optimum photocatalytic activity of immobilized Ag-TiO_2 was obtained at 3 wt. % of Ag to TiO_2 under 30 min of N_2 purging (denoted as 3AT-DO^{30}) with a 1st order rate constant value of 0.112 min^{-1}. The photodegradation rate of immobilized Ag-TiO_2 under different concentrations of dissolved oxygen has shown different degradation rates where it was *ca.* 0.112 > 0.085 > 0.059 > 0.048 > 0.041 min^{-1} for 3AT-DO^{30}, 3AT-DO^{10}, 3AT-DO^{0}, 3AT-DO^{60} and TiO_2 respectively. For the solvent impact study, the highest performance was achieved with the water-based prepared sample with a degradation rate of 0.096 min^{-1} surpassing other solvents-prepared samples. The acquired results from XRD (32.3°, 39.6°) and FTIR (509,1384 cm^{-1}) indicated the presence of Ag^+ and Ag^0 onto TiO_2 photocatalysts. The FESEM-EDX confirmed the composition of Ag in the photocatalysts with the obtained loading are 0.2, 0.6 and 0.9 wt. % of Ag corresponding to 1AT, 3AT and 5AT. The UV-Vis/DRS for Ag-decorated samples presented a strong visible light absorption and bandgap energy reduction due to Ag's surface plasmonic resonance (SPR) effect. From photoluminescence analysis, it was observed that the intensity of the signal for Ag-TiO_2 is lower than the unmodified TiO_2 suggesting the deposition of Ag lowered the e^-/h^+ recombination. The XPS analysis indicated the composition, oxidation states, and the existence of Ag^+ and Ag^0. The combination of a specific ratio of Ag^+ and Ag^0 in the Ag-TiO_2 can reduced the e^-/h^+ recombination making the pairs able to produce hydroxyl radicals and enhance the photocatalytic performance. Therefore, the level of dissolved oxygen during the preparation of Ag-TiO_2 is significant in designing a good formation of Ag^+ and Ag^0 which can influence the photocatalytic degradation of RR4 dye.

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CHAPTER 1

INTRODUCTION

1.1 Research Background

The depletion of clean water is one of the biggest concerns nowadays as water is essential in our daily activities (Fuzil et al., 2021). One of the main constituents that pollute the water bodies is the release of untreated waste like dye from industries like textile, paint, and leather manufacturers (Cemalgil et al., 2021). The discharge of untreated coloured dyes into the water bodies has caused major distress to human health as well as to the aquatic ecosystem (Asha et al., 2021). As mentioned by Mokhtar et al. (2017), exposure of humans to these dyes can cause allergies and cancers, while for aquatic organisms, it can pose toxicity by maximizing the chemical oxygen demand (Ahsan et al., 2018). Moreover, it is difficult to degrade the organic dyes as they are stable in structure and easily soluble in water. Thus, research on the elimination of the discharged dyes in a green and energy-efficient process is highly preferred.

These days, semiconductors such as titanium dioxide (TiO_2) are widely studied by researchers worldwide to overcome environmental problems. TiO_2 is a nanomaterial that meets the criteria of a good photocatalyst in terms of stability, cost efficiency, non-toxicity, and the most important feature is the ability to degrade harmful materials (Low et al., 2017). Despite the outstanding characteristics, TiO_2 also has some limitations, for example, the fast recombination rate of photogenerated electrons and holes which can cause decrement in the photocatalytic performance. Other than that, the photocatalytic application of TiO_2 is limited because of the wide bandgap energy of 3.2 eV and is only active in the UV region. This can lead to the limitation of application under sunlight where only 6% of the energy can be utilized by the photocatalyst, as can be seen in Figure 1.1. Thus, the modification of TiO_2 is needed to overcome the limitations, where doping with metal is one of the alternatives to enhance the potential of TiO_2.