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Effect Of Ag Doped On Phase Transformation, Morphology And Photocatalytic Activity Of TiO_2 Powders

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ABSTRACT

The purpose of this research was to study the effect of doped Ag on phase transformation, morphology and photocatalytic activity of TiO_2 powders. The composites powders were prepared by sol-gel method via calcinations at a temperature 400 °C for 2 h with a heating rate of 10 °C/min. The microstructure and crystallite size of TiO_2 and TiO_2-Ag powders were characterized by XRD, EDX and SEM. Finally, photocatalytic activity was evaluated by UV-vis spectrophotometer. The results show all samples have only anatase phase and the agglomeration. It was apparent that Ag added in TiO_2 has significantly effect on photocatalytic reaction under UV irradiation. It can be noted that TiO_2-5Ag powders was found to give the highest photocatalytic, 53% under UV.

Keywords **-** Ag doping, TiO_2, Phase transformation, Morphology, Photo catalytic activity.

I. INTRODUCTION

Titanium dioxide (TiO_2) is almost the only suitable for industrial use at present and also probable in the future. This is because TiO_2 has the most photocatalytic activity, chemical stability, non-toxic nature, large band gap and low cost [1-3]. TiO_2 has three crystalline phases: anatase, brookite and rutile, being anatase the material that shows the highest photocatalytic activity, which is attributable to the low recombination rate of its photo-generated electrons and holes. However, for practical applications, the photocatalytic activity of TiO_2 needs further improvement. For this reason, much attention has been paid to doping the material with transition and noble metals, such as Pd, Pt, Rh, Au and Ag. Ag is the most promising one for the improvement of the photocatalytic activity of TiO_2. Ag increases the electron hole separation and can also facilitate the electron excitation by creating a local electric field [4].

Many approaches have been used to obtain TiO_2 powders, including inert gas condensation [5], hydrothermal processing [6], solution combustion [7], and sol–gel method [8-9]. The sol–gel method as recently developed as a general and powerful approach for preparing inorganic materials such as ceramics and glasses. In this method, a soluble precursor molecule is hydrolyzed to form a colloidal dispersion (the sol). Further reaction causes bonds to form among the sol particles, resulting in an infinite network of particles (the gel). Then the gel is typically heated to yield the desired material. This method for synthesis of inorganic materials has a number of advantages over more conventional synthetic procedures. For example, high-purity materials can be synthesized at low temperatures [10-11]. In addition, homogeneous multi component systems can be obtained by mixing precursor solutions, which allows for easy chemical doping of the materials prepared.

In the present experiments, we report on the effect of Ag doped TiO_2 powders were prepared by using a sol-gel method. The samples have been characterized using XRD EDX, SEM and UV-vis spectrophotometer. Phase transformation, crystallite size, morphology and photocatalytic activity of powders were investigated.

II. MATERIALS AND METHOD

A. Raw materials

Titanium (IV) isoproxide (TTIP, 99.9%, Fluka Sigma-Aldrich), and Silver nitrate ($AgNO_3$, 99.9%, Fluka Sigma-Aldrich),) were used as raw materials. Ethanol (C_2H_5OH, 99.9%, Merck Germany) was used as a solvent.

B. Preparations of TiO_2 and TiO_2-Ag powders

TiO_2 and TiO_2-Ag powders were prepared via a conventional sol-gel method (Fig. 1). Firstly, $AgNO_3$ to maintain the mole ratio of Ag to TiO_2 at 0, 1, 2, 3, 4 and 5 mol% of TiO_2 and TTIP with fixed at 10 ml were mixed into 150 ml C_2H_5OH and the mixture was vigorously stirred at room temperature for 15 min. The pH of mixed solution was adjusted to about 3 by 3 ml of 2 M nitric acid (HNO_3). Finally, the solution was stirred for 30 min, dried at 100 °C for 24 h and calcinations at a temperature 400 °C for 2 h with a heating rate of 10 °C/min.

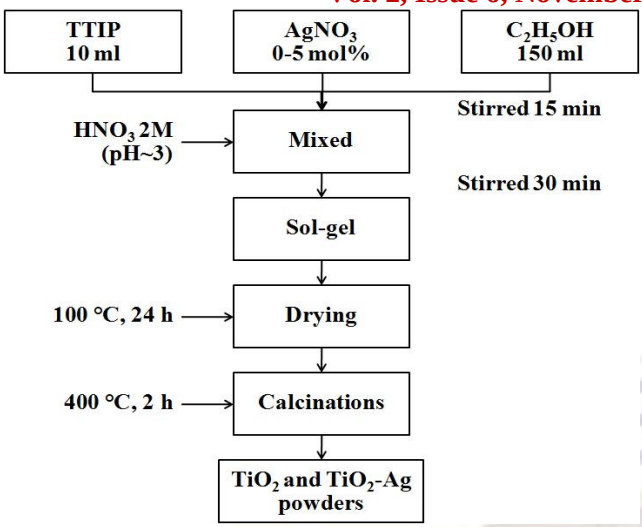


Fig. 1. The preparation produces of TiO_2 and TiO_2-Ag powders by sol-gel method

C. *Characterizations of TiO_2 and TiO_2-Ag powders*

The phase composition was characterized using an x-ray diffractometer (XRD) (Phillips X'pert MPD, Cu-K). The crystallite size was calculated by the Scherer equation, Eq.1, [12]. The morphology of the synthesized powders was characterized by Scanning Electron Microscope (SEM) (Quanta 400).

$$D = 0.9\,\lambda/\beta\cos\theta_B \qquad (1)$$

Where D is the average crystallite size, λ is the wavelength of the Cu K_α line (0.15406), θ is the Bragg angle and β is the full-width at half-maximum (FWHM) in radians.

D. *Photocatalytic activity test*

The photocatalytic activity was evaluated by the degradation of MB under UV and visible light irradiations using eleven 50W of black and fluorescent light lamps, respectively. A 10 ml of MB with a concentration of 1×10^{-5} M was mixed with 0.0375 g of TiO_2 and TiO_2-Ag powders and kept in a chamber under UV and visible light irradiation for 0, 1, 2, 3, 4, 5 and 6 h. After photo-treatment for a certain time, the concentration of treated solution was measured by UV-vis. The ratio of remained concentration to initial concentration of MB calculated by C/C_0 was plotted against irradiation time in order to observe the photocatalytic degradation kinetics.

III. RESULT AND DISCUSSION

A. *Characterizations*

The result of XRD patterns of TiO_2 and TiO_2-Ag powders are shows in Fig. 2. It was found that TiO_2 and TiO_2-Ag powders reveal that only the anatase phase. Ag-compound phase can't be verified in these XRD peaks due to a very small amount of Ag doping. The crystallite sizes of anatase phases are 20.7, 20.7, 23.6, 23.6, 23.6 and 23.6 nm for 0, 1, 2, 3, 4 and 5 mol% of Ag doping, respectively. It was found that the crystallite size increases with Ag doping due to the contribution of Ag effect. The presence of Ag and Ti in TiO_2 and TiO_2-Ag powders was determined by EDX spectra shown in Fig. 3. The result indicates the presence of Ti and Ag in the powders.

The surface morphology was observed with SEM. Fig. 4 shows surface morphologies of TiO_2 and TiO_2-Ag powders. It was seen that for both TiO_2 and TiO_2-Ag powders, the agglomeration was observed and the particle size decreases with increases Ag doping.

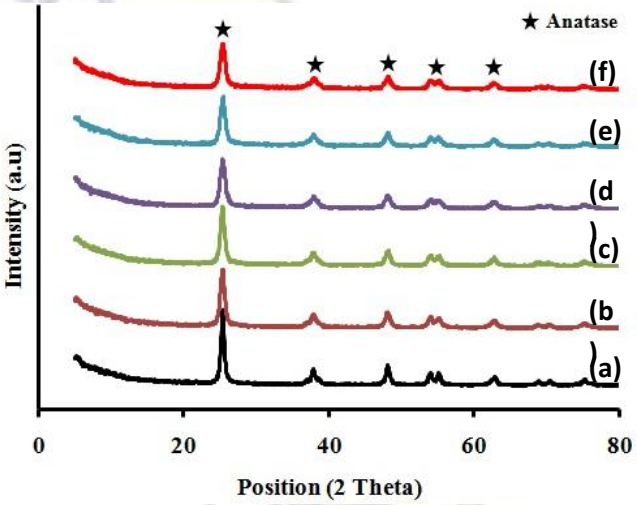
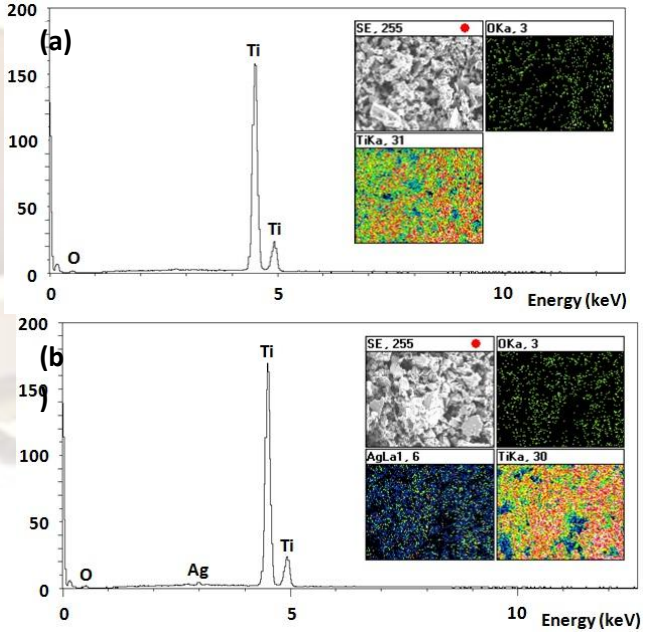


Fig. 2. XRD patterns of (a) TiO_2, (b) TiO_2-1Ag, (c) TiO_2-2Ag, (d) TiO_2-3Ag, (e) TiO_2-4Ag and (f) TiO_2-5Ag powders



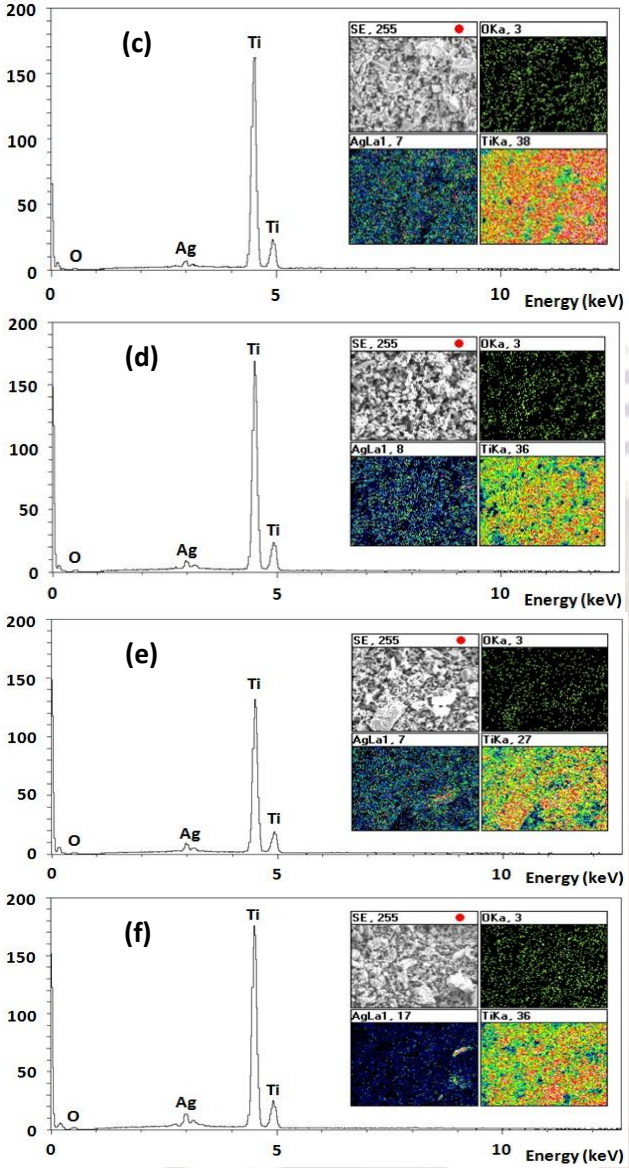
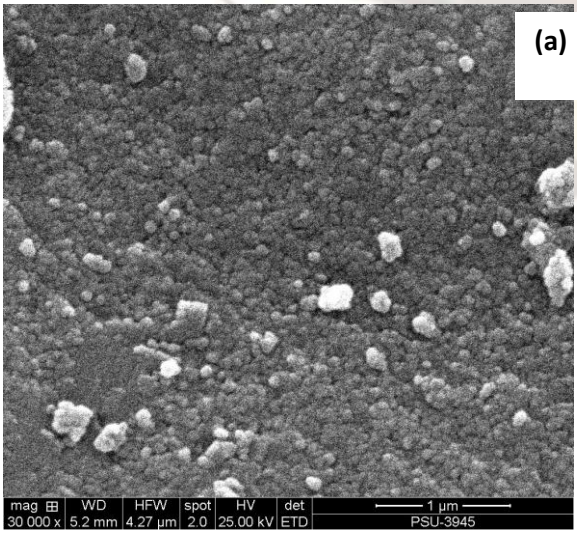
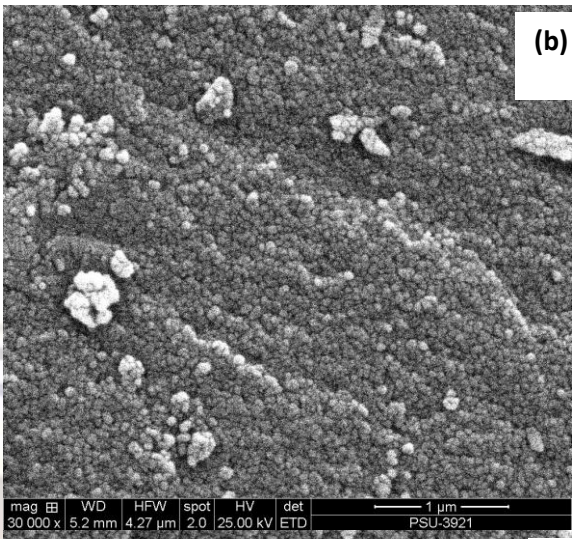
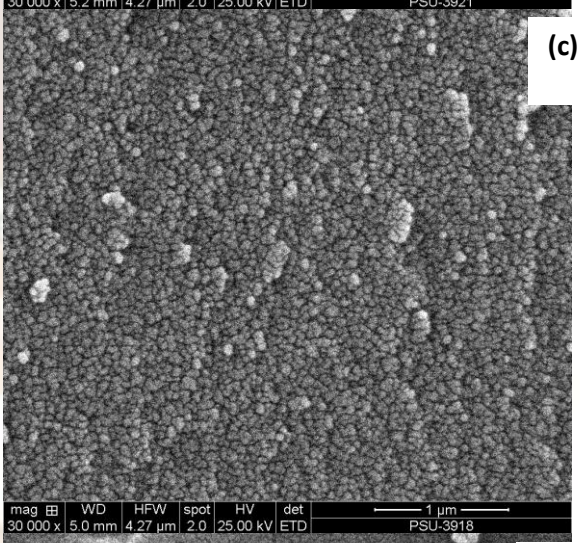
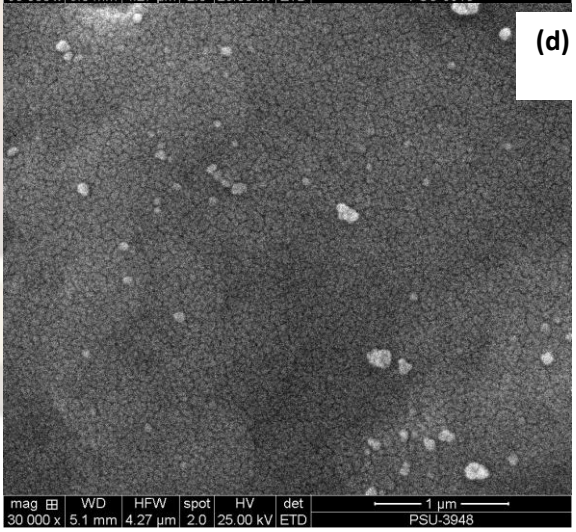


Fig. 3. EDX spectra of (a) TiO_2, (b) TiO_2-1Ag, (c) TiO_2-2Ag, (d) TiO_2-3Ag, (e) TiO_2-4Ag and (f) TiO_2-5Ag powders









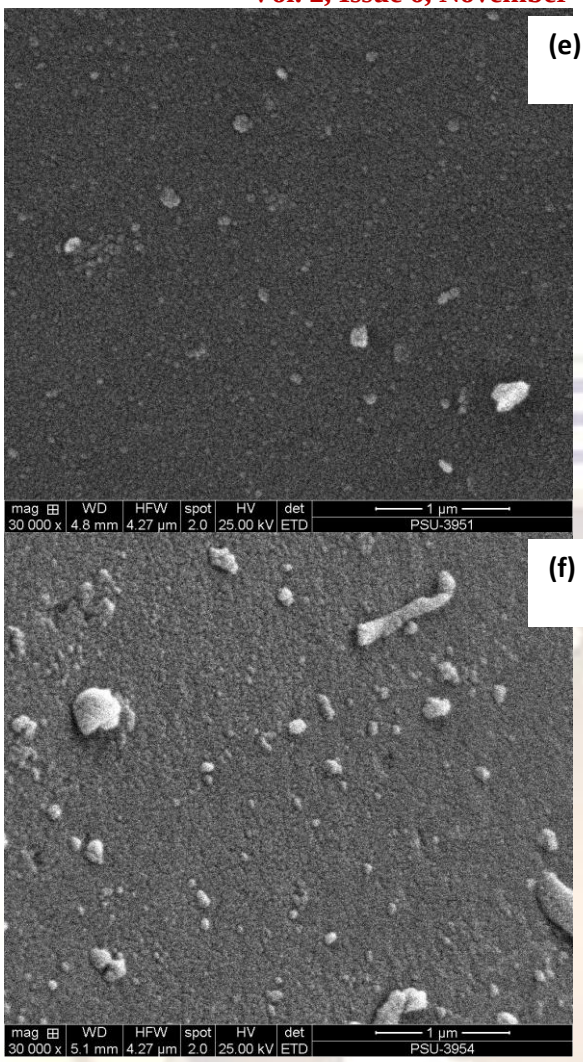


Fig. 4. SEM surface morphologies images of (a) TiO_2, (b) TiO_2-1Ag, (c) TiO_2-2Ag, (d) TiO_2-3Ag, (e) TiO_2-4Ag and (f) TiO_2-5Ag powders

B. Photocatalytic activity

The photocatalytic degradation of MB by using TiO_2 and TiO_2-Ag powders under UV irradiation is show in Fig. 5. It was apparent that Ag added in TiO_2 has significantly effect on photocatalytic reaction under UV irradiation, with the photocatalytic activity increases with increases Ag doping. The MB degradation percentage of TiO_2 and TiO_2-Ag powders under UV irradiation for 6 h are 44, 47, 48, 49, 50 and 53% for 0, 1, 2, 3, 4 and 5 mol% of Ag doping, respectively. It was found that TiO_2-5Ag powders show the best photocatalytic activity. The photos of MB concentration of before UV irradiation and after UV irradiation for 6 h of TiO_2-5%Ag powders are illustrated in Fig. 6.

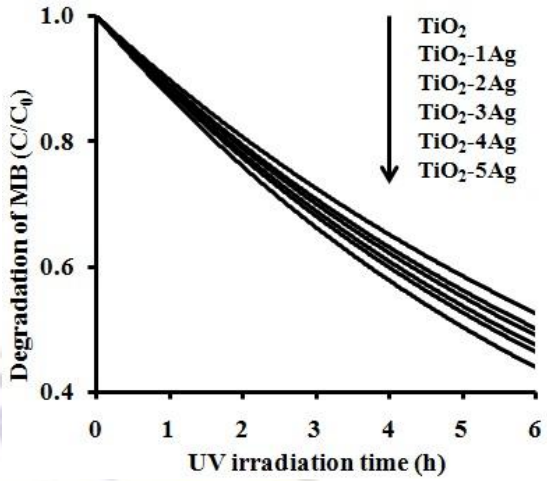


Fig. 5. Photocatalytic activity of TiO_2 and TiO_2-Ag powders

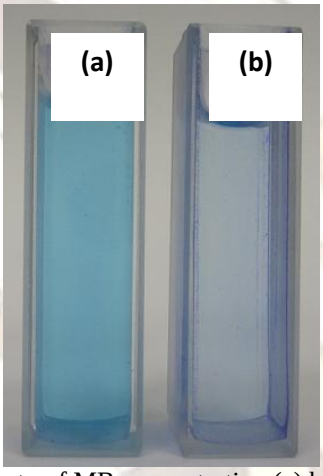


Fig. 6. Photo of MB concentration (a) before UV irradiation and (b) after UV irradiation for 6 h of TiO_2-5Ag powders

IV. CONCLUSION

1. TiO_2 and TiO_2-Ag powders reveal that only the anatase phase. All samples of TiO_2 and TiO_2-Ag powders have the agglomeration was observed and the particle size decreases with increases Ag doping.
2. The photocatalytic activity of TiO_2-Ag powders were increased when Ag doping compared with TiO_2 un-doped Ag.
3. It can be note that TiO_2 doped with 5% Ag powders exhibited higher photocatalytic under UV irradiation is 53%.

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