PHOTOCATALYTIC ACTIVITY OF TIO_2-SNO_2NANOHYBRID FOR DECOMPOSITION OF METHYL ORANGE

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Abstract- The main aim of this study is the comparison between photocatalytic activity of the single TiO_2 nanoparticles and decorated TiO_2 nanoparticles using SnO_2 nanoparticles. The X-ray diffraction (XRD) pattern of the synthesized hybrid demonstrates that the SnO_2 nanoparticles can successfully are synthesized on the surface of TiO_2 nanoparticles. The photocatalytic activity investigation of samples reveals that the decomposition of methyl orange increase with respect to the weight fraction of samples and irradiation time. Meanwhile, the results show that the photocatalytic performance of synthesize hybrids is higher than that of single TiO_2 nanoparticles.

Keywords - TiO_2 nanoparticles, SnO_2 nanoparticles, decorated, photocatalytic activity, methyl orange

I. INTRODUCTION

Titanium dioxide (TiO_2)nanoparticles are one kinds of photocatalysts which are used for decomposition of dye organic pollutants such as methyl orange (MO) and methylene blue (MB). The importance of TiO_2 nanoparticles is due to the photocatalytic activity, high stability and non-toxicity, which leads to the application of them in gas sensors, refineries, pigments and inorganic membranes [1, 2]. The major crystalline forms of TiO_2 nanoparticles are anatase, rutile and brookite. Among these three crystalline structures, the thermodynamic stability of rutile structure is more than anatase and brookite[3]. The application of TiO_2 nanoparticles as decomposer of organic pollutants leads to the degradation of pollutants to the carbon dioxide [4]. The photocatalytic performance of semiconductor nanoparticles can be related to the excitation of electron from valence band to the conduction band and preparation of electron hole pairs [5-7]. The generated electron hole pairs act as a main factor for formation of decomposer agents. Therefore, the separation of produced electron hole pairs leads to the enhancement of photocatalytic activity of semiconductor nanoparticles. One of the main procedures for separation of the produced charges is modification of semiconductor nanoparticles using other nanoparticles with higher bang gap [8-10]. Therefore, in this study we want to modify the outer surface of TiO_2 nanoparticles with SnO_2 nanoparticles to enhance the photodecomposition of MO as organic pollutants.

II. MATERIALS AND METHODS

Tetra chloride titanium ($TiCl_4$, M= 189.79, 99%, Merck) and Stannous chloride dehydrate ($SnCl_2.2H_2O$, M=225.63, Scharlau) are used as titania and tin precursors without further purification. Ethanol (C_2H_5OH, M= 32, 99%, Merck) and Ammonia solution (25%, Merck) are applied as the synthesize materials.

TiO_2 nanoparticles are synthesized according to our previous works [11, 12].
The synthesis method of the TiO_2-SnO_2 hybrids is as follow: Firstly, 1 g of the synthesized TiO_2 nanoparticles is added into 100 ml of distilled water. Then, 1 g of $SnCl_2.2H_2O$ dissolved in the prepared suspension and stirred for 15 min using a magnetic stirrer. Subsequently, for the formation of sol, 1 mL of ammonia solution is added drop wise to the above solution. Finally, the obtained sol is filtered, washed several times with distilled water, dried at 80 °C for 24 h and calcined at 520 °C for 2.5 h. the prepared samples are characterized using X-ray diffraction pattern (Cu Kα (λ =1.542°A) radiation). The photocatalytic measurements are carried out for degradation of MO (10 ppm MO aqueous solution) using a Hg vapor lamp (150 W) at different concentration of synthesized photocatalysts (0.1, 0.2 and 0.3 %wt). The concentration of MO at any intervals can be calculated according to the Equation 1 [5, 9].

$$\text{Photocatalytic performance (\%)} = \frac{A_0 - A_t}{A_0} \times 100 = \frac{C_0 - C_t}{C_0} \times 100 \quad (1)$$

The A and C refer to the absorbance and concentration of MO. The subscript of 0 and t refer to the initial and remainder parameter.

III. RESULTS AND DISCUSSION

Fig. 1 demonstrates the XRD patterns of TiO_2-SnO_2. According to this Figure, it is clear that besides the characteristic peaks of the anataseTiO_2 nanoparticles (which corresponded to the (101), (004) and (200) lattice plane), the main characteristic peaks of the SnO_2 nanoparticles can be observed. The main peaks centered at 26.57°, 33.87°, 37.95°, 51.75°and 54.75°

refer to the (110), (101), (200), (211) and (220) lattice plane of the SnO_2 nanoparticles, respectively.

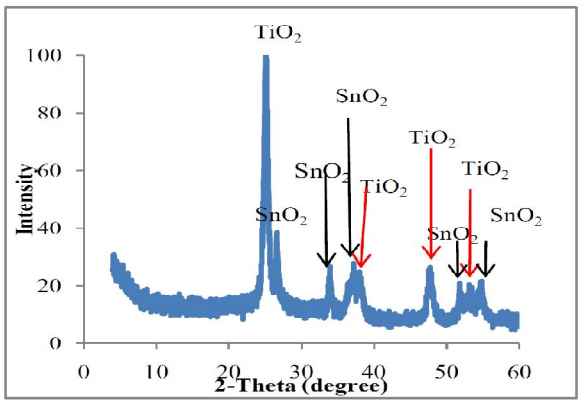


Fig. 1.XRD pattern of the TiO_2-SnO_2.

decomposition with UV irradiation time at different weight fraction of the prepared samples using TiO_2 and TiO_2-SnO_2, respectively. According to the results, it is clear that the removal efficiency of MO increased with respect to the weight fraction of the TiO_2 and TiO_2-SnO_2. The augmentation of MO decomposition using TiO_2 and TiO_2-SnO_2 can be attributed to the effect of synthesized photocatalysts concentration on the generated electron-hole pairs. Meanwhile, increasing the concentration leads to the enhancement of specific surface area that is subject to the UV irradiation. Therefore, it eventuates to the increasing the amount of exited electrons from valence band to the conduction band. Thus, the number of generated electron-hole pairs, oxidant radicals and removal efficiency of organic pollutants enhanced[13].

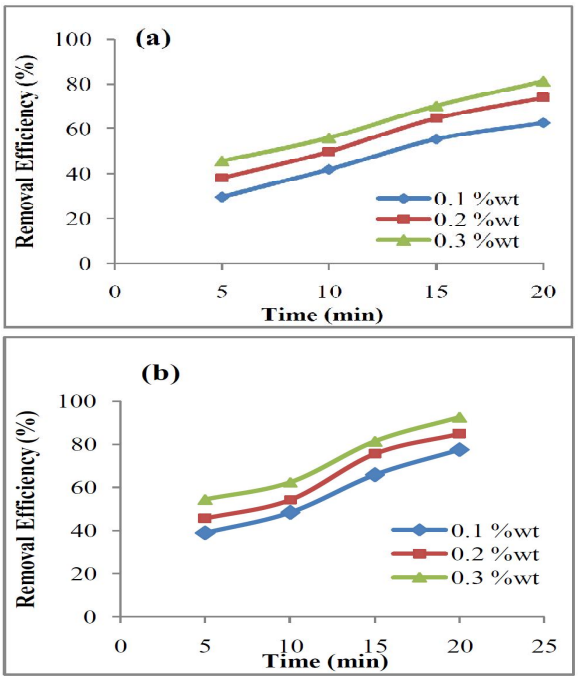


Fig. 2.Removal efficiency variation of MO using a) TiO_2, b) TiO_2-SnO_2.

The comparison among the photo degradation of MO using TiO_2 and TiO_2-SnO_2 is depicts in Fig. 3. According to this Figure, it is clear that the photocatalytic performance of TiO_2-$SnO_2$is higher than that of pure TiO_2. It can be attributed to the influence of coated SnO_2 nanoparticles on the outer surface of TiO_2 nanoparticles. According to the band gap of TiO_2 nanoparticles (3.2 eV) and SnO_2 nanoparticles (3.8 eV), it can be confirmed that the coated nanoparticles with higher band gap (SnO_2 nanoparticles) can improve the separation of the produced electron-hole pairs [5, 14]. Therefore, the separation of the generated charges prevent from the fast recombination of the produced electron-hole pairs.

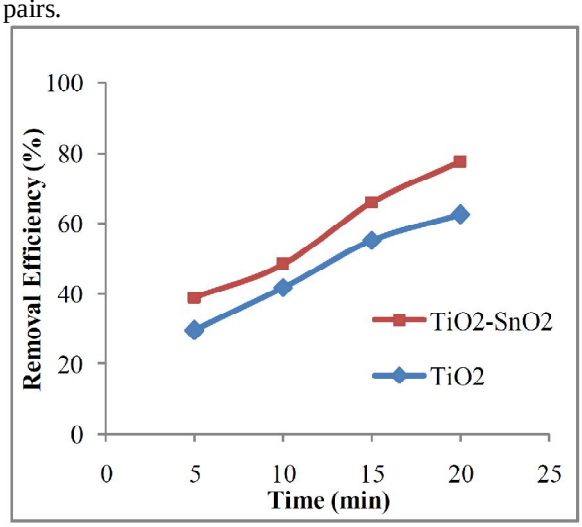


Fig. 3.Comparison of the removal efficiency of MO using TiO_2 and TiO_2-SnO_2.

CONCLUSIONS

In this study, we investigate the effect of UV irradiation time and weight fraction of synthesized photocatalysts of the photo degradation of methyl orange using single TiO_2nanoparticles and TiO_2- SnO_2 hybrid. The obtained results show that the increasing both of the studied factor lead to the enhancement of the photo degradation of pollutant. Meanwhile, the results demonstrate that the decomposition of methyl orange using TiO_2- SnO_2 hybrid is more than that of single TiO_2 nanoparticles.

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REFERENCES

[1] U. I. Gaya and A. H. Abdullah, "Heterogeneous Photocatalytic Degradation of Organic Contaminants over Titanium Dioxide: A Review of Fundamentals, Progress and Problems," Journal of Photochemistry and Photobiology C: Photochemistry Reviews, vol. 9, pp. 1-12, 2008.

[2] Y. Yan, X. Qiu, H. Wang, L. Li, X. Fu, L. Wu, and G. Li, "Synthesis of titanate/anatase composites with highly photocatalytic decolorization of dye under visible light irradiation," Journal of Alloys and Compounds, vol. 460, pp. 491–495, 2008.

[3] T. A. Kandiel, L. Robben, A. Alkaima, and D. Bahnemann, "Brookite Versus Anatase TiO_2 Photocatalysts: Phase Transformations and Photocatalytic Activities," Photochemical & Photobiological Sciences, vol. 12, pp. 602-609, 2013.

[4] Z. Li, S. Cong, and Y. Xu, "Brookite vs Anatase TiO_2 in the Photocatalytic Activity for Organic Degradation in Water," ACS Catalysis, vol. 4, p. 3273−3280, 2014.

[5] N. Roozban, S. Abbasi, and M. Ghazizadeh, "The experimental and statistical investigation of the photo degradation of methyl orange using modified MWCNTs with different amount of ZnO nanoparticles," Journal of Materials Science: Materials in Electronics, vol. 28, pp. 7343–7352, 2017.

[6] S. Abbasi and M. Hasanpour, "Variation of the photocatalytic performance of decorated MWCNTs (MWCNTs-ZnO) with pH for photo degradation of methyl orange," Journal of Materials Science: Materials in Electronics, vol. 28, pp. 11846–11855, 2017.

[7] N. Roozban, S. Abbasi, and M. Ghazizadeh, "Statistical analysis of the photocatalytic activity of decorated Multi-Walled carbon nanotubes with ZnO nanoparticles," Journal of Materials Science: Materials in Electronics, vol. 28, pp. 6047–6055, 2017.

[8] S. Abbasi, "Photocatalytic Removal of Methyl Orange in Suspension Containing ZnO and SnO_2 Nanoparticles and Investigation the Influence of Effective Variables on the Process," Iranian Journal of Health and Environment, vol. 9, pp. 433-442, 2016.

[9] S. Abbasi, S. M. Zebarjad, and S. H. N. Baghban, "Decorating and Filling of Multi-Walled Carbon Nanotubes with TiO_2 Nanoparticles via Wet Chemical Method," Engineering, vol. 5, pp. 207-212, 2013.

[10] S. Abbasi, S. M. Zebarjad, S. H. N. Baghban, and A. Youssefi, "Synthesis of TiO_2 nanoparticles and decorated multiwalled carbon nanotubes with various content of rutile titania," Synthesis and Reactivity in Inorganic, Metal-Organic, and Nano-Metal Chemistry, vol. 45, pp. 1539–1548, 2015.

[11] S. Abbasi, M.-S. Ekrami-Kakhki, and M. Tahari, "Modeling and predicting the photodecomposition of methylene blue via ZnO-SnO_2 hybrids using design of experiments (DOE) " Journal of Materials Science: Materials in Electronics, 2017.

[12] A. Ghaderi, S. Abbasi, and F. Farahbod, "Synthesis of SnO_2 and ZnO Nanoparticles and SnO_2-ZnO Hybrid for the Photocatalytic Oxidation of Methyl Orange," Iranian Journal of Chemical Engineering, vol. 12, pp. 96-105, 2015.

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