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Effect of Thickness on the Photocatalytic Performance of ZnO/SBR Composites

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ABSTRACT

Photocatalyst of zinc oxide/styrene butadiene rubber (ZnO/SBR) composite with 80/20 (wt./wt.) concentration were prepared by conventional rubber processing technique. The composite was mixed using two-roll mills at 27 °C for 10 min and compressed into a flat sheet with a thickness ranging from 0.15 to 1.08 mm. The characteristics of photocatalyst were studied by Fourier-transform infrared spectroscopy (FTIR) and ultraviolet-visible spectroscopy (UV-Vis). The photocatalyst activity of ZnO/SBR was evaluated using methylene blue (MB) as a pollutant under visible light. The ZnO/SBR with 0.54 mm thickness showed the highest performance of photodegradation of MB compared to other thicknesses. This is due to the sheet buoyancy increasing the light-capturing ability.

Keywords: *Styrene Butadiene Rubber, Zinc Oxide, Methylene Blue, Photocatalytic, Visible Light*

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INTRODUCTION

Zinc oxide (ZnO) is an efficient and the most investigated photocatalyst. It is used in many applications [1], for example, chemical sensors, biosensors, solar cells, semiconductors and drug delivery. This is credited to its unique properties like low cost, nontoxicity, high photocatalytic activity with a broad range of absorption energy and being commercially available. However, it had yet to be fully utilised for wastewater treatment due to the costly and time-consuming post-treatment recovery of loose ZnO particles. Thus, extensive research from the government and industry are carried out to immobilise photocatalyst on various substrates such as glass, reactor walls, and synthetic and natural polymers [2]. Among those, polymeric substrates are very promising in wastewater treatment.

Styrene butadiene rubber (SBR) is actively investigated as a substrate in a photocatalyst. SBR offers a wide range of qualities, such as lightweight, easily processed, economically friendly and crack endurance. However, SBR is typically used in applications such as chewing gum, shoe heels, pneumatic and rubber. The current research work by Nordin et al. [3] showed that ZnO/SBR give the highest photocatalysis performance at 80/20 (wt%) compared to ZnO blended with natural rubber (NR), epoxidised natural rubber (ENR) and ethylene propylene diene monomer (EPDM) substrates. In order to expand the usage of ZnO/SBR, it is essential to investigate the effect of photocatalyst thickness on the floating properties. This property is valuable, especially for the photocatalytic degradation of dyes in situations whereby natural sunlight is to be used as the light source. Therefore, this study studied the effect of increasing the thickness of ZnO/SBR sheets ranging from 0.15 mm to 1.08 mm on the photocatalysis of methylene blue.

EXPERIMENTAL

Materials

Styrene butadiene rubber (SBR) 1502, with a styrene content of 23.5 %, was supplied by the Malaysian Rubber Board (MRB), Selangor (Malaysia). ZnO (99.8 % purity) was purchased from CHEMETAL (Malaysia) Sdn. Bhd., Selangor (Malaysia) and methylene blue (MB) (373.88 g/mol) was obtained from HmbG Chemicals, Hamburg (Germany). In this study, the particle sizes of ZnO were in the range of 38– 90 µm.

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Composites preparation

The preparation of ZnO/SBR at a ratio of 80:20 (wt%) was carried out on a laboratory-sized two-roll mill (160×320 mm) model K-160 (China) friction ratio of rollers 1:1.4 for about 10 min. The samples were compression moulded into a specific thickness using a hydraulic press at 150 bars at 27 °C for 2 min.

Photocatalytic degradation of methylene blue (MB)

The photocatalytic degradation was investigated using MB solution as a model pollutant under visible light (7.5 W Vis-LED lamp, Philips). Photocatalytic degradation was carried out in a 29.61 l closed rectangular compartment (31.9 cm height, 34.9 cm length and 26.6 cm width) equipped with an exhaust fan in a photoreactor. About 2 g square-shaped (3×3 cm) photocatalyst samples were set afloat in a petri dish containing 60 mL MB solution (1.0 mg/l). The solutions were stirred for 15 min at 100 rpm in the dark to achieve adsorption-desorption equilibrium before testing. The photoreactor was then irradiated with constant stirring, and 5 ml of MB solution was collected at regular intervals (20 min) and centrifuged (6000 rpm for 10 min). The distance between the petri dish and the Vis lamp was fixed to 10 cm. The concentration of MB was calculated through a calibration curve of the absorbance at λ_{max} = 661 nm using a portable UV-Vis spectrophotometer (HACH DR 1900, United States of America). The photocatalytic degradation (D %) of MB was calculated from Equation (1):

$$D\ \% = \frac{C_0 - C_t}{C_0} \times 100 \qquad (1)$$

where C_0 is the initial concentration of MB (mg/l) and C_t is the concentration of MB (mg/l) at irradiation time (t).

RESULTS AND DISCUSSION

Floatability test

The floatability of the ZnO/SBR sheet depends on the right thickness. Setting the right thickness is essential in a way that it could affect light adsorption and photocatalytic performance. The thickness of the ZnO/SBR 80/20 sheet varies at 0.15, 0.30, 0.54 and 1.08 mm. With or without agitation, the 0.15 mm sheet thickness float at the air-water interface while the 1.08 mm sink at the bottom of the petri dish, as shown in Figure 1.

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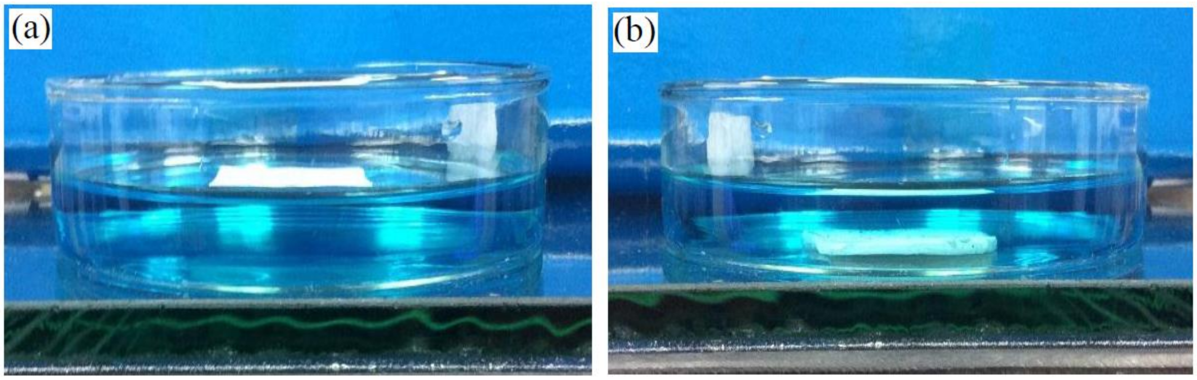

Figure 1: Photograph of (a) float and (b) sink ZnO/SBR sheet

Photocatalytic analysis of ZnO/SBR sheets

Figure 2 illustrates MB molecules' adsorption and photocatalytic decomposition with different ZnO/SBR sheet thicknesses at 360 minutes of irradiation. The thickest sheet has the highest adsorption capacity compared to any other sheet thickness (inset of Figure 2). Also, MB dye continuously decomposed for all sheet thicknesses during the entire irradiation time. The 0.54 mm sheet thickness shows the highest removal efficiency, while the thickest sheet (1.08 mm) has the lowest efficiency. Several reasons can explain the factor that leads to these results. First, the increased amount of ZnO with various sheet thicknesses followed the sequence: 1.08 > 0.54 > 0.30 > 0.15 mm. This sequence also suggests the adsorptions of MB dye on these sheets 0.15 mm. Bensouici et al. [4] reported that thicker sheet has a larger amount of mass matter, reflecting the higher adsorption process. Furthermore, the 0.54 and 1.08 mm sheets have the advantage of having both sides for adsorption due to direct contact with the MB solution (Figure 3).

Meanwhile, the light intensity decreases in an orderly manner of 0.15 > 0.30 > 0.54 > 1.08 mm. Voudoukis and Oikonomidis [5] reported that light intensity is inversely proportional to the distance of the light. Between these four sheets, the thinnest sheet has the greatest light intensity compared to other sheet thicknesses due to the closest distance between the sheet and light. Additionally, light travel at a different rate in a different medium. Light travels faster in the air between air and water due to water being denser than air [6]. The floated sheet will get more light than the sinked sheet (Figure 3). It is well known that light is responsible for the redox reactions that happen as it involves the separation of charge on the surface to generate electrons and holes. As photocatalytic is light and catalyst-dependent, the optimum condition is achieved by a 0.54 mm thickness sheet with a balanced amount of light and catalyst.

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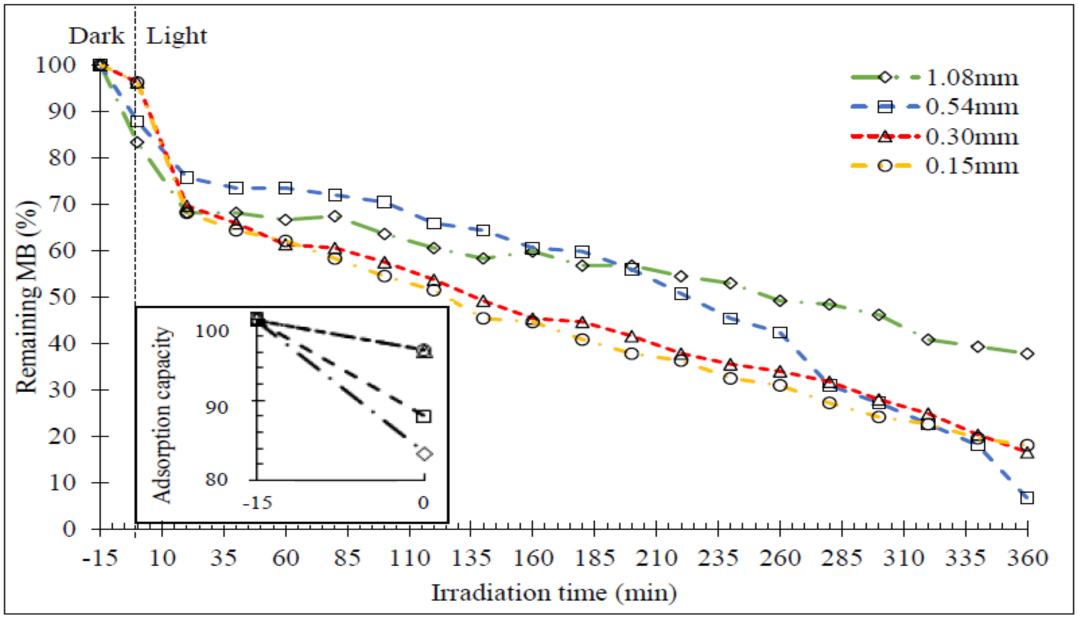

Figure 2: The remaining MB over irradiation time of ZnO/SBR with different thicknesses and its absorption capacity (inset)

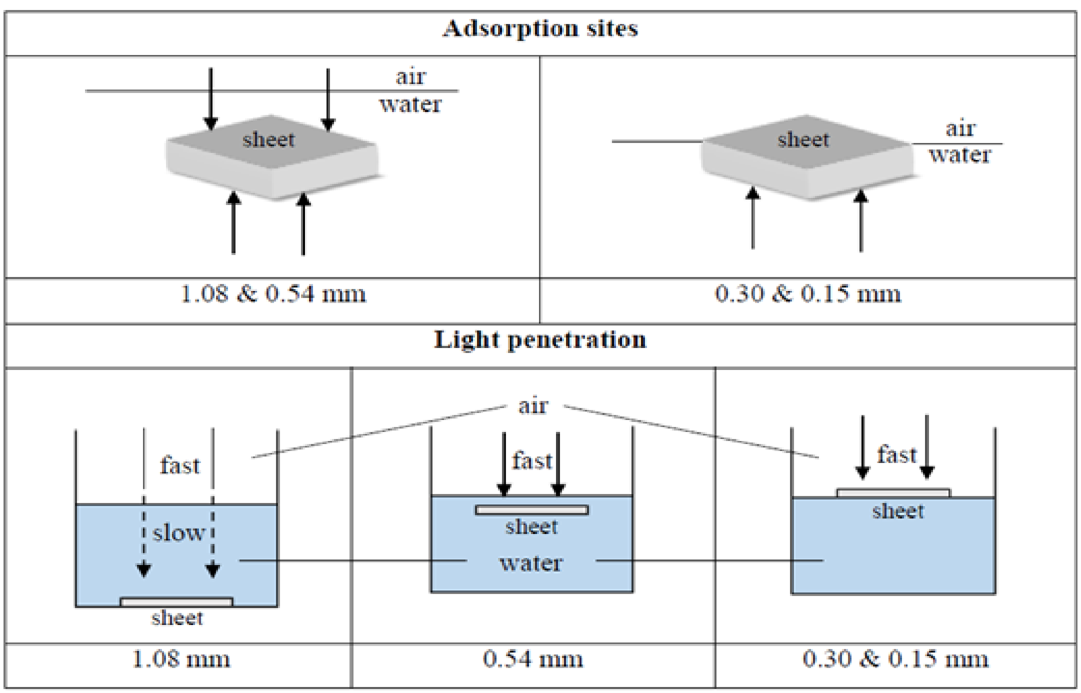

Figure 3: Adsorption sites and light penetration for different ZnO/SBR sheet thicknesses

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CONCLUSION

This study concludes that ZnO/SBR sheet with 0.54 mm thickness shows the highest efficiency (95%) and faster degradation of MB than other thicknesses. It is found that sheet buoyancy increases the light-capturing ability and dissolved oxygen. The thickest sheets have the lowest efficiency, with only 67.7 % MB dye degraded, which is attributed to light intensity reduction. Therefore, it is essential to know that the sheet thickness is not directly proportional to the photocatalytic activity.

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AUTHOR'S CONTRIBUTION

All the authors have accepted responsibility for the entire content of this submitted manuscript and approved the submission.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest regarding this article.

REFERENCES

[1] Kołodziejczak-Radzimska, A., & Jesionowski, T. (2014). Zinc oxide—from synthesis to application: a review. *Materials, 7*(4), 2833-2881. doi.org/10.3390/ma7042833
[2] Sohrabi, S., Moraveji, M. K., & Iranshahi, D. (2020). A review on the design and development of photocatalyst synthesis and application in microfluidic reactors: Challenges and opportunities. *Reviews in Chemical Engineering, 36*(6), 687-722. doi.org/10.1515/revce-2018-0013
[3] Nordin, R., Latiff, N., Yusof, R., Nawawi, W.I., Salihin, M.Z., Ishak, Z.A.M. (2020). Effect of several commercial rubber substrates for zinc oxide in the photocatalytic degradation of

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methylene blue under visible irradiation. eXPRESS Polymer Letters, 14(9), 838-847. doi.org/ 10.3144/expresspolymlett.2020.69
[4] Bensouici, F., Bououdina, M., Iratni, A., Toubane, M., & Tala-Ighil, R. (2015). Effect of thickness on photocatalytic activity of TiO 2 thin films. In *Progress in Clean Energy, Volume 1* (pp. 763-776). Springer, Cham. doi.org/10.1007/978-3-319-16709-1_56
[5] Voudoukis, N., & Oikonomidis, S. (2017). Inverse square law for light and radiation: A unifying educational approach. *European Journal of Engineering and Technology Research*, *2*(11), 23-27. doi.org/10.24018/ejeng.2017.2.11.517
[6] Brody, J., Griffin, L., & Segre, P. (2010). Measurements of the speed of light in water using Foucault's technique. *American Journal of Physics*, *78*(6), 650-653. doi.org/10.1119/1.3373942

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