Research Article

Bio-synthesized Tin Oxide Nanoparticles (SnO2 NPs) as a Photocatalyst Model

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Abstract: *In the textile industries, most of the consumers attracted to colored fabrics. Unfortunately, the substance that use to color fabrics contributes serious environmental pollution. In this work, we have designed an environmental-friendly to control the negative effect using solution-based approach. By using this method, the cost can be reduced up to one-fourth from the commercial price. The non-toxic materials of tin (iv) oxide nanoparticles (SnO2NPs) were synthesized via green bio-synthesis. Bio-synthesis was conducted using the bioactive compound in Aquilaria Malaccensis (agarwood) leaves extracts. The photocatalytic activity of methylene blue (MB) degradation was investigated. The photocatalytic degradation was found to 82 % and 80 % with the presence of UV light, and fluorescent light, respectively. Both of the measurement has been done within 70 minutes. The result shows that SnO2 NPs could be the best option for efficiently, economically, and ecologically treating dye-polluted water.*

Keywords: Tin oxide nanoparticles; Biosynthesis; Photocatalytic.

1. INTRODUCTION

The textile industry adds color to fabrics, which is the main attraction for the consumer. It is one of the most important industries in the world economy in several Asian countries. Compared to natural dyes, synthetic dyes offer excellent lightfastness, good resistance to microbial attack and temperature, color consistency, color variations, simplicity in the manufacturing process, and low price, which has encouraged their use. However, this economic activity also has a disadvantage, which is severe environmental pollution. Most countries where textiles are manufactured discharge the effluents into the mainstream, such as rivers or ponds, which later flow into the sea. It has been estimated that about 7 × 105 tons of various dyes are generated each year and more than 10,000 tons of synthetic dyes are used during the dyeing process. There are increasing reports of environmental and health hazards from dyes. The high retention capacity of dyes in the environment ensures that they persist for extended periods of time due to their superior resistance to biodegradation and thermal and photochemical stability. The presence of dyes in water affects the food chain by reducing the photosynthesis of algae. In addition, the biological activity of aquatic life is disrupted when high levels of dye molecules in water prevent the ability to reoxygenate and block sunlight. Wastewater containing dyes should be treated efficiently with an environmentally friendly technological approach to avoid harmful and undesirable effects on water resources. Currently, nanotechnology is a rapidly growing topic among the numerous interdisciplinary sciences that produce metal oxides, which are potent applications for this problem through photocatalytic processes. Green synthesis of metal oxides has attracted the attention of many researchers as it uses less polluting and aggressive materials whereby it utilized bioactive compounds (polyphenols, flavonoids, proteins and sugars) in plant parts that act as capping and reducing agents during the biosynthesis process. Therefore, this study are focusing on the synthesis of tin oxide nanoparticles (SnO2 NPs) using under biosynthesis method using the leaves extract of agarwood (gaharu) leaves and its potential is displayed by the performance under photocatalytic activity (Ismail, Akhtar, Khan, Kamal, Khan, M. Asiri, Seo & Khan, 2019; Kavitha, Baker, Rakshith, Kavitha, Yashwantha, Harini & Satish, 2022).

2. METHOD & MATERIAL

The method for the synthesis of SnO2 NPs consists of mixing the aqueous agarwood extract with a SnCl4.5H2O solution for three hours. The obtained gelatinous solution was centrifuged and dried at 80oC for 2 hours to remove the water content. The obtained black powder was then ground with mortar and pestle followed by calcination at 700oC for three hours to obtain SnO2 NPs. The synthesized powder was again crushed in mortar and pestle. The obtained powder was again crushed in mortar and pestle to perform the next characterization steps (Bhosale, Shinde, Gavade, Babar, Gawade, Sabale, Kamble, Shirke & Garadkar, 2018).

3. FINDINGS

The characterization involves FTIR analysis to determine the functional groups and XRD analysis to determine the crystallite size using Scherrer's formula equation. The next experimental part was photocatalytic activity by adding 50 mg of SnO2 NPs in 50 ml methylene blue solution (15 ppm) and stirred under UV irradiation (9 watt), whereby 2 ml of the solution was taken every hour for UV absorbance measurement.

3.1 Fourier-transform infrared Analysis (FTIR)

The analysis of FTIR confirmed the production of synthesized SnO2 NPs using an aqueous extract of agarwood leaves by having pertinent functional groups. The absorption band within region 3031-3590 cm-1 corresponds to OH vibrations due to the water absorption on the surface of the SnO2 NPs . In comparison, the absorption band at 1673 cm-1 revealed the presence of OH group derived from the water absorption during the analysis. Within region 1387, the appearance of Sn-OH group is observed, followed by absorption peak of SnO2 group at 1032 cm-1 giving more evidence of pure tin oxide construction. The strong vibration of stannous material can be observed at 1032 cm-1 which is an agreeable value from the previous reports indicating the presence of SnO2 group (Dobrucka, Dlugaszewska& Kaczmarek, 2019).

3.2.2 X-ray Diffraction Analysis (XRD)

The result of the XRD diffraction pattern of the synthesized SnO2 NPs indicated planes (110), (101), and (200) correspond to 2θ values of 26.5°, 33.7°, and 37.8°, respectively, and all peaks agree well with previous studies. Using JCPDS No. 01-077-0452, the SnO2 NPs prepared were found to have a tetragonal structure. The purity was confirmed as no other peaks were detected. Based on the sharpness of the XRD peaks, it is assumed that they are crystalline(Selvakumari, Ahila, Malligavathy & Padiyan, 2017).

4. DISCUSSION

Typical fluorescent light was used as the next experiment, which surprisingly showed little difference between the two irradiation sources. After 70 minutes of irradiation, the samples reached 83% and 80% degradation for UV and fluorescent light, respectively (Figure 1). In order to obtain the accurate kinetic data, the methylene blue degradation rate constants were calculated by first-order kinetic reaction $\ln(C/C_0) = -kt$, where C is the final concentration of the methylene blue solution, C_0 is the initial concentration of the methylene blue solution, k is the rate of reaction constant, and t is time. The obtained first-order kinetics results gave $-k$ = 0.37878 or (0.37878×10^{-3} min^{-1}), indicating that the degradation of MB 0.37878 per minute as shown in figure 2 (Ramanathan & Murali, 2022)

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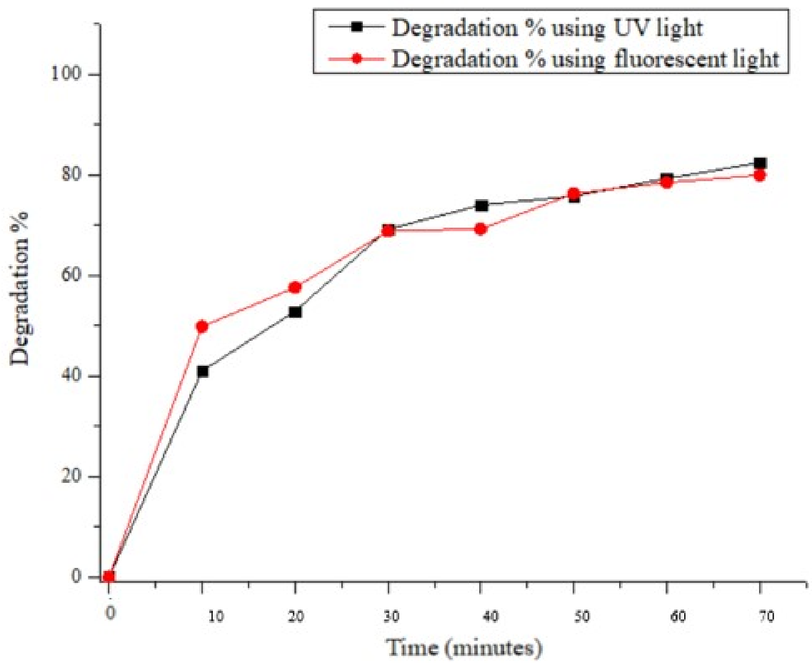

Figure 1. Percentage of methylene blue degradation

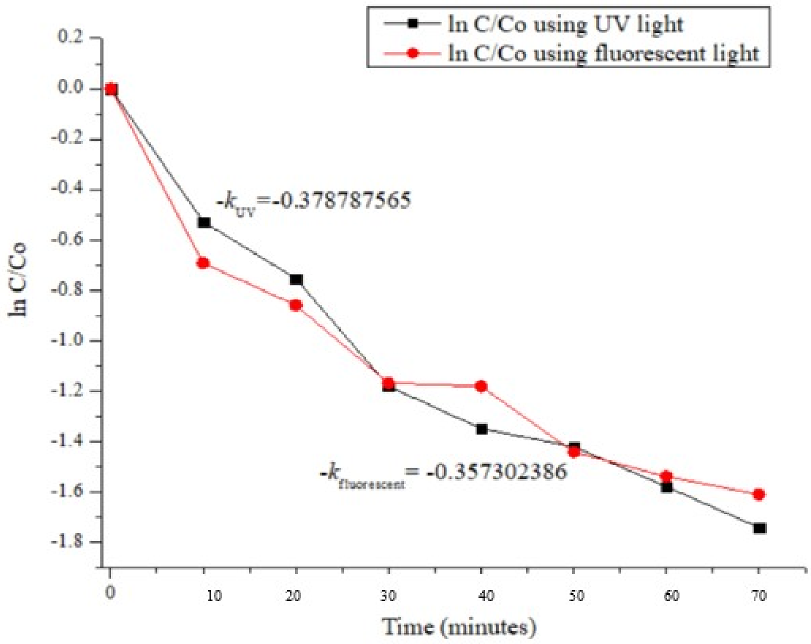

Figure 2. Rate constant of methylene blue.

5. CONCLUSION

In this proposed study, the SnO2 NPs were successfully synthesized using an aqueous extract of agarwood leaves, which is green, economical, easy to handle and nontoxic. The bioactive compounds in agarwood leaves, namely polyphenolic compounds, acted as reducing and capping agents. FTIR analysis confirmed the presence of SnO2 functional groups and XRD shows that the SnO2 NPs have a tetragonal structure. The SnO2 nanoparticles showed good photocatalytic activity using MB solution, degrading with UV light almost like a fluorescent lamp, with degradation of about 80% within 70 minutes. Hence, this low-cost and easy-to-use photocatalytic activity of SnO2 NPs offers a promising prospect for water remediation.The research results and scientific findings have remarkable implications for the development of environmentally friendly and renewable technologies. The knowledge gained through this project will encourage further activities in the field of nanotechnology in Malaysia.

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