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The Performance of ZnOCN4 in POMSE Treatment Using Photocatalytic Reactor

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Abstract : This paper reports on the performance of different loads of ZnOCN4 in POMSE treatment using a photocatalytic reactor. Palm oil mill secondary effluent (POMSE) has a high colour intensity which still has not achieved the discharged requirement by the department of environment and led to detrimental to aquatic life. The Photocatalysis process is one of the promising methods in wastewater treatment due to its advantages. Three different weight of ZnO-CN4 which is 0.09 g, 0.2 g, and 0.4 g were used in this experiment to treat POMSE using a photocatalytic reactor. The sampling of the samples were carried out from 0 to 60 minutes at 10 minutes interval. The treated POMSE was observed for the colour parameter. From this experiment, it was found that 0.09 g of ZnOCN4 gives the best performance in the color removal of POMSE.

Keywords: Zinc Oxide, Photocatalytic Reactor, Palm Oil Mill Secondary Effluent, Colour

1. Introduction

Malaysia is one of the largest producers and exporter's country of palm oil in the world. Due to the palm oil production industry continuously every year, pollution-related issues involving this palm oil mill effluent (POME) are fiercely discussed. POME high-strength wastewater derived from the processing of palm fruit. It is generated in large quantities in all oil palm-producing nations where it is a strong pollutant amenable to microbial degradation being rich in organic carbon, nitrogen, and minerals [1]. There are so much research and improvement about the POME have been done to reduce the problem encountered. In the POME, there are high amounts of organic materials and residual oil that can devalue the water quality and unconsciously can harm the environment including human health.

Palm oil mill secondary effluent (POMSE) is produced from the treatment of palm oil mill effluent (POMSE). Typically, POMSE is the result of the biological treatment of POME and is characterized by having a thick, brownish color and bad odor. Even if the effluent from the secondary treatment process

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complies with standard chemical oxygen demands (COD) and biological oxygen demand (BOD) discharge limit, it does not suffer from significant contributors to pigment contamination [2].

Advanced Oxidation Processes (AOPs) are known as promising methods for the removal of contaminants of emerging concern from wastewater effluents. Among AOPs, photocatalysis is widely studied for wastewater treatment [3]. Photocatalysis is the science of employing a catalyst that is utilized for speeding up chemical reactions that require or engage light. Photocatalysis creates strong oxidizing radicals that degrade the pollutant as for this research. The photocatalysis process decomposes and mineralizes organic contaminants into simple substances such as water (H_2O), carbon dioxide (CO_2), and mineral salts, while the membrane separates the photocatalyst from the reaction media for reuse. Photocatalysis, using nanosized semiconductor photocatalysts, is a newly emerging clean and cost-effective alternative for a large-scale treatment of water polluted with dyes and other organic compounds [4]. The advantages of using metal-oxide semiconductors, such as titania (TiO2) and zinc oxide (ZnO), are not only their high photocatalytic efficiency but also their high photosensitivity, non-toxic nature, low cost, and eco-friendliness [5].

A photocatalyst is defined as a material that is capable of absorbing light, producing electron-hole pairs that enable chemical transformations of the reaction participants and regenerate its chemical composition after each cycle of such interactions. Various types of materials with semiconductor properties have been studied as photocatalysts such as Fe_2O_3, ZnO, ZnS, CdS, SiO_2, and TiO_2. TiO_2 and ZnO are the best-possible photocatalysts to their high chemical, mechanical and thermal resistance. ZnO is a semiconductor with a high photochemical reactivity that, aside from being non-toxic, has good photocatalytic properties [6]. The utilization of ZnO as a photocatalyst has also become one of the most intensively explored areas. Many researchers have embarked on the subject of maximizing the surface area of nanoparticles to improve the performance or efficiency of the photocatalytic activity. The large specific surface area of ZnO enables more contaminants to be adsorbed onto its active surface and thus leads to more pollutants being attacked by hydroxyl radicals [7].

ZnO nanoparticles can be obtained using chemical, physical or biological methods. Chemical methods include precipitation, microemulsion, chemical reduction, sol-gel, and hydrothermal techniques, which may lead to high energy consumption when high pressure or temperature conditions are required in the process [8]. Thus, the green synthesis of ZnO nanoparticles is developed as an approach to avoid the drawbacks of synthesis by conventional methods, which were found to be more expensive and involved the use of toxic and hazardous chemicals. Green ZnO nanoparticle is used as a photocatalyst, considering green techniques eliminate the use of expensive chemicals, consume less energy, and generate environmentally friendly products and by-products [9,10]. In recent years, green synthesis of ZnO nanoparticles using different plant extracts has gained significant importance and has become one of the most preferred methods. Recently, *Cymbopogon citratus* and *Cymbopogon nardus* have shown the potential to be used in the green synthesis of photocatalysts for wastewater treatment. Sidik *et al*. [11] have synthesized green ZnO nanoparticles from *Cymbopogon citratus* for the treatment of palm oil mill secondary effluent (POMSE). Meanwhile, Kamarudin *et al*. [12] used *Cymbopogon nardus* to synthesize Ag nanoparticles for photocatalytic degradation of 2,4-dicholorophenoxyacetic acid. Ag nanoparticles have been synthesized from the alkalinized leaf extract of *Cymbopogon citratus* for antibacterial application [13].

This research would be focusing on the POMSE treatment using a photocatalytic reactor at various weights of ZnOCN4 nanoparticles. The ZnOCN4 used in this study was prepared using 4% *Cymbopogon nardus* extract from the previous study. The treated POMSE was evaluated for color removal.

2. Materials and Methods

The palm oil mill secondary effluent (POMSE) sample was collected from the Palm Oil Mill Industry in Kluang, Johor. The ZnOCN4 was selected due to its best performance compared to commercial ZnO, ZnO-CN1, ZnO-CN8, and without ZnO in the previous study. The various weight of ZnOCN4 of 0.09 g, 0.2 g and 0.4 g were used in this study. **Figure 1** shows the schematic diagram of a laboratory-scale photocatalytic reactor.

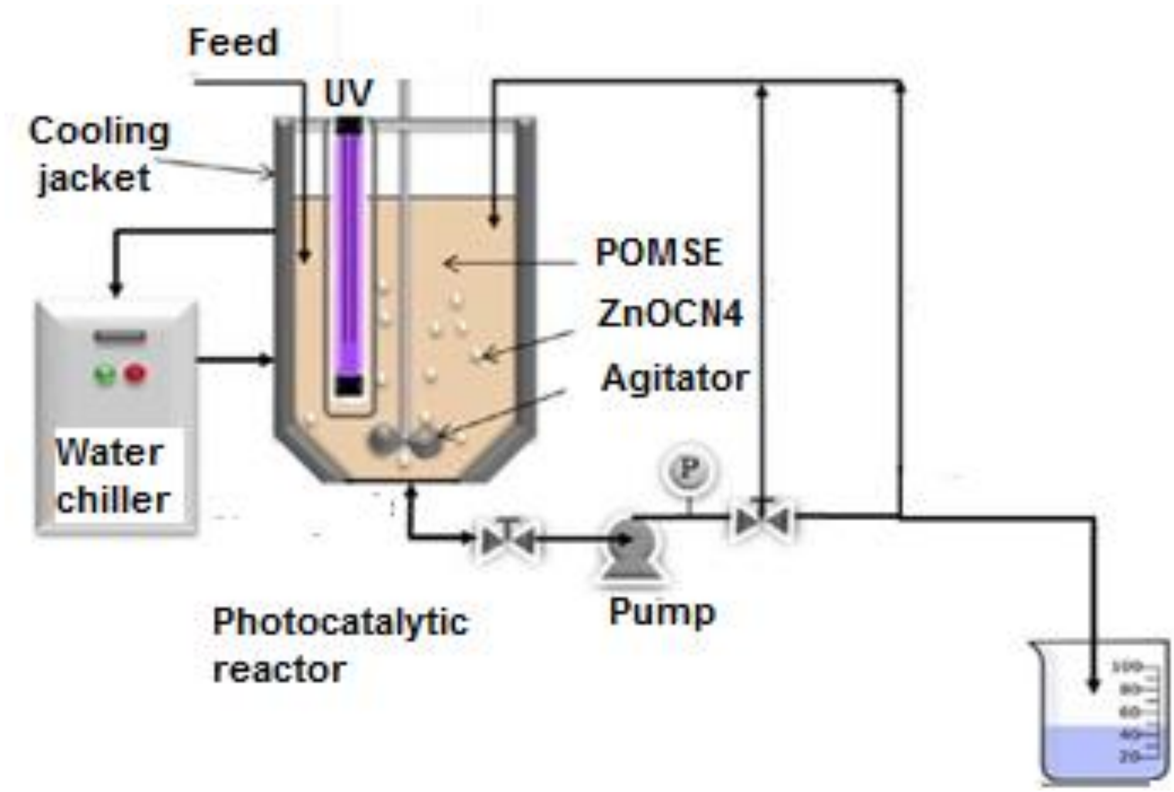

Figure 1 : Schematic diagram of a laboratory-scale photocatalytic reactor

1 L sample of POMSE was used in this study. The ZnOCN4 was added to the reactor and well agitated at 150 rpm for 30 minutes in the dark to achieve the equilibrium of the photocatalyst. The operation temperature will be kept constant at room temperature (25ºC). After 30 minutes of the photocatalysis process, the degraded POMSE was sampled at 10 minutes intervals. The treated POMSE was analysed for color using ADMI method of Hach DR6000. The percent removal of color was calculated using the following equation.

$$R = [\frac{(C_0 - C_t)}{C_0}] \times 100 \quad \textbf{Eq. 1}$$

where C_0 in **Eq. 1** is the initial colour intensity of the untreated sample, C_t is the colour intensity of treated POMSE at reaction time *t* (min).

3. Results and Discussion

Table 1 shows the performance of ZnOCN4 at various weight in POMSE treatment.

Table 1: Performance of ZnO-CN4 on three different weights

Time (min)	0.09 g ZnOCN4 (ADMI)	0.02 g ZnOCN4 (ADMI)	0.4 g ZnOCN4 (ADMI)
0	630.00	630.00	630.00

10	310.00	325.00	325.00
20	308.00	321.33	323.33
30	305.00	312.00	319.00
40	306.33	318.00	315.00
50	306.00	310.67	313.67
60	299.00	311.33	312.33

From **Table 1**, data shows the results of color for three different weight of ZnOCN4. All three data show fluctuating readings of the ZnOCN4 performance. At the end of sampling taken which is at the 60^{th} minutes, the reading show the effectiveness of ZnOCN4. For the ZnOCN4 0.09g, 0.2g and 0.4g, the color ADMI were 299.00, 311.33, and 312.33 ADMI respectively. Meanwhile, **Figure 2** shows the percentage of color removal in three different weight of ZnO-CN4. As we can see the best performance between three weight of catalyst used is 0.09g of ZnOCN4 which results in 52.54% of color removal. This was observed by looking at the end of the process result that is at minute of 60. For the ZnOCN4 weight 0.2g and 0.4g, the value of percentage of color removal is 50.58% and 50.42% respectively.

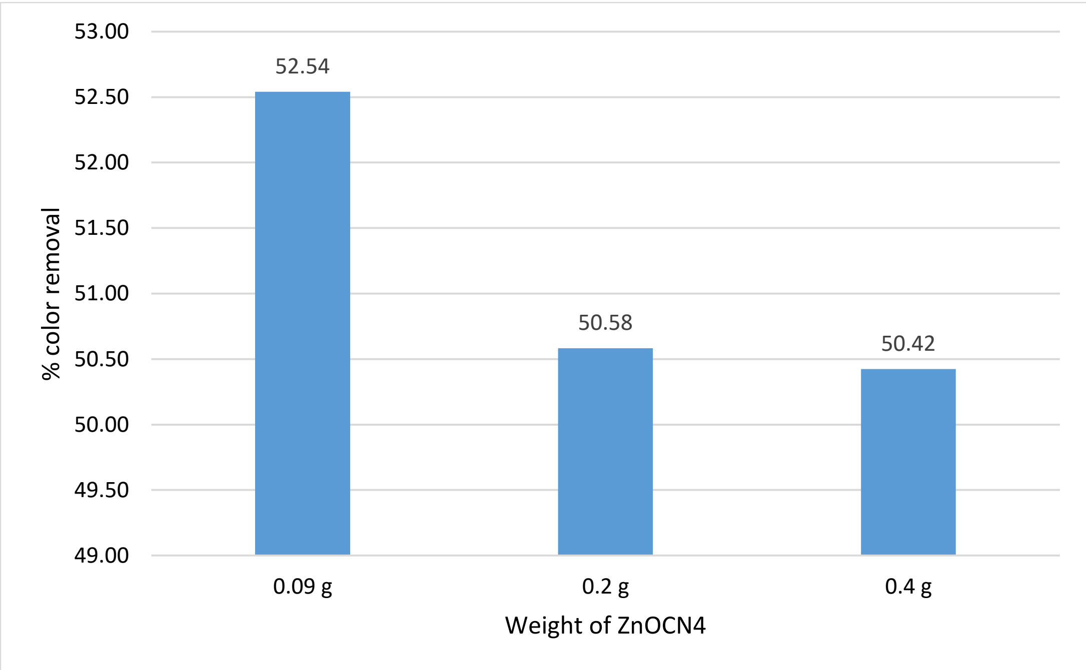

Figure 2: % color removal of POMSE at various weight of ZnOCN4

4. Conclusion

The characteristics of river water, POMSE and polluted river water were successfully characterized using photocatalytic process. From the result obtained, it can be concluded that the best performance of the removal was 52.54 % for the 0.09 g as the percent removal higher than the 0.2 g and 0.4 g of ZnO-CN 4. As a result, POMSE treatment with photocatalytic reactor-assisted ZnOCN4 nanoparticles at optimum conditions can be considered as an alternate strategy to reduce the colour. For future research, the other parameter such as BOD, COD, and turbidity can be used to analyze the treated polluted river water to strengthen the result for percent removal.

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