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Effects of pH on Adsorption of Remazol Turquoise Blue Dyez on MgO/TiO_2 Nanocomposite

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Abstract. A magnesium oxide and titanium (II) oxide nanocomposite, MgO/TiO_2 was synthesized to improve its surface area thus its adsorption capability may be risen. The synthesis was applying sol-gel method, combining MgO and TiO_2 nanoparticles with NaOH becomes a nanocomposite with higher surface area. The pH effect on adsorption were analyzed. The expectation of using MgO/TiO_2 compared with TiO_2 and MgO alone is it may react faster on an adsorption trial with remazol turquoise blue dye, and the TiO_2 may give its photocatalysis ability to the synthesized material. Less acid the condition of the solution, the capability of the MgO/TiO_2 catalyst on adsorbing the remazol turquoise blue dye will increasing. After 90 minutes, the photocatalysis rate surpass the adsorption rate and reach equilibrium.

Keywords: nanocomposite, magnesium oxide, titanium dioxide, adsorption

1. Introduction

The extraordinary properties of nanomaterials, including large surface area, small size effect, quantum effect, photosensitivity, catalytic activity, and electrochemical and magnetic properties, greatly benefit their potential applications in dye wastewater treatment [1]. The utilization of nanomaterials can be found in many studies, which some had applied as a good adsorption agent. [2] synthesized graphite oxide grafted titanate nanotubes to degrade dye pollutants in water. In another example, Selvaratnam and Koodali [3] made a TiO_2-MgO composite for solar energy conversion, conclude a good composition between oxides mixed rule its ability for water-splitting that potentially may be used for pollutant removal in gas and aqueous phases. However, the feasibility and price are important to make the development of applicable nanomaterials. Some of the well-known materials that can achieve this are titanium (Ti) and magnesium (Mg).

Titanium, especially Titanium (II) oxide (TiO_2) is a material that is widely used for water-splitting by photocatalysis mechanism. As a cheap material, TiO_2 has many beneficial characteristics such as its hydrophilicity, chemical stability, long durability, non-toxic, and its ability to degrade organic pollutants. There are many factors that may effects its removal performance including size, BET surface area, pore volume and structure, and its exposed surface facets. Park, et al. [4] had classified TiO_2 modification methods according to how the surface is modified. They are metal-loading, impurity doping, inorganic adsorbates, polymer coating, dye-sensitization, and charge transfer complexation.

Each method has a distinct effect on pollutant removal performance. Metal-loading is one of the most popular concerns, as its ease of production. Metals that can be used for the loading can be Pt, Au, Pd, Ag, and Mg whether as a noble metal or as a metal oxide, such as MgO.

The effect of pH in an adsorption process is well known as there is a charge between the surfaces of adsorbent and adsorbate. During adsorption and photocatalysis, the pH value of the solution in which the net total of the adsorbent particle charge is zero is the isoelectric point or the point of zero charges (pzc). It will become very important as it will demonstrate the variable-charge surfaces of the reaction. In this study, a MgO/TiO_2 nanocomposite will be synthesized as a catalyst that is expected it will able to do adsorption and photocatalysis for wastewater pollutants, which will be represented by remazol turquoise blue dye. The catalyst will be produced using sol-gel method. Previous study had shown that the synthesized catalyst will adsorb the remazol dye with its C=O and amides group[5]. This research will figure out more the effect of pH of the remazol turquoise blue dye to the catalyst, and see the pH_{pzc} of the synthesized catalyst. Later, the ability of the catalyst to do adsorption and photocatalysis will also be examined.

2. Research Method

The MgO nanoparticles in this research had been made with sol-gel method referencing to Moussavi and Mahmoudi [6]. To make the nanoparticles of MgO, 100 g of $MgCl_2.6H_2O$ (purity 100%) was initially diluted in 500 mL of dd-water in a 1 liter of an erlenmeyer flask. In the mixture, 50 mL of 1 N NaOH solution was added. The fusion was then vigorously stirred for 4 hours to generate the magnesium hydroxide precipitates. The formed suspension was then sentrifuged at 2500 rpm for 5 minutes to get the $Mg(OH)_2$ gel. Obtained gel was then washed with dd-water, dried at 60 °C for 24 hours. Finally, the dried powder was calcinated in air at 450 °C for 2 hours, and the MgO nanoparticles is ready.

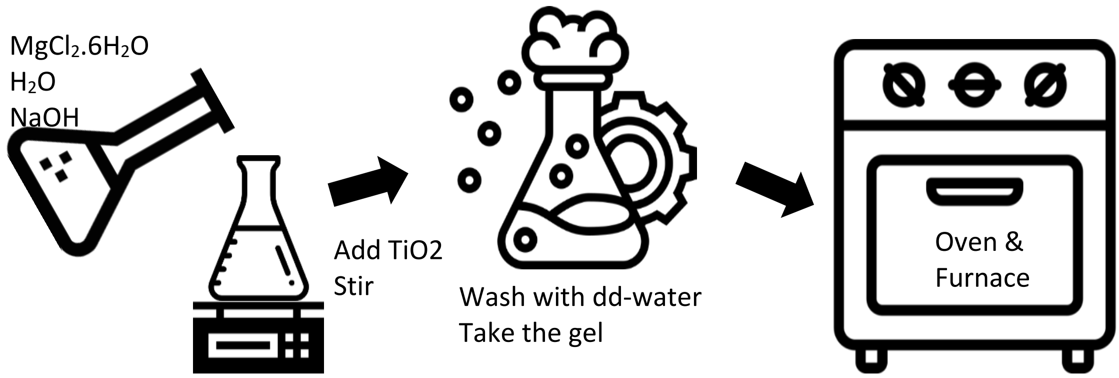

Figure 1. Procedure on synthesize of the MgO/TiO_2

The procedure to prepare the MgO/TiO_2 nanocomposite is similar with the method to prepare the MgO nanoparticles. The difference is in the first step during mixing the $MgCl_2.6H_2O$ with dd-water, an amount of TiO_2 P25 (Purity 100%) is added, then the next steps are similar.

The dye solution in this study is prepared using commercial remazol blue dye. To prepare the dye solution a 500 mg of the dye powder was weighted, and then mixed with dd-water in a 1000 mL of volumetric flask. Adsorption of the remazol experiment was held on a 50 mL closed reaction bottle. The pH was studied by varying pH from 1.75 – 13.2, with 0.05 g of MgO/TiO_2 and 50 mL of 75 mg/L remazol blue. To vary the pH, 0.1 M of NaOH and HCl were added dropwise.

3. Result and Discussion

A study on pH can reveal information about how is an adsorbent adsorp pollutant in water, especially with its dependency on electrostatic attraction. Here, the pH was studied by varying pH from 1.75 – 13.2, with 0.05 g of MgO/TiO_2 and 50 mL of 75 mg/L remazol blue. To vary the pH, 0.1 M of NaOH and HCl were added dropwise. The result can be seen in Figure 3. From the figures, it is obvious that MgO/TiO_2 (0.25) on adsorbing remazol blue has a strong dependency on the solution's pH. Higher adsorption capacity as the pH increases maybe caused by the deprotonation of oxygen-containing surface groups (amide groups) which favors the adsorption of cationic ions from the remazol solution through electrostatic attraction.

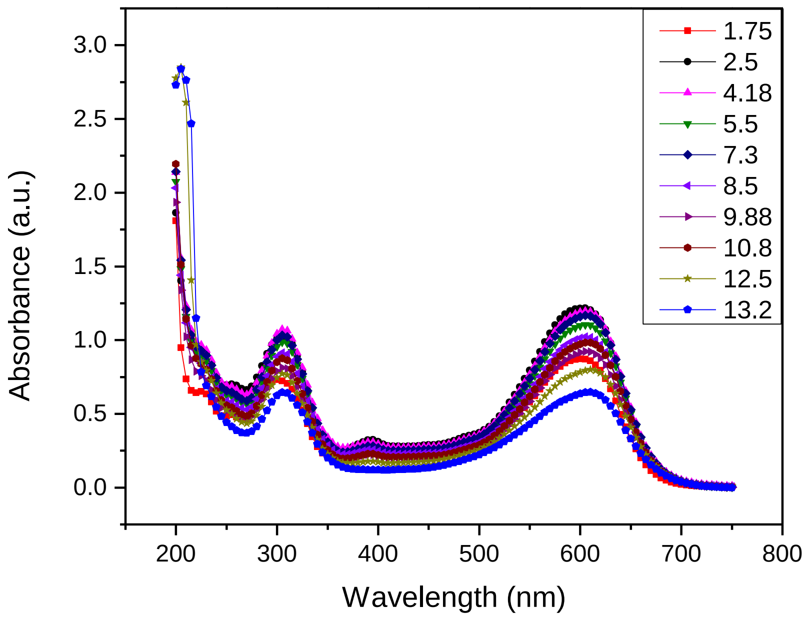

Figure 2. UV-Vis absorption spectrum of remazol blue treated with MgO/TiO2 (0.25) with different intial pH

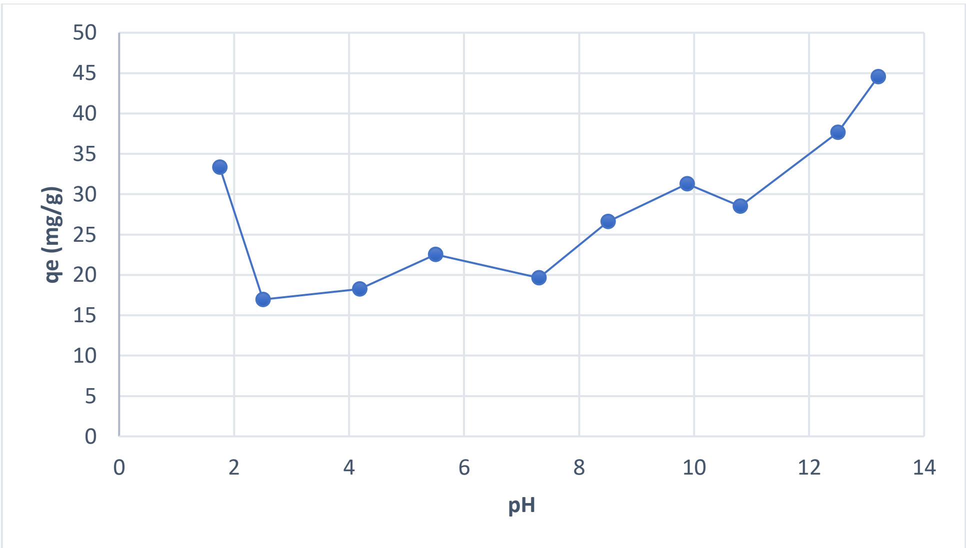

Figure 3. Adsorption capacity (q_e) of MgO/TiO_2 (0.25) on treating remazol blue in different pH

To understand more about adsorption capability of the used catalysts, an adsorption batch experiment were carried out. Despite adsorption isotherm study may not give a precise information about the mechanism of adsorption, it can be helpful to describe the relationship between pollutant concentration in solution and adsorbent at a constant temperature under given conditions. It also reveals adsorption capacity of an adsorbent that can be used for designing an adsorption system [7]. In this study, remazol blue with initial concentration ranged from 10 – 125 mg/L were treated with 0.05 g of catalysts for 24 hours at ambient room temperature.
Figure 4, 5, and 6 show the adsorption isotherm pattern of MgO, TiO_2, and MgO/TiO_2 respectively to adsorp remazol blue dye in water. From the graph, MgO and MgO/TiO_2 were showing it's equilibrium trend, but TiO_2 still not indicated its equilibrium yet. This result is still the same with the previous batch studies which conclude TiO_2 does not have a good adsorption capability.

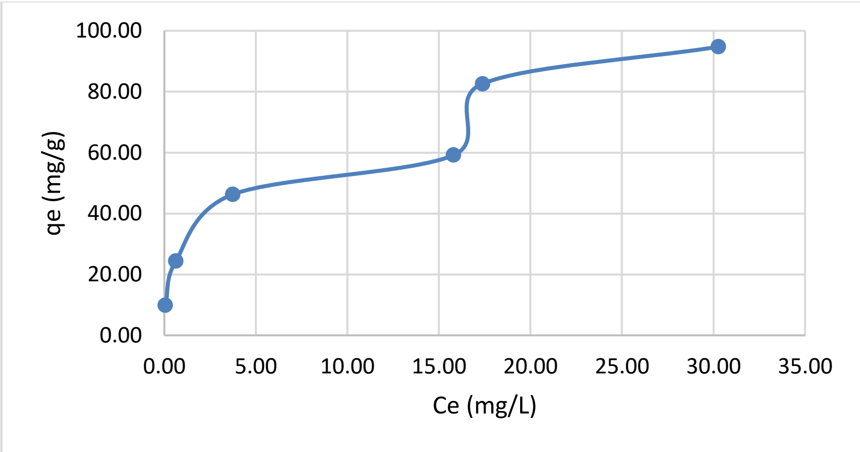

Figure 4. Adsorption isotherm curve of MgO

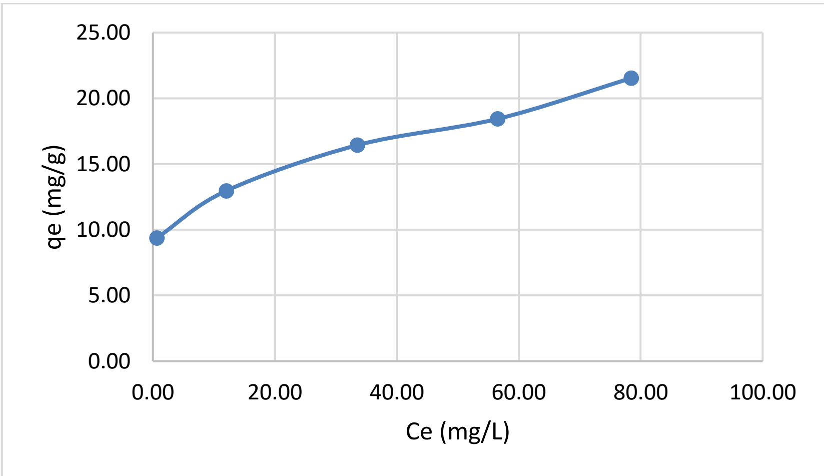

Figure 5. Adsorption isotherm curve of TiO_2

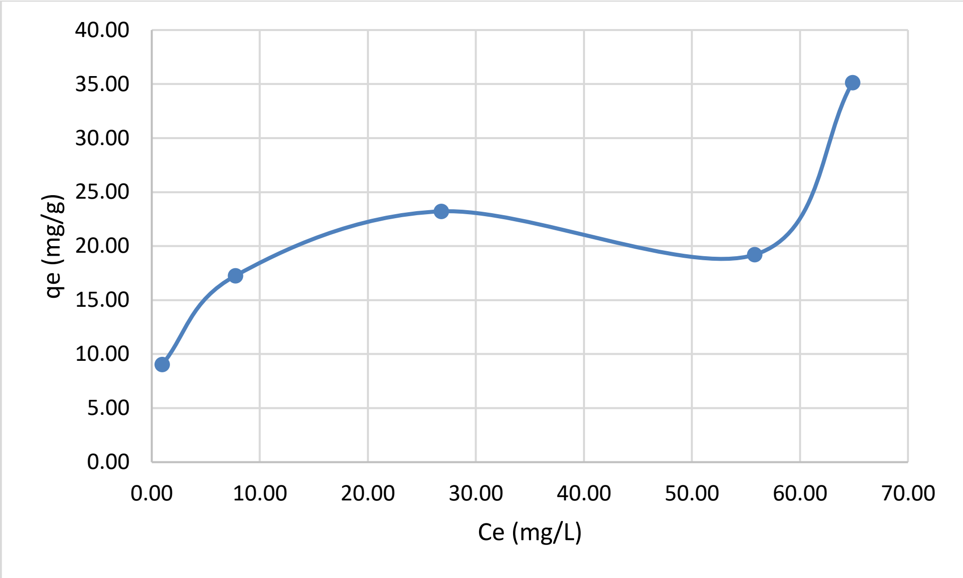

Figure 6. Adsorption isotherm curve of MgO/TiO_2 (0.25)

Figure 5 and 6 displays comparison between adsorption and photocatalysis of remazol blue using TiO_2 and MgO/TiO_2. The TiO_2 which assumed has heterogeneous surface with monolayer adsorption, shows a quick equilibrium since its first minutes, then the gap between adsorption and photocatalysis getting bigger, then the gap became stable after 150 minutes. However the MgO/TiO_2 which assumed has more homogeneous surface with multilayer adsorption, in its first 90 minutes the multilayer adsorption occurred faster than if it is degrading with photocatalysis. The hypothesis in here is the photocatalytic activity that may produces remazol blue's derivative products inhibit the multilayer adsorption arrangement on MgO/TiO_2 surface. After 90 minutes, the photocatalysis rate surpass the adsorption rate and reach equilibrium.

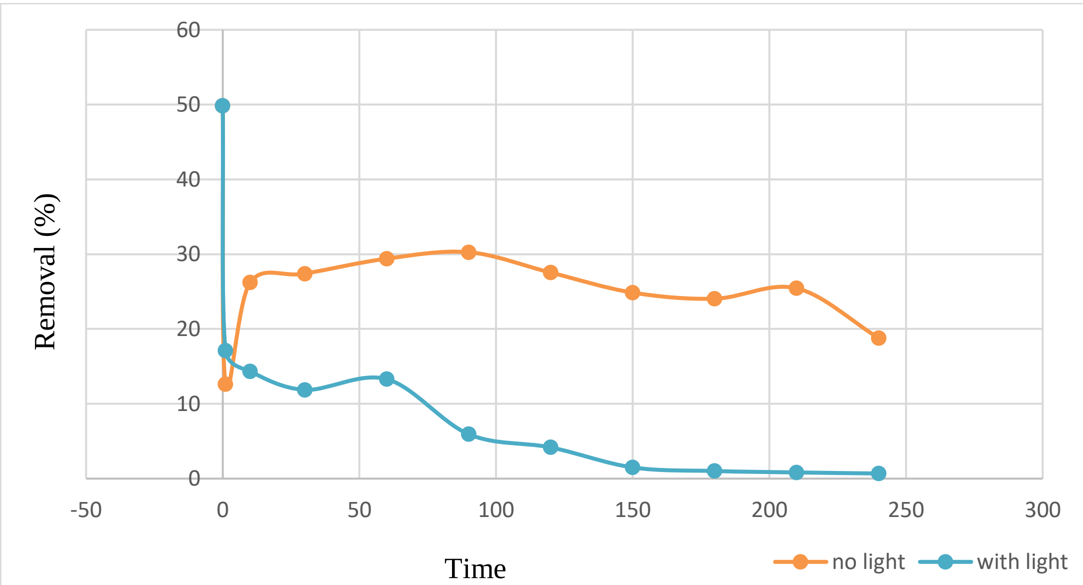

Figure 7. Comparison between adsorption and photocatalysis of remazol blue using TiO_2

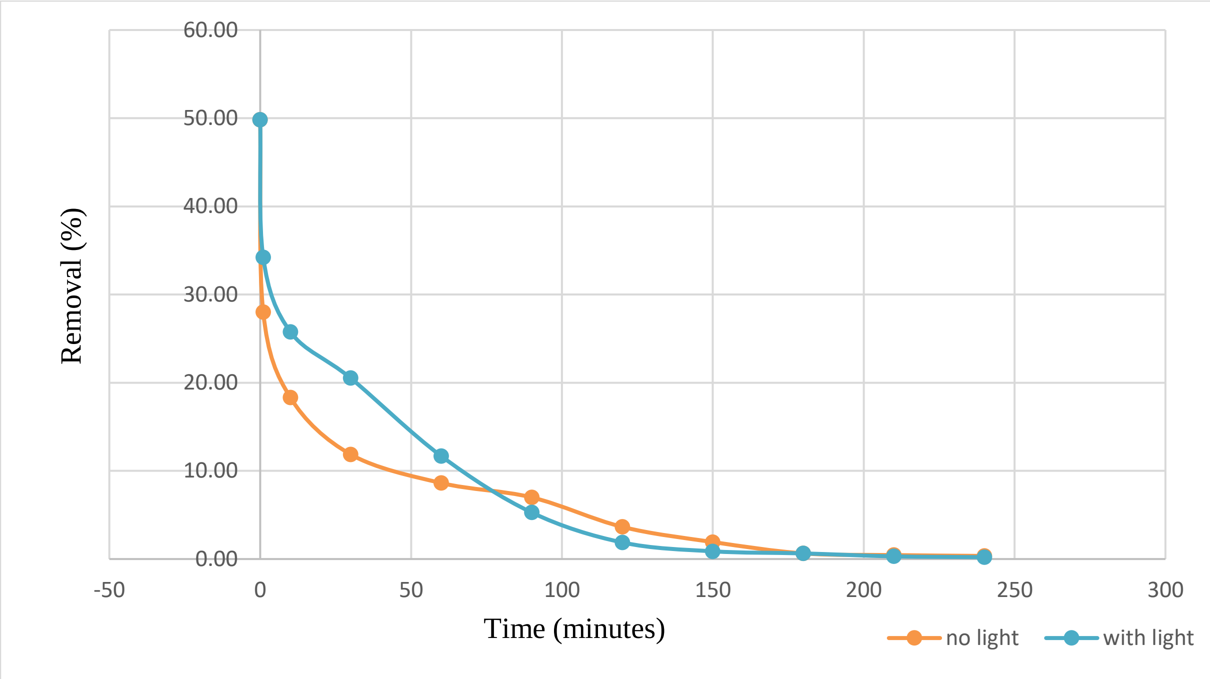

Figure 8. Comparison between adsorption and photocatalysis of remazol blue using MgO/TiO_2

4. Conclusions

It can be concluded that the less acid the condition of the solution, the capability of the MgO/TiO_2 catalyst on adsorbing the remazol turquoise blue dye will increasing. MgO/TiO_2 which assumed has more homogeneous surface with multilayer adsorption, in its first 90 minutes the multilayer adsorption occurred faster than if it is degrading with photocatalysis. The hypothesis in here is the photocatalytic activity that may produces remazol blue's derivative products inhibit the multilayer adsorption arrangement on MgO/TiO_2 surface. After 90 minutes, the photocatalysis rate surpass the adsorption rate and reach equilibrium.

5. References

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