RESEARCH ARTICLE

Methacrylic Acid-Acrylamide based ZnO Hydrogel Nanocomposite Assisted Photocatalytic Decolorization of Methylene Blue Dye

Ayad F. Alkaim[1*], Firas H. Abdulrazzak[2], Shaimaa M. Essa[3], Usama S. Altimari[4], Montather F. Ramadan[5], Aseel M Aljeboree[6]

[1,6]*Department of Chemistry, College of Science, University of Babylon, Hilla, Iraq.*
[2]*Department of Chemistry, College of Science, Al-Karkh University of Science, Baghdad, Iraq.*
[3]*Department of Chemistry, College of Education, University of Al-Qadisiyah, Al-Qadisiyah, Iraq.*
[4]*Department of Medical Laboratories Technology, AL-Nisour University College, Baghdad, Iraq.*
[5]*College of Dentistry, Al-Ayen University, Thi-Qar, Iraq.*

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ABSTRACT

In this research, preparation of methacrylic acid-acrylamide based ZnO hydrogel nanocomposite (MAA-AM)/ZnO hydrogel nanocomposite by way of co-polymerization *via* used acrylate acid (AA) (or acrylate salt) (AA) or methacrylic acid (MAA)) and acrylamide (AM). Nanocomposites based on acrylate are characterized via being hydrophilic and able to retain water. Nanocomposite properties were studied using different techniques (FE-SEM, TEM, and EDX). The photocatalytic degradation of methylene blue MB dye under different conditions was studied using nanocomposite like time of irradiation, mass of catalyst (MAA- AM)/ZnO hydrogel nanocomposite, initial MB dye concentration onto photocatalytic degradation and reactivation were studied. The result increases the photocatalytic degradation with the rise weight of catalyst (MAA- AM)/ZnO hydrogel nanocomposite range (0.1–0.25 g). Too, a decrease in photocatalytic degradation was observed with an increase in MB. Observed that after reuse, ((MAA- AM)/ZnO) nanocomposite hydrogel appear photocatalytic efficiency from of the use 1 to 6 cycle 87.88 to 58.87%, showing that ((MAA- AM)/ZnO hydrogel nanocomposite surface appear good stability.

Keywords: Nanocomposite, Photocatalytic degradation, Dye, hydrogel, Zinc oxide.

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INTRODUCTION

Textile dyes usually contain dangerous and toxic organic or organic compounds, and the frequent use of these dyes in industries makes them a source of concern for marine and microorganisms as well as human life. Based on their applications, dyes are classified into basic, acidic, direct, disperse, sulfur, mordant, vat, reactive, azote. Pigments and dyes are widely utilized in industries that manufacture and process paper, textiles, plastics, food, leather, and cosmetic products.[1-8] Thus, several techniques have been utilized to remove these dyes from wastewater. The most significant of these are ways, advanced oxidation processes (AOPs) are of great interest in water purification from dyes.[9-11] Several chemical, physical, and biological decolorization techniques like coagulation, flocculation, membrane separation, bio-degradation methods, adsorption, ozonation or oxidation, electro-coagulation and photodegradation, oxidation methods, filtration membrane, and adsorption, photodegradation have been utilized for the removal of dyes from in aqueous water.[12-15] In the middle of these methods, photocatalytic degradation has been found to be a cost-effective and simple way to removal of dyes wastewater. This study, (MAA- AM)/ZnO hydrogel nanocomposite, was utilized as an effective adsorbent in decolorizing MB dye.[16-19] Several parameters that affect photocatalytic degradation were studied, including concentration MB dye, weight of (MAA- AM)/ZnO hydrogel nanocomposite and surface reactivation.

MATERIALS AND METHODS

Material and Chemicals

Methacrylic acid (MAA) (molar mass = 71.9 g/mol) and chemical formal $C_3H_4O_2$ N, N methylene bis-acrylamide (MBA) chemical formal $C_7H_{10}N_2O_2$ (molar mass = 155.0 g/mol), sodium persulfate (KPS) chemical formal $K_2S_2O_8$ (molar

**Author for Correspondence: alkaimayad@gmail.com*

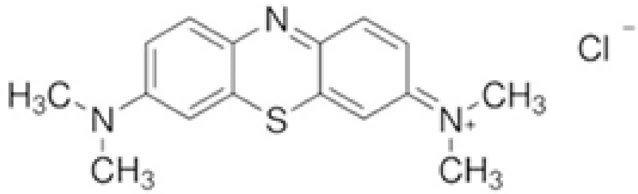

Figure 1: chemical structures of methylene blue MB dye

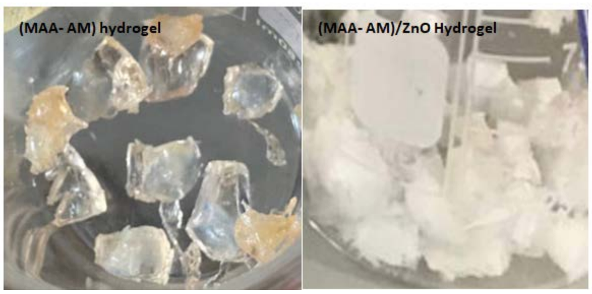

Figure 2: Image preparation of (MAA- AM)/ZnO hydrogel nanocomposite

mass = 271.0 g/mol), methylene blue MB dye, chemical formal $C_{16}H_{18}ClN_3S$ (molar mass = 319.85 g/mol), wavelength 663 nm as shown in Figure 1.

Preparation of (MAA- AM)/ZnO Hydrogel Nanocomposite

Methacrylic acid (MAA) distilled water 40 mL dissolving 2 g with stirring until generally the substrate is dissolved in distilled water at 60 minutes distilled water 20 mL of acryl amide (Am) dissolving 2 gm with stirring about 1-hour after that mixing using MAA solution. ZnO distilled water 20 mL of dissolving 1-g by stirring 1h and mixing, N, N'-methylenebisacrylamide about 0.05 gm and KPS about 0.03 gm in 5 mL dissolving. In order to complete the reaction co-polymerization, at 70°C for 6 hours. After that submerged in distilled water to remove un-reached components, the ((MAA- AM)/ZnO hydrogel nanocomposite was dried at 45°C. Figure 2 appears real photo of the preparation of (MAA- AM) hydrogel and (MAA- AM)/ZnO hydrogel nanocomposite.

Experiments of the Photocatalytic Degradation

The photodegradation of the (MAA- AM)/ZnO hydrogel nanocomposite was determined by MB degradation. Wholly experiments carry out in a 250 mL beaker. The reaction beaker was placed under ultra violet light, considering the distance between the solution's surface and the light source. Before each test, the lamp is heated for 10 minutes to obtain accurate results. Thus, a mass of 0.2 g of (MAA- AM)/ZnO hydrogel nanocomposite was added to MB solution conical flask 200 mL,and the investigation was in the beginning for (15 minutes) called adsorption (darkness).

Influence of different parameters like amount of (0.1–0.25 g L^{-1}), concentration MB dye (40–100 mgL^{-1}). The photodegradation efficiency% of MB and apparent rate constant first-order were estimation in eq. 1:

$$\text{Photodegradation efficiency\%} = ((C_o - C_t)) / C_o)100 \quad (1)$$

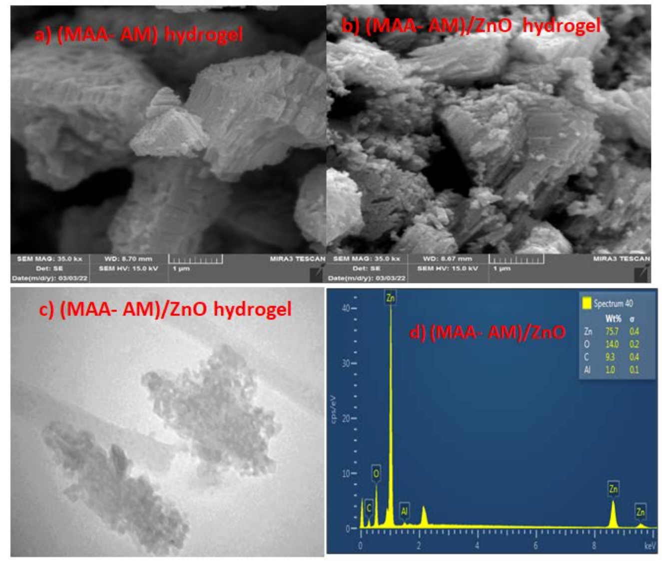

Figure 3: FE-SEM a) ((MAA- AM) hydrogel, b) ((MAA- AM)/ZnO hydrogel nanocomposite, c) TEM ((MAA- AM)/ZnO hydrogel nanocomposite,d) EDX of (MAA- AM)/ZnO hydrogel nanocomposite

RESULTS AND DISCUSSION

Characterization of Hydrogel Nanocomposite

Image FE-SEM make use of study the properties and morphology of (MAA- AM)/ZnO hydrogel nanocomposite before and after loading (ZnO), as appear in Figure 3 (a).[20] Micrographs of (MAA- AM) hydrogel show that the surface is irregular and contains rough clusters and the (MAA- AM)/ZnO hydrogel nanocomposite surface. It has large, irregular particles, coarse, and too data from spherical clusters resulting from ZnO NPs loading as shown in Figures 3 (b and c) appear TEM image (MAA- AM)/ZnO hydrogel nanocomposite, where ZnO was observed embedded inside the hydrogel. EDX of (MAA-AM)/ZnO hydrogel nanocomposite as show in Figure 2 (d). The nanocomposite have O, C and Zn, which indicates the existence of ZnO NPs onto (MAA- AM)/ZnO hydrogel nanocomposite. values elements highest and values elements lowest that existed in the modified (MAA- AM)/ZnO hydrogel nanocomposite by 75.7 and 9.3 wt.%.[6, 21-25]

Effect of Weight ((MAA- AM)/ZnO Hydrogel Nanocomposite

Effect of photocatalyst MB dye concentration (0.1-0.25 g/200 mL) on the PDE% MB was studied at an initial dye. The best optimum condition concentration of MB 80 mg/L, solution pH 6.8 and light intensity (1.3 mW/cm^2) .as show in Figure 4 when mass (MAA- AM)/ZnO hydrogel nanocomposite were increase, the rate of degradation was rise for increase number of active sites. In the region among 0.1 to 0.25 g, appear an approximate plateau curve which indicates the numbers of active sites have an equilibrium among the numbers of photon-induced that absorbed via the catalyst and a particle of dye adsorbed represents the percent degradation of MB against the different quantity of hydrogel. This shows that the percent degradation of modified catalysts rise with the increase in

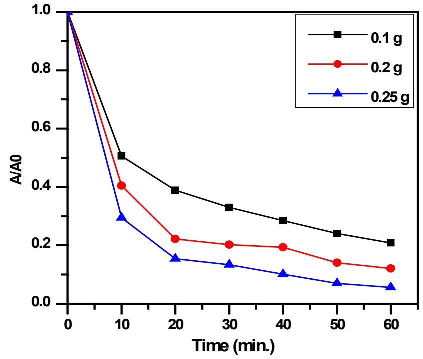

Figure 4: Photodegradation of MB at a changed weight of the nanocomposite

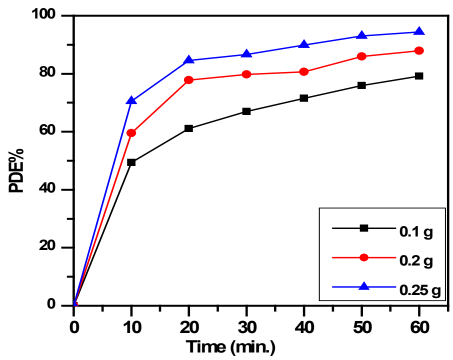

Figure 5: PDE% MB at several mass of hydrogel

amount of catalyst from 0.2–0.25 gL^{-1} and above this limit there is not much change[26-29] as show in Figure 5.

Effect Concentration of MB Dye

The effect of MB dye concentration have been studied at solution pH solution 6.8, weight of (MAA- AM)/ZnO hydrogel nanocomposite 0.2 g/200 mL, concentrations of dye (40–100 mg/L) and light intensity (1.3 mW/cm^2). The investigational information could be analyzed to agree on kinetic first-order shown in Figure 6.

The excess of MB prevents the penetration of light through the successive layers of MB onto the surface (MAA- AM)/ZnO hydrogel nanocomposite is feeble to generate the required excited state of the MB onto nanocomposite. The conc. of MB dye 80 mg/L gave better photocatalytic efficiency (87.88%).[27,30,31] The result of the change in (PDE%) with MB appears in Figure 7.

Re-usability of ((MAA- AM)/ZnO Hydrogel Nanocomposite

(MAA- AM)/ZnO hydrogel nanocomposite were recovered from the reaction mix by filtration and reused several times under similar best conditions: MB dye (80 mg/L), pH solution (8.6), and irradiation time 1-hour. After completing all the photodegradation experiments, ((MAA- AM)/ZnO nanocomposite was collected over filtration and washed several times DW, then dried for 24 hours at 160°C. The result of the first to six experiments shown in Figure 8 showed that after reuse, nanocomposite paper lower photocatalytic efficiency from of the 1st use 87.88 to 58.87% of 6th use repeated. This

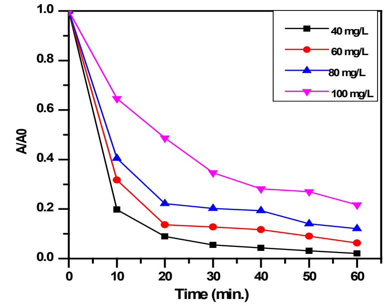

Figure 6: Photocatalytic degradation of MB dye at different concentrations

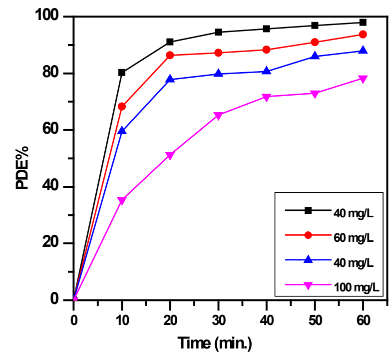

Figure 7: Photodegradation efficiency (PDE%) of MB dye at different concentrations

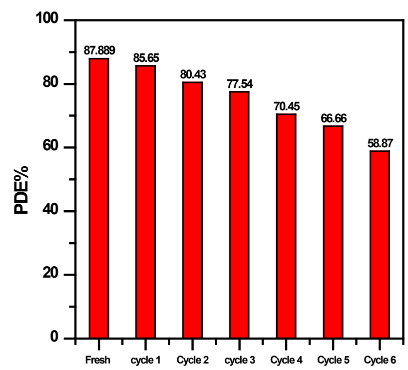

Figure 8: Re-usability of ((MAA- AM)/ZnO hydrogel nanocomposite

result shows that nanocomposite surface appear higher stability.[32]

CONCLUSION

Preparaction new nanocomposite methacrylic acid-acrylamide based ZnO hydrogel by way of co-polymerization.

The MB dye concentration 80 $mg.L^{-1}$, good photocatalytic degradation efficiency% (87.88%).

Photo catalytic degradation increases with the rising weight of catalyst (MAA- AM)/ZnO hydrogel nanocomposite.

hydrogel nanocomposite surface appears good stability and can be reactivation 6 cycles.

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