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Cite as: AIP Conference Proceedings **2386**, 080030 (2022); https://doi.org/10.1063/5.0067431
Published Online: 11 January 2022

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Synthesize rGO-Ag Nps Nanocomposite by a Simple Physical Method and Applying in Water Treatment

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Abstract The nanocomposite of reduced graphene oxide- silver nanoparticles (rGO-Ag NPs) samples, was prepared in a simple and environmentally friendly physical method, using a pulsed laser with (200-600) pulses in an aqueous solution. The shapes of the nanoparticles are spherical with sizes range between (40-49) nm as shown in scanning electron microscopy (SEM). The nanocomposite rGO-Ag NPs were used in the adsorption of the methylene-blue dye that is used in coloring the clothing. We noted that the efficiency of dye removal increased with the increase of the concentration of Ag nanoparticles another meaning the increase in the number of pulses. On the other hand, the nanocomposite rGO-Ag NPs was also used to sterilize the water by applying it to kill two kinds of bacteria *Staphylococcus aureus* and *Escherichia coli*. These results show can be used the nanocomposite rGO-Ag NPs to treat the wastewater by remove the dyes and killed the bacteria at the same time.

Keywords: Silver Nanoparticles, Laser Ablation, Graphene oxide, Dye Removal, Killing Bacteria.

INTRODUCTION

Graphene, an astounding nanomaterial, has pulled in gigantic consideration because of its superb properties that emerge from its flat monolayer of carbon atoms pressed in a two-dimensional honeycomb lattice, and have unique properties, for example, high surface area, high chemical stability, greatest mechanical strength, individual electronic, and thermic conductivity properties [1, 2, 3].

3rd International Scientific Conference of Alkafeel University (ISCKU 2021)
AIP Conf. Proc. 2386, 080030-1–080030-8; https://doi.org/10.1063/5.0067431
Published by AIP Publishing. 978-0-7354-4150-7/$30.00

In recent times, the greater part of graphene nanomaterials utilized and advised are graphene oxide (GO) and reduced graphene oxide (rGO) [4]. The blend of silver and graphene as nanocomposite has a fascinating structure, and has potential in different applications, for instance as an antibacterial specialist [5-7], nanofluids for cooling technology [8], water treatment [9].

The presence of dyes in effluents is a significant worry because of their unfavorable consequences for some kinds of life. There was a major concern about the discharge of dyes in the environment due to both toxic and aesthetic reasons [10]. Industries, for example, material, leather, paper, plastics, and so on, use dyes to color their items and furthermore waste considerable volumes of water. Accordingly, they produce a lot of colored wastewater [11]. Methylene-blue (MB) is the most ordinarily utilized substance for coloring cotton, wool, and silk. It can cause many problems which might be answerable for perpetual injury to the eyes of humans and animals. On the inward breath, it can offer ascent to brief times of fast or troublesome breathing while ingestion through the mouth creates a consuming sensation and may cause sickness, vomiting, liberal perspiring, mental tangle, and methemoglobinemia [12-14].

Among the various strategies of dye abstraction, adsorption is the method to be utilized to eliminate various types of coloring materials. Meanwhile, the bacteria in water caused many problems to humans and making diseases [15-17].

The blend of rGO and Ag NPs at the same time is promising to have superb adsorption, transparency, reusability, and controllability, which could assist efficient impure filter and sterilizer (antibacterial) simultaneously [18].

So, the aim of the study is to use a friendly method to synthesis rGO-Ag NPs and applied them to the treatment of the wastewater.

EXPEREMENTAL

The nanocomposite samples were prepared by a physical method using the pulsed laser ablation in liquids (PLAL) using a pulsed Nd:YAG laser with energy 160 mJ ,1064 nm of wavelength and a frequency of 6 Hz . 10 ns pulse duration and variable number of pulses varying between (200,300,400,500,600) pulses (S1, S2, S3, S4, and S5) respectively, as described in our previous work [19].

For removal of the methylene blue (MB) dye, which is used in coloring cotton, wool, etc., which is a dye with a toxic effect on living organisms. The stored concentration of MB was 5 μM that tested with three types of compounds, first with silver nanoparticles Ag NPs, which has been synthesis by the immersed silver plate with water and irradiated with the Nd-YAG laser at wavelength 1064 nm, energy 160 mJ, repetition rate 6 Hz, 10 ns pulse width and 600 pulses, the second was the graphene oxide that has been synthesis by Hummers' method as in previous work [20] and the last was the nanocomposite rGO-Ag NPs that we study. The removal producer was done by adding 2 ml from each compound to 5 ml from dye, separately and measured the absorption before and after the adding as in Figures (2, 3).The efficiency of removal was done according to equation (1).

$$\text{Removal efficiency } \% = \frac{A^{\circ} - A^{t}}{A^{\circ}} \times 100 \quad (1)$$

Where A° and A^{t} are the absorbance of MB at 664 nm and at t minutes, respectively [21].

For testing the antibacterial properties of rGO, Ag nanoparticles colloidal solution and rGO-Ag NPs for only S5 on two types of bacteria Staphylococcus aureus ATCC 25923 and Escherichia coli ATCC 25922 model strains of Gram positive and Gram negative bacteria, respectively were used in this study.

The bacteria were prepared by the conventional plate count method; the bacteria were diluted final bacterial concentration of 104 to 105 CFU/ml using 0.85% sterile saline. One milliliter of each adjusted bacterial culture was spread and inoculated to the Muller Hinton agar plate.

The materials were autoclaved at 121°C for 15 min and tested for their antibacterial efficacy by added filter paper and inoculated in Muller Hinton agar with the bacterial solution and incubated at 37°C for 24 hours. The inhibition of bacterial growth was tested by measuring the inhibition zone for each one as shown in Figures (4) and (5) respectively.

RESULTS AND DISCUSSION

The Fig.1 shows the examination of the SEM, which describes the size and shape of the nanocomposite, where the spherical silver nanoparticles appear uniformly scattered on the graphene oxide flakes, whose sizes range between (40-49) nanometers for the fifth sample it was attended by pulse laser ablation at 600 pulses. All the characterization of the rGO-Ag NPs has been done and published in our previous work [19].

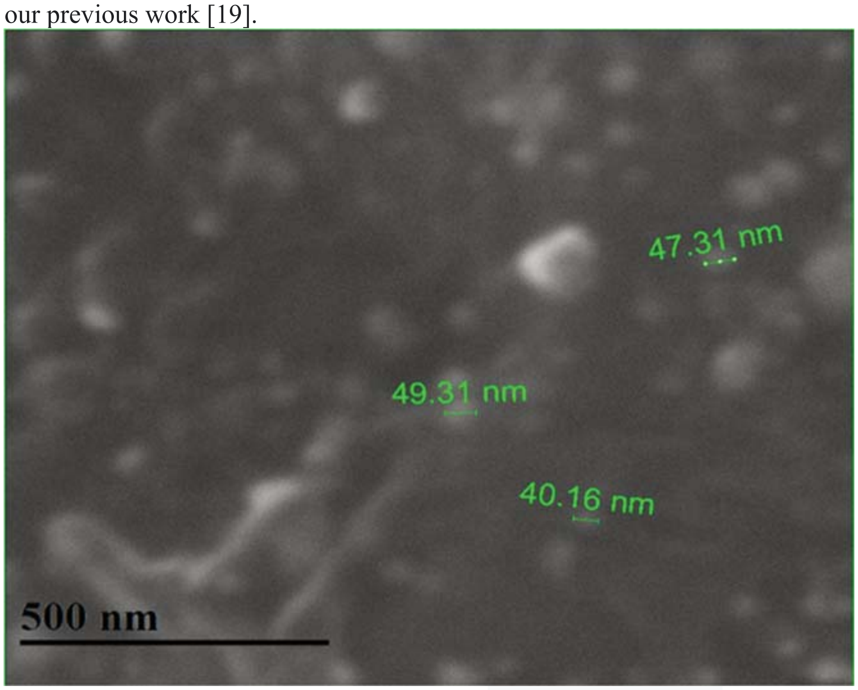

FIGURE 1. SEM for S_5 of rGO-Ag NPs nanocomposite.

For applied the nanocomposites to removal the MB from aqueous solution, as in the experimental part, Fig.2 show the result when adding GO and Ag NPs separately to the MB aqueous solution, The removal efficiency of GO and Ag NPs are 50% and 14.2% respectively. These result show that GO is a highly effective adsorbent of methylene blue (MB) than silver nanoparticles and combatable with reports [22].

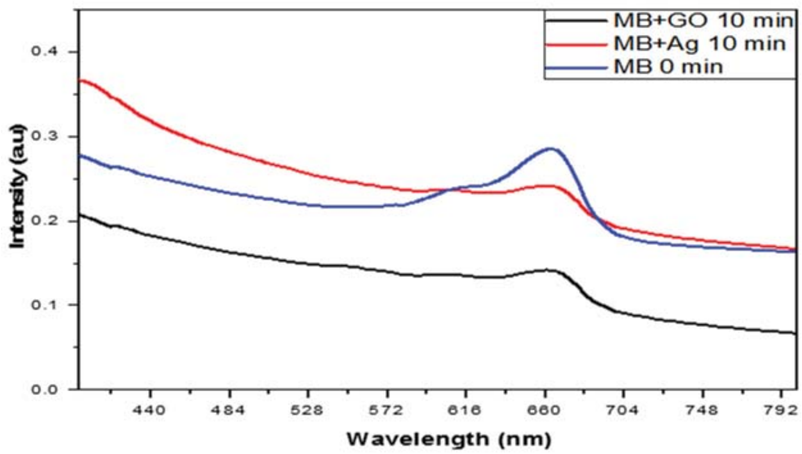

FIGURE 2. : UV-VIS spectra removal effect for each of GO and Ag NPs on MB.

For the rGO-Ag NPs nanocomposite were applied for the five samples prepared by pulse laser ablation as in the result was shown in Fig.3.
The removal efficiency for all samples at 30 sec on MB as shown in Table 1. These results the adsorption efficiency of the five prepared nanocomposites increases with the increase in the number of pulses and the increase in the concentration of silver nanoparticles on the reduced graphene oxide nanosheets

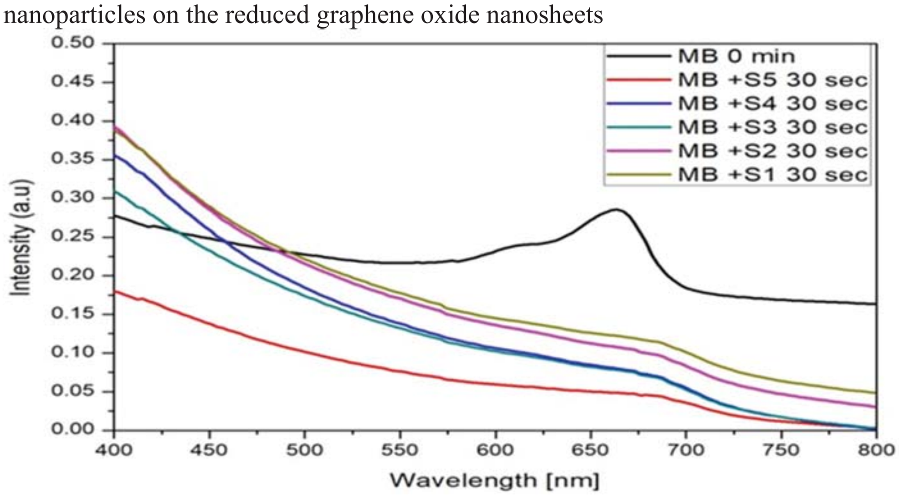

FIGURE 3. UV-VIS spectra removal effect for the five samples of the rGO-Ag NPs nanocomposite on MB.

Additionally, by comparing this result with GO and Ag NPs adsorption, the rGO-Ag NPs nanocomposite show higher efficiency and fast adsorption, candidate it to be used as a membrane to remove dyes from aqueous solution.

TABLE 1. the removal efficiency for all samples at 30 sec on MB

Sample No.	Removal Efficiency%
S1	55.3
S2	60
S3	73.2
S4	73.2
S5	82

Moreover, apply the rGO-Ag NPs nanocomposite as a bactericidal agent for water disinfection. The inhibition of bacterial growth was tested by measuring the inhibition zone for each one as shown in Figures (4) and (5) respectively.

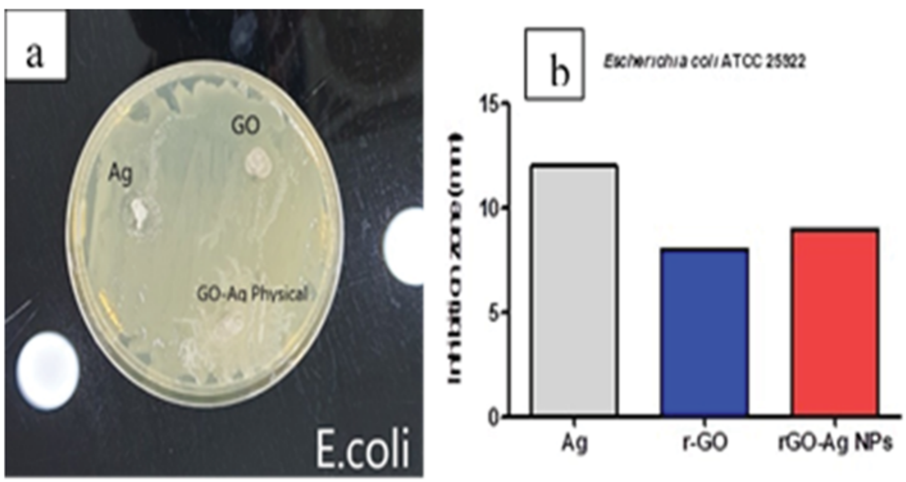

FIGURE 4. a) Zone of inhibition diameter of among Ag, GO and rGO- Ag NPs nanocomposite against Escherichia coli ATCC 25922 bacteria. b) The differences between the inhibition zone in (mm) among Ag, GO and rGO- Ag NPs nanocomposite against Escherichia coli ATCC 25922 bacteria.58

From the results noted that there was a clear effect of the nanocomposite in the inhibition of bacteria due to the presence of silver nanoparticles with toxic effect on the bacteria where silver has improved the properties of the reduced graphene oxide on the inhibition of the bacteria as shown in Table 2.

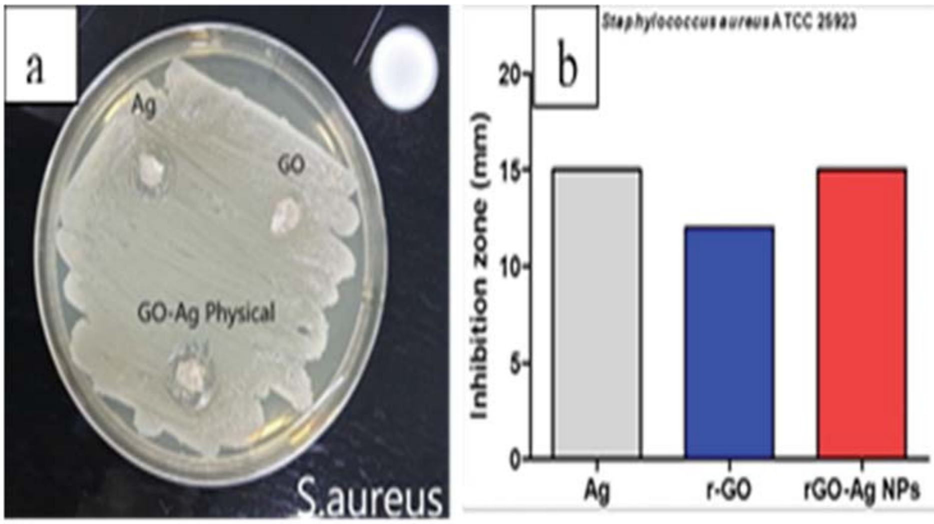

FIGURE 5. a) Zone of inhibition diameter of among Ag, GO and rGO- Ag NPs nanocomposite against Staphylococcus aureus ATCC 25923 bacteria) the differences between the inhibition zone in (mm) among Ag, GO and rGO- Ag NPs nanocomposite against Staphylococcus aureus ATCC 25923 bacteria.

TABLE 2. Zone of inhibition diameter of among Ag, GO and rGO- Ag NPs nanocomposite (S5) against Escherichia coli and Staphylococcus aureus.

Bacteria model	Inhibition zone in (mm) for Ag NPs	Inhibition zone in (mm) for GO	Inhibition zone in (mm) for rGO-Ag NPs nanocomposite
E.coli	12	8	9
S.aureus	15	12	14.5

The incorporation of Ag NPs into GO inhibits the agglomeration of both GO nanosheets and Ag NPs. Enhanced antibacterial performance was observed for the rGO-Ag NPs nanocomposite. The plate counting method illustrates that this antibacterial ability remains effective even in aquatic media.

We can see the magnificence of this nanocomposite through this application where the reduce graphene oxide and silver nanoparticles improve the properties of each other and thus obtain satisfactory results.

CONCLUSIONS

The pules laser ablation successfully used to prepared rGO-Ag NPs as a friendly and simple method with an average size between (40-49) nm for silver nanoparticles. When applied the rGO-Ag NPs nanocomposite utilizing to remove the methylene blue color was successful that was found in wastewater. Moreover, the rGO-Ag NPs used as antibacterial to killed two types of bacteria. The rGO-Ag NPs nanocomposite proved is a promising material that can be used for water treatment to remove the dyes and kill bacteria at the same time with good efficiency.

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