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Photolysis and photocatalysis of methylene blue by graphene oxide nanoparticle under sunlight irradiation

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Abstract:
The Hummer technique was utilised to produce graphene oxide (GO), for this research. X-ray diffraction (XRD), energy dispersive X-ray (EDX), and a field emission scanning electron microscope (FESEM) were used to examine the structural properties of GO nanoparticles.By boosting adsorption, expanding the light absorption range, and blocking electron-hole pair recombination, GO enhances the photocatalytic efficiency. The GO have enormous potential uses in the degradation of organic contaminants from wastewater, and their manufacturing is expected to be scalable using this simple process. The improved catalytic activity of GO nanoparticle has been linked to the greater adsorption susceptibility of dye molecules, high charge separation, and suppressed recombination of photogenerated electron-hole pairs brought about by the presence of GO. These results demonstrated the promising prospects for future use of graphene-based semiconductor nanocomposites as visible-light photocatalysts in the field of water purification.
Keywords: Hummers’ method, Graphene oxide, Methylene blue dye, Photocatalytic.

1- INTRODUCTION

In recent years, graphene oxide (GO) has emerged as a promising carbon-based nanoscale material that may one day replace graphene [1]. Graphene oxide, which is derived from graphite oxide crystals, is a low-cost monatomic layer material. Similar to graphene sheets, but with oxygen-containing groups at its base, graphene oxide exhibits interesting properties. This class has a high affinity for water molecules, making it hydrophilic and solvent in a wide variety of media. Thin films or networks may therefore be reliably deposited on a wide range of substrates, making it a promising candidate for use in microelectronics [2]. Despite graphene oxide's lack of conductivity, most of graphene's original functionality may be restored by exposure to heat, light, or chemical reduction. One of the first graphene compounds available for commercial use was graphene oxide. Graphene oxide's basal and terminal sides are functionalized with exogenous groups such as hydroxyl, epoxy, and carbonyl [3, 4], and GO NPs have attracted the attention of the scientific community because of their potential use in solar cells, flat panel displays, and the creation of new sensing devices. One such way they come in use is as a replacement for traditional electrode materials [5]. Graphene-based low-dimensional metal oxide composites are a rising star in the field of materials science. Graphene and metal oxide nanoparticles have caught the attention of scientists throughout the globe due to their peculiar properties. Since graphene-based metal oxide composites have unique properties and broad potential applications in science and technology, especially in the resolution of energy crises and environmental issues [6]. The produced nanocomposites were analysed for their structural morphology and elemental composition with the use of XRD, FE-SEM, and EDX.

2- MATERIALS AND METHODS

2-1 Synthesis Of GO

Natural graphite powder was oxidised using Hummers' method, which resulted in GO. In short, 50 ml of concentrated sulfuric acid was used to dissolve 1 g of graphite and 1 g of Sodium nitrate $NaNO_3$ while the mixture was stirred for 2 hours over an ice bath. The temperature of the suspension did not go over 10 degrees Celsius despite the addition of 6 grammes of potassium permanganate $KMnO_4$ to the solution over the course of four hours. After that, we mixed the suspension at 30 degrees Celsius for another 48 hours. The suspension was then chilled at 30 degrees Celsius for 30 minutes. The suspension was stirred for 48 hours at 30 degrees

Celsius after being taken out of the ice bath. Then, 30 mL of hydrogen peroxide H_2O_2 (30%) and 100 mL deionized water were added individually. After centrifuging, the material was washed with a 10:1 v/v hydrochloric acid HCl solution and deionized water until the pH of the upper layer was between 6 and 8. Graphene oxide powder was obtained after the solution was sonicated for 45 minutes and then dried at 50 degrees Celsius for 24 hours.[7]

2-2 Methodology Of Photocatalytic Degradation Of Methylene Blue (MB)

To a 100 ml solution of 10 ppm methylene blue (MB), 6 mg of and GO photocatalysts were added. To maintain the adsorption/desorption equilibrium between methylene blue (MB) and the photocatalyst, the solution was stirred in the dark by Magnetic stirrer for 2 hours before being exposed to sunlight. The suspension was shaken around before being exposed to light. The photocatalyst particles were separated by centrifuging 3 ml of the solution at 4000 rpm for 15 minutes. Methylene blue (MB) dye solution (UV-752) concentration was determined using a UV-visible spectrophotometer.

3- RESULTS

3-1 XRD pattern for GO nanoparticles

The XRD pattern of GO nanopowder synthesised using Hummers' method is shown in Figure (1). The diffraction peak at ($2\Theta = 9.9$) after graphite oxidation is the interlayer distance ($d = 0.81$ nm). The (111) crystallographic plane has a crystallite size of 29.58 nm using Scherrer equation [32]. $D = K\lambda/(\beta \cos \theta)$ where K is constant(0.9), λ is the wavelength($\lambda = 1.5418$ A°) (Cu Kα), β is the full width at the half-maximum of the line and θ is the diffraction angle. (JCPDS Card No. 24-0735).

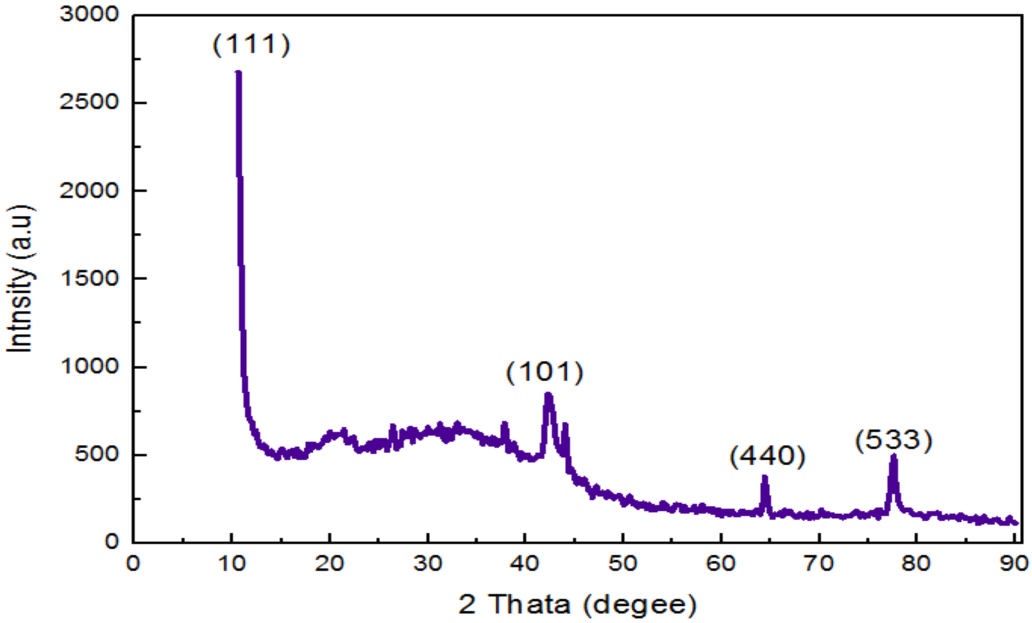


Figure 1 : XRD pattern for GO nanoparticles

3-2 (FE-SEM) Mcrograph Graphene Oxide (GO)

FE-SEM Analysis The grain size and surface morphology were studied using field emission scanning electron microscopy (FESEM). In Figure 2, we see a FESEM image of graphene oxide (GO) with a loose sponge-like porosity network formed by well-defined and connected 3D graphene sheets.

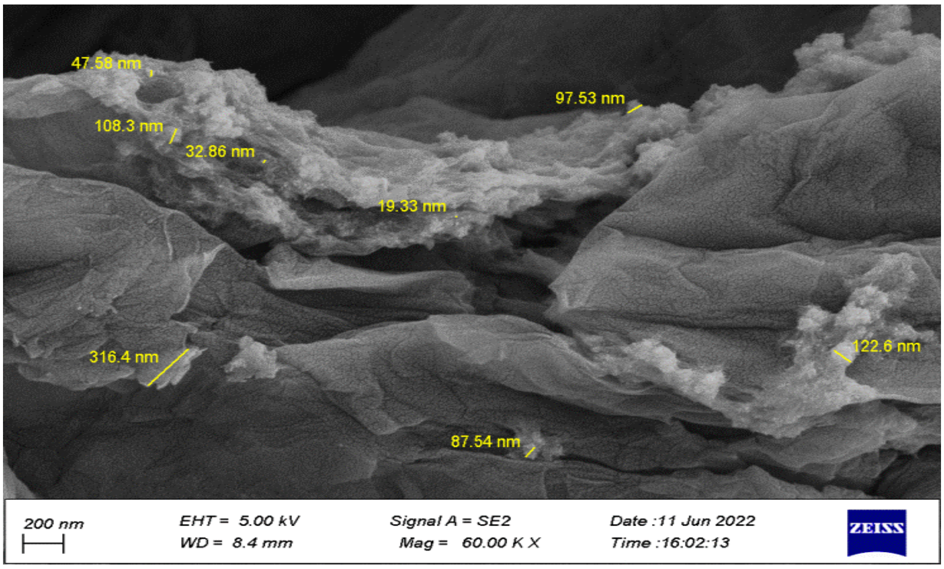


Figure 2 . FE-SEM image of GO nanoparticles .

3-3 EDX of Graphene Oxide (GO)

To determine and distinguish the chemical composition of the chosen nanomaterial. EDX measurements were performed on it, as shown in Figure 2. The largest weight percentage of carbon in GO was 60.72%, as reported in Table 1, followed by the presence of oxygen coupled with hydroxyl and carbonyl groups at 34.68%.

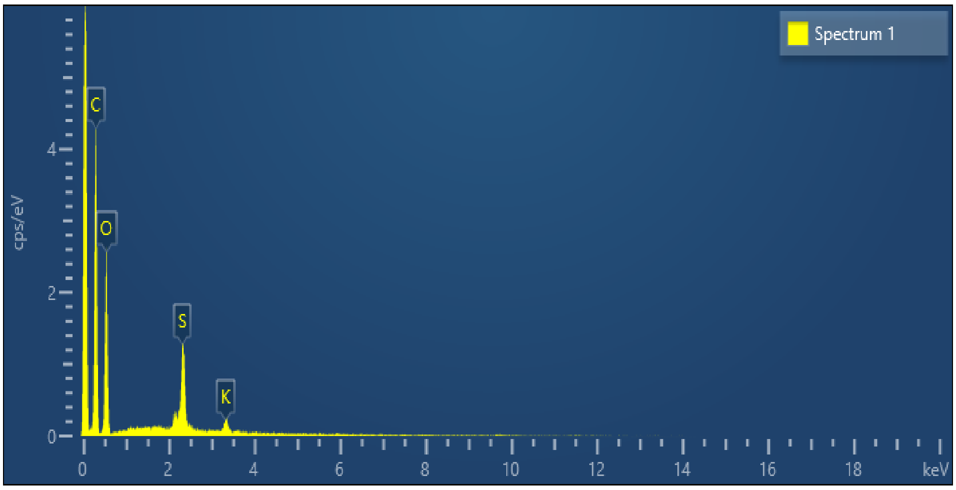


Figure 3. EDX spectrum of GO nanostructure

Table 1 : Shows the elements formed in graphene oxide**.**

Element	Line Type	Weight %	Weight % Sigma	Atomic
O	K series	34.68	0.60	29.44
S	k series	3.73	0.12	1.58
C	K series	60.72	0.63	68.67
K	K series	0.87	0.07	0.30
Total		100.00		100.00

3-4 Photocatalytic Activities

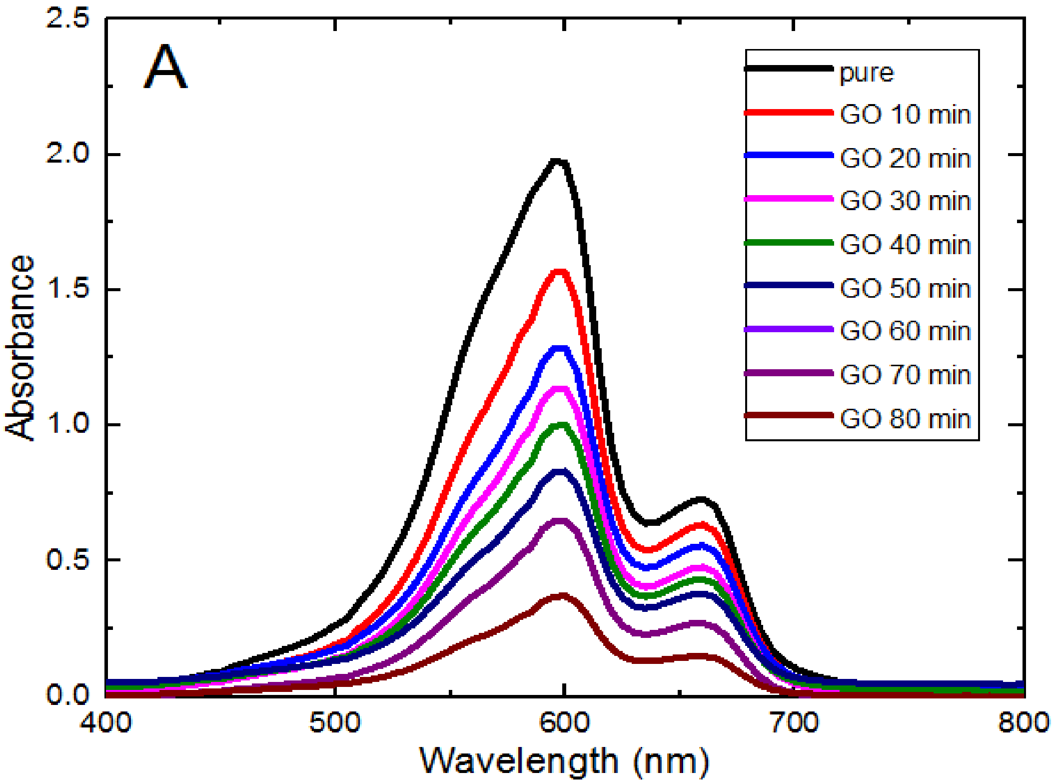
3.4.1 GO photocatalyst

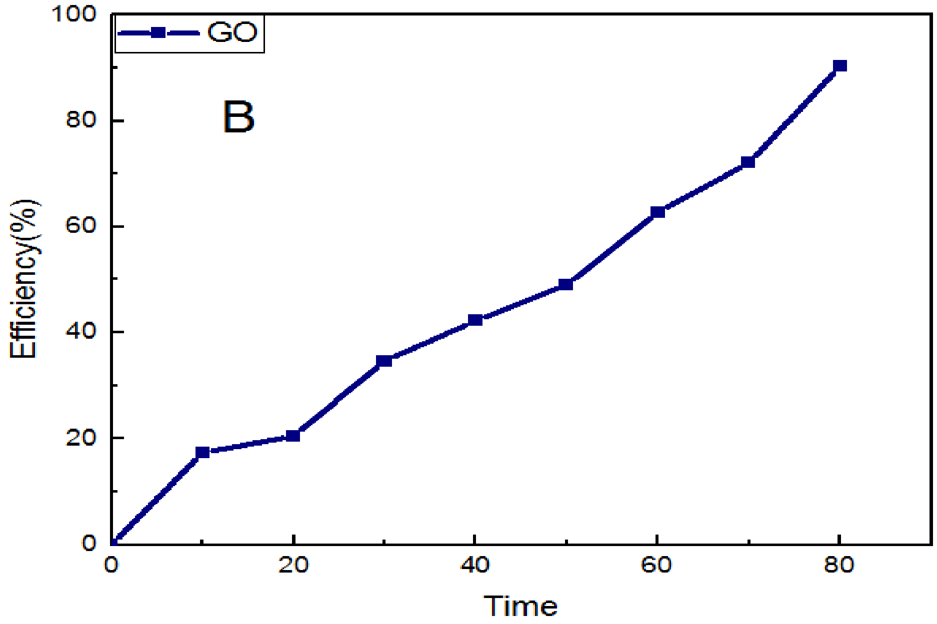
Figure 4 : (A) : presents the time-dependent UV-vis spectra of the dye-catalyst solution. The dye solution has been kept in dark for 30 min under continuous stirring to reach desorption–adsorption equilibrium. The time-dependent UV-light absorption peak of MBdecreases with the passage of time. In the blank test, the concentration in the absence of photocatalyst was hardly re duced which indicates the stability of MB dye. However, the results demonstrate that the photocatalytic degradation is totally governed by the GO photocatalyst. The photocatalytic degradation also depends upon dose of catalyst and increase on in creasing the dose of catalyst.

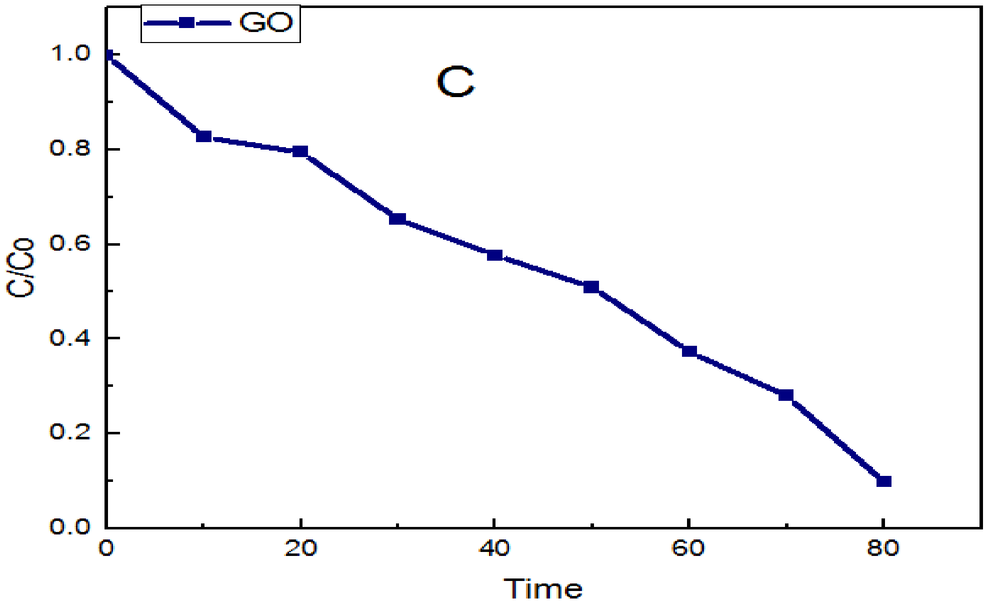
The MBdye shows complete degradation in the presence of GO catalyst in just 80 min. The reason behind the fast degradation of dye is the majority of oxygen-containing functional groups in graphene structure, which enhance the rate of degradation [8]. As GO has a semiconducting nature, the dye degradation mechanism can be understood in terms of migration of an electron from valence to conduction band with generation of a hole. This process starts with photon absorption, exhibiting greater energy than GO catalyst's band gap . Superoxide radicals are generated on the reaction of electrons with adsorbed O_2 molecules on the surface of catalyst.

The hole in valence band reacts with water to form hydroxyl radicals. These radicals generated leads to the production CO_2 and H_2O. In addition, GO provides high surface area as a catalyst thus facilitating the fast adsorption of O_2 molecules on surface. continuously lowers with increase in irradiation time and with higher degradation efficiency for higher doses. The better photocatalytic activity for degradation of organic pollutants can be attributed to the formation of oxygen containing functional groups between the layers of GO and intercalation of water molecules. Figure4 : (B). It can clearly be seen that the GO nanoparticle sample shows maximum photodegradation efficiency (PE) of almost 90 % in 80 min which is much higher in comparison to other samples at same time [9]

It was observed that when the concentration of GO , the percentage degradation was found to get increased while the C/C0 ratio decreased, as shown in Figure 4: (C). This is due to the excellent charge transporting capability of GO, where the electrons are directed towards the organic molecules of the MB dye adsorbed on the material, hindering the recombination rate of charge carriers in the system. Thus, inclusion of GO in the material has enhanced the photocatalytic activity . The reaction kinetics involved during the removal of MB dye was estimated by determining the first-order kinetics. From Figure 4 : (D), the MB degradation rate . The higher performance of the GO may have resulted from higher charge carrier separation or due to broad range of absorbed light in the visible region [10].




GO
B
Efficiency(%)
Time
0
20
40
60
80
100


GO
C
C/Co
Time
0.0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80

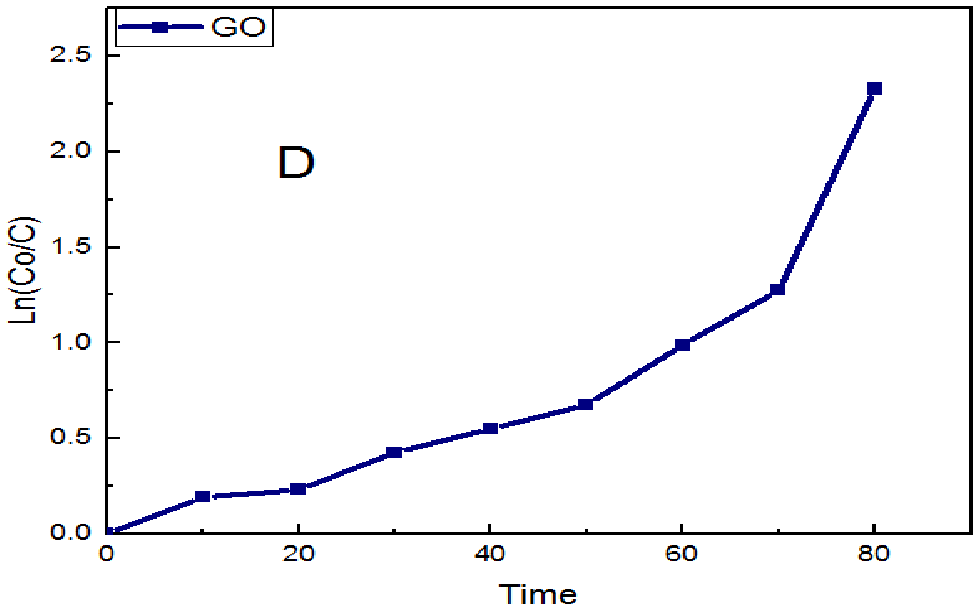


Figure 4: (A) Shown the absorption spectrum of MB decolorisation using GO nanoparticles. (B) Shown the Methylene blue Decolorisation efficiency with respect to time. (C) Plot of C/C0 vs time for the photodegradation of MB under Sun light by GO NPs. (D): kinetics of the degradation of (MB) dye with irradiation time using GO NPs

4- CONCLUSION

Here, we show how to make GO that is driven by visible light in the presence of sunlight by synthesising 2D graphene oxide sheets The structure was characterised by XRD, FESEM, and UV-Vis spectroscopy. The MB test pollutants were used to assess the photocatalytic applicability of the as-prepared photocatalyst materials as visible-light-driven photocatalysts for the degradation of organic dyes. GO's large surface area and composition allowed for faster photocatalytic degradation of organic dyes, and in only 80 minutes, 90% MB degradation was achieved. The photocatalytic activity of GO nanomaterials is enhanced by the incorporation of GO , the expansion of the light absorption range, and the suppression of electron-hole pair recombination. GO have enormous potential uses in the degradation of organic contaminants from wastewater, and their manufacturing is expected to be scalable using this simple process.

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