Retraction

Retracted: Industrial Waste Water Recycling Using Nanographene Oxide Filters

Advances in Materials Science and Engineering

This article has been retracted by Hindawi, as publisher, following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of systematic manipulation of the publication and peer-review process. We cannot, therefore, vouch for the reliability or integrity of this article.

Please note that this notice is intended solely to alert readers that the peer-review process of this article has been compromised.

Wiley and Hindawi regret that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] P. Yuvarani, S. Vijayachitra, V. Ranganayaki et al., "Industrial Waste Water Recycling Using Nanographene Oxide Filters," *Advances in Materials Science and Engineering*, vol. 2021, Article ID 4528949, 7 pages, 2021.

Research Article

Industrial Waste Water Recycling Using Nanographene Oxide Filters

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Nanomaterials play a vital role in healthcare, electronics, manufacturing industries, biotechnology, and security systems. One such material is graphene and its oxides are specifically used for recycling industrial waste water. Graphene, a single layer in honeycomb cross section, provides excellent attention because of its significant optical, mechanical, and physical properties. GO was utilized to decrease the acidic or essential centralization of the mechanical wastewater into reusable water for the modern reason utilizing graphene channels. In this paper, sample solution (waste water) is taken from paper industry. Graphene channels can be created from the pencil graphite. Graphene has the high goals of separating capacity, and graphene is considered as "a definitive RO film" in light of its stronger, thinner, and more chemically safe nature than the polymer layers. Graphene oxide layers are likewise to be used in the desalination plant in place of the RO membrane.

1. Introduction

Nowadays, waste water coming from industries produces major problem to surroundings as well as creates pollution to the environment. Public and government forced the industries to recycle or reduce the waste coming out to stringent standards. Water is one of the primary sources for the process industries such as chemical industry, paper industry, food processing, and cement industry, as well as some other industries which used as coolants' boiler feed water. So, the water used should be free from toxic substances, scale-forming solutes, corrosive substances, and pathogens. Improper treatment will cause contaminations and reduction in processes and may result in poor performance, product deterioration, and sometimes overall

process failure. So, various factors need to be considered before designing the plant such as quality and quantity of water resources, water recycle, and discharge standards. So, appropriate water treatment facility should be planned earlier. Another important aspect in water treatment is that it should be fully investigated in order to analyse the nature of the constituents in the waste water because it may contain some microorganisms, other relative hazards, and metal ions. So, waste water treatment may be done in several levels. So, many industries are looking forward to implement better and portable treatment technologies. Graphene is obtained from pencils, and then, the oxidation process is carried out in order to scatter the carbon layers with oxygen molecules; then, carbon layers are completely separated into single or multilayer by means of reduction

[1]. Graphene not only possesses extremely strong bond mechanically but also has high electromigration [2–8]. As well as, it cannot be dispersed in water or any other organic solvent [9]; other admirable properties are the improvement of a reasonable, biodegradable, and mass GO production, which would be highly significant [10, 11]. GO-silicon bilayer structure is experimented for humidity-sensing detection which exhibited outstanding humidity sensitivity [12]. Graphene has extended potential research applications in solar cells, corrosion prevention, fuel cells' display panels, circuit boards, detection of diseases [13–15], and flexible films [16]. The mechanical properties of polyurethane/graphene oxide/multilayer-graphene (PU/GO-MG) composites exhibit excellent chemical bonding [17]. Chemically reduced graphene oxide (RGO) revealed high sensitivity to NO_2 at the room temperature of 200°C [18]. Polypyrrole/graphene oxide (PPy/GO) indicates enhanced electrochemical performances because of its flexibility and electrochemical activity [19]. Liquid crystallinity nature of the graphene oxide has been well demonstrated [11]. Graphene oxide (GO) membranes are clearly exhibited as an excellent membrane for gas separation process, and it blocks everything except water vapour [20]. Graphene oxide (GO) derived chemically has been used as humidity sensitive coating deposited over quartz crystal microbalances (QCMs) to detect various relative humidity at room temperature [21, 22]. The capacity for graphene oxide to direct electrons relies upon the measure of oxidization in the compound, just as the strategy for amalgamation. It is the oxidization in the arrangement that aggravates electrical conductivity [23, 24], while profoundly oxidized graphene oxide would be an extremely poor channel of power, regardless of whether graphene oxide is to be vigorously decreased. However, it would potentially have the capacity to lead power, and it would in any case not be executed just as high-quality graphene monolayers as far as electron versatility is concerned. In any case, there are techniques that can be used to check this circumstance, and those are by a procedure frequently alluded as functionalization, which intends to artificially change a substance in request to build up its properties to suit a particular application. The properties include dispersibility, toxicity, hygroscopicity, and filtering ability. The subsequent artificially adjusted graphene could then conceivably turn out to be much increasingly versatile for practically boundless applications. Functionalization of graphene oxide can be done by numerous techniques.

2. Materials and Methods

Several methods were used for synthesis of GO such as Hummer's method, modified Hummers method, graphite oxide reduction method, graphite intercalation method, electrochemical method, organic synthesis method, carbon nanotubes conversion method, liquid stripping method, solvent thermal method, and arc-discharge method shown in Figure 1. One of the most commonly used methods was Hummer's method [25].
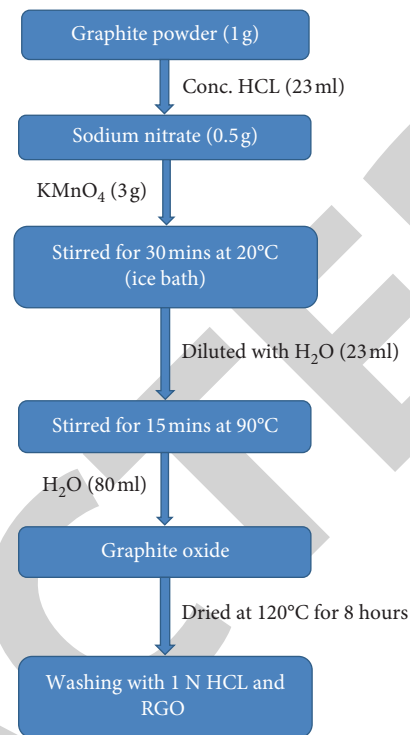

Figure 1: Process flowchart of graphene synthesis [25].

In this paper, the reduced graphene oxide is obtained through chemical synthesis. This method was highly recommended because the GO yield is high and the cost is also low compared with other methods.

2.1. Chemicals Required. Graphite powder, concentrated HCL (hydrochloric acid), sodium nitrate, potassium permanganate, distilled water, sulphuric acid, and hydrogen peroxide.

2.2. Hummer's Method of Synthesis. Graphene oxide is synthesized by Hummer's method through oxidation of graphite [25, 26]. The stepwise procedure is mentioned in Figure 2.

(1) Graphite powder (1 g) and conc. HCL (23 mL) are taken in a beaker and kept in an ice bath at temperature 0–5°C, as shown in Figure 3

(2) Sodium nitrate (0.5 g) is added in a beaker and stirred for 30 minutes at 20°C and $KMnO_4$ (3 g) is added into the beaker

(3) After 30 minutes, it is diluted with H_2O (23 mL) and stirred for 15 minutes at 90°C; after some time, H_2O (80 mL) is added to the solution

(4) After stirring some time, graphite oxide is synthesized and then washed with 1N HCL (hydrochloric acid) several times

(5) The washed graphite oxide is dried at 120°C for 8 hours, as shown in Figure 4, centrifuged, as shown in Figure 5, and dried, as shown in Figure 6, and, finally, reduced graphene oxide (rGO) is obtained
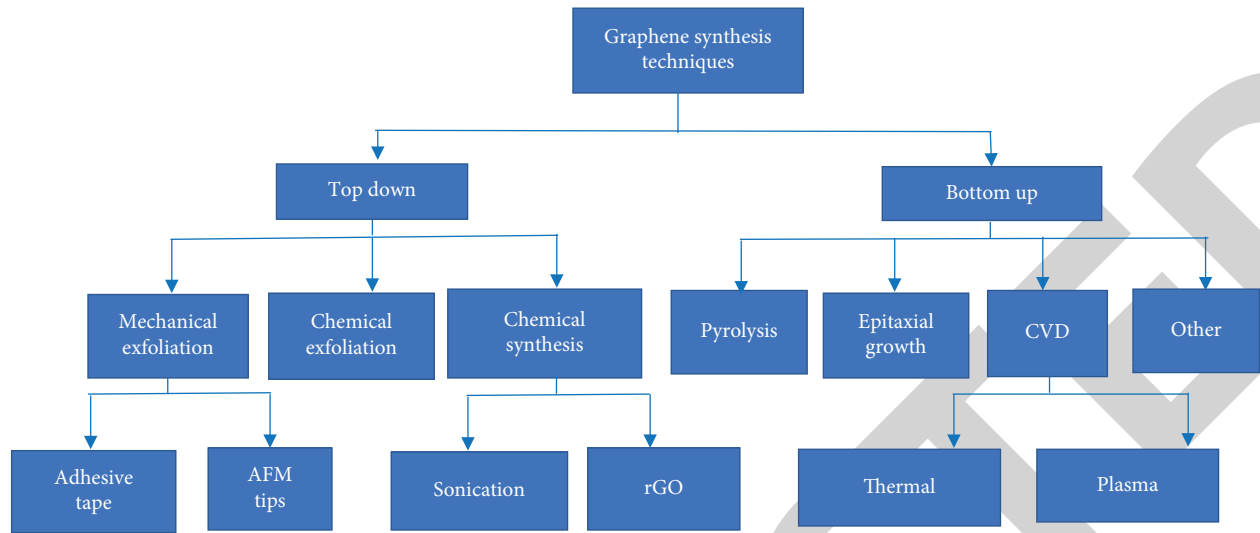
Figure 2: Flowchart of Hummer's method [27].

Figure 3: Mixture in ice bath below 2°C for about 1 hour.

Figure 4: Nanoparticles settled down after 8 hours.

(6) The obtained graphene oxide may have some other chemical impurities; after centrifugation and further drying process, the final graphene oxide acts as nanofilters

The reaction between potassium permanganate and sulphuric acid will be represented by the following equation [26]:

$$KMnO_4 + 3H_2SO_4 \longrightarrow K^+ + MnO_3^+ + H_3O^+ + 3HSO_4^-,$$
$$MnO_3^+ + MnO_4^- \longrightarrow Mn_2O_7$$
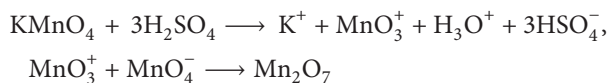
(1)

GO was analysed using the FTIR analysis for atomic characteristics. The FTIR analysis proved that the sample was converted into a graphene oxide compound. The water samples from the industries and other impure water samples were taken, and it was analysed and filtered using graphene oxide nanoparticles. Graphene oxide allows only the water molecules and filters out various other chemical particles and impurities in the water sample. Graphene possessed the ability to filter out the various microorganisms, dissolved salts, and types of impurities in the water or industrial wastewater.

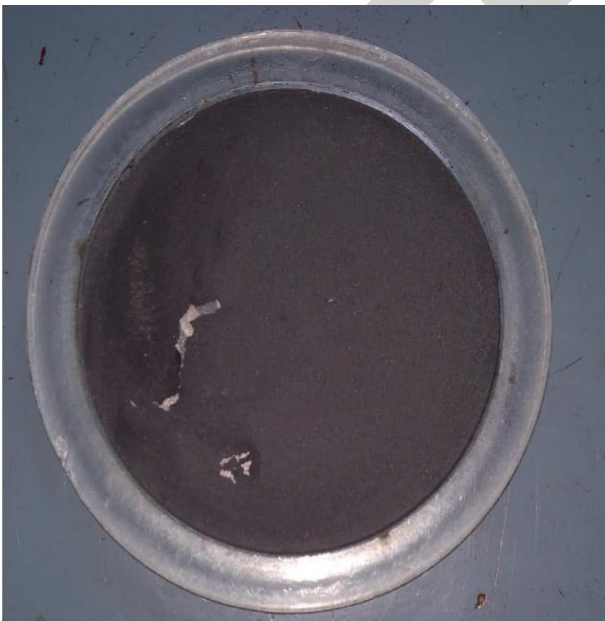Figure 5: Centrifugation at 1500 rpm for 20 minutes.

Figure 6: Dried at 120°C for 8 hours.

2.3. Industrial Wastewater Analysis and Treatment. pH indicates the percentage of hydrogen ions present in the solution. It is necessary to analyse the acidity, alkalinity, and salinity of the water coming out from the industry. Figure 7
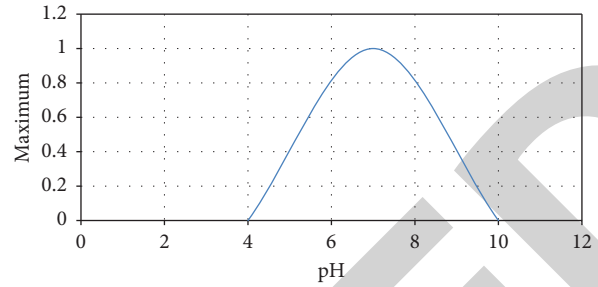

Figure 7: A plot for the growth of aquatic organisms as a function of pH.

shows the range of pH for the living organisms. The pH range is between 4 and 10 for the organisms alive.

In paper industries, the measurement of pH is most important due to various reasons:

(1) Monitor the effluent from SO_2 plants from cooling towers in order to check the right operation of the process equipment

(2) To prevent from corrosion

(3) To maintain appropriate chemical equations

(4) To help the operators to maintain the paper machines under good operating conditions

(5) To adjust the alkaline or acid conditions for wastewater treatment

Earlier colour changing technique was used, but nowadays, it is replaced by standard pH indicating measurement and control. When neutral compounds are mixed with water, it breaks into more particles. The disassociation of this particle is called ions. When hydrochloric acid breaks, $HCl \longrightarrow H^+ + Cl^-$; and it will become a strong acid. Likewise acetic acid breaks up, $HAC \longrightarrow H^+ + AC^-$; it will become weak acid. The pH value of neutral solution (pure water) is 7. The definition to represent the pH will be given by the equation as $pH = -\log[H+]$, i.e., negative logarithm of hydrogen ion concentration or $pH = \log 1/[H^+]$ log of reciprocal of hydrogen ion concentration.

Figure 8 shows the various levels of wastewater treatment. Majorly, it has been categorized into four types. In the preliminary treatment, all the nonfavourable wastes are eliminated or reduced. Suspended solids and other organic matters have been removed in primary treatment. In secondary treatment, soluble and colloidal organics was removed. Significant amount of phosphorous, heavy metals, viruses, bacteria, and biodegradable organics are removed in tertiary or advanced wastewater treatment.

3. Results and Discussion

The incorporated graphene oxide (GO) was prepared by Hummer's method, and the result was revealed by FTIR.

3.1. Fourier Transform Infrared Spectrum Analysis. Fourier transform infrared spectroscopy is used to examine the bonding structure. It is a framework grasped to get an
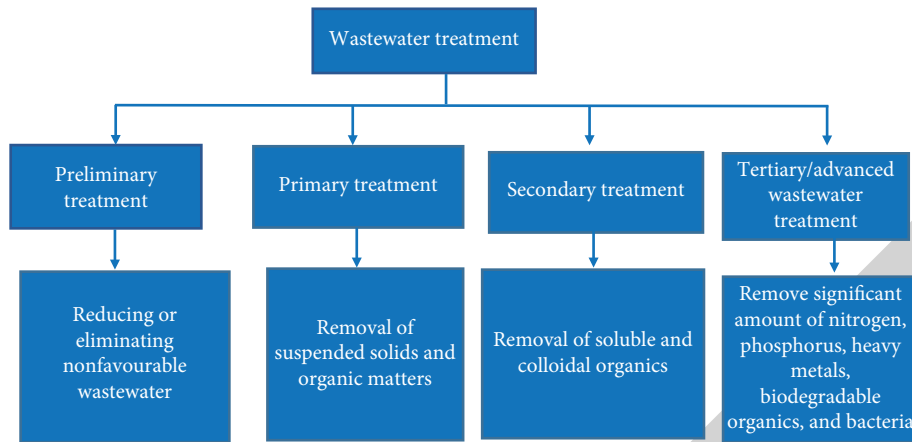
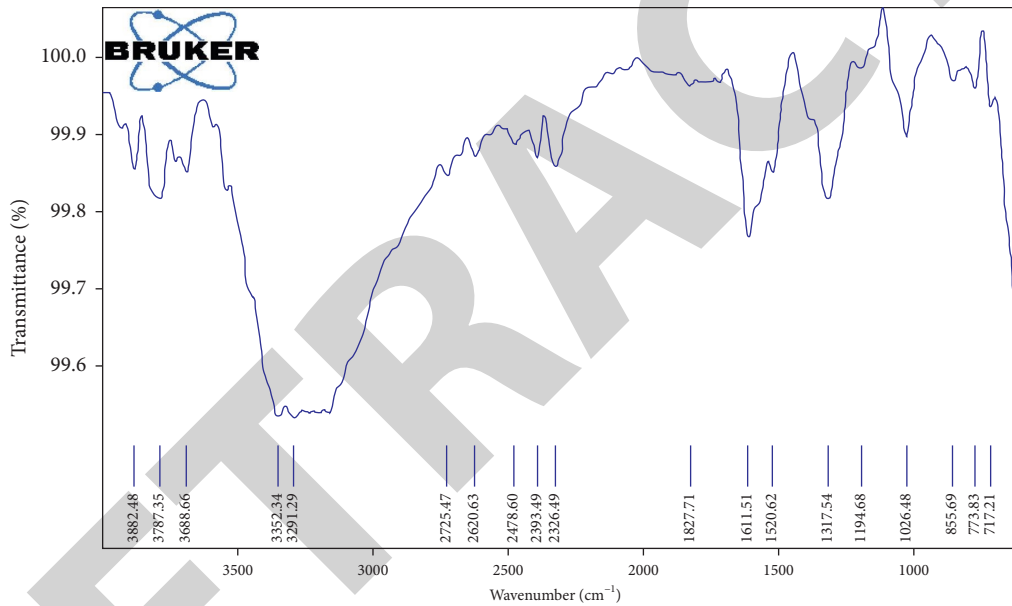Figure 8: Various levels of wastewater treatment.

Figure 9: Fourier transform infrared spectra of GO.

infrared scope of maintenance, transmission, and photo-conductivity of a solid, gas, or liquid. It expects the powers of the pinnacles which are specifically identified with the sum of test present [28]. The incorporated GO has a crest at 1081 cm^{-1} which is described to the C-O bond, affirming the nearness of oxide useful gatherings after the oxidation procedure. The crests in the scope of 1630 cm^{-1} to 1650 cm^{-1} demonstrate that the C=C security still stayed previously, furthermore, after the oxidation procedure shown in Figure 9. Water absorbed by GO was revealed by wide peak at 2885 cm^{-1} to 3715 cm^{-1}, contributed by the O-H stretch of H$_2$O particles. The size of the nanoparticles is around 27–28 nm [26].

3.2. pH Analysis. The sample solution in Figure 10 containing some impurities and acidic content is first analysed and pH of that sample solution is measured. Then, synthesized GO nanoparticles are placed over the filter paper, and the sample solution is tested by pouring over the filter paper, as shown in Figure 11.

Table 1 shows the pH value of the sample solution at different levels. Before filtration, the sample indicates the pH value of 6.47. After first filtration, the pH value of the sample is 6.82, as shown in Figure 12. After the second filtration, the pH value is 6.91, as shown in Figure 13, which is around the neutral.

FIGURE 10: Sample solution pH value.

FIGURE 12: pH value after first filtration.
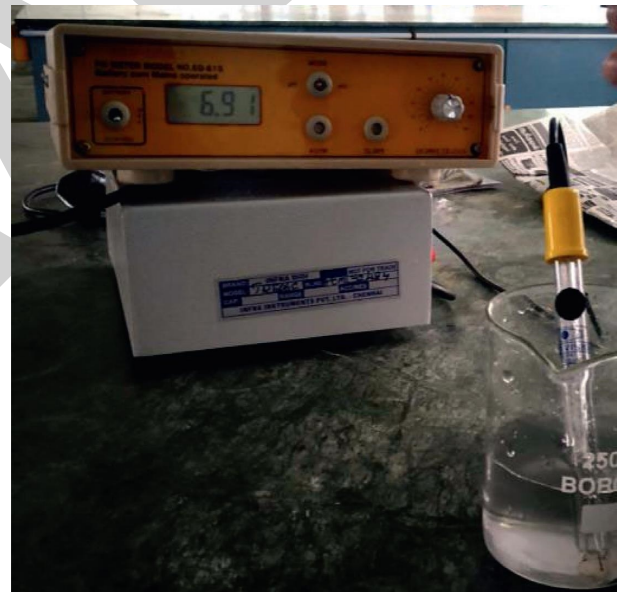

FIGURE 11: Filter using GO nanoparticles.

FIGURE 13: pH value after second filtration.

TABLE 1: pH value at different stages.

Nature of the sample	pH value
Sample before filtering	6.47
Sample after first filtration	6.82
Sample after first filtration	6.91

GO was produced from pencil graphite, so it may have some impurities, and it reduces the pH level. On further filtration with the purified GO nanoparticles' layer or paper, it will give better reduction in the pH value to around the neutral level.

4. Conclusion

Nanographene oxide filter paper was obtained by the Hummers method. Fourier transform infrared spectrum revealed the presence of C–O and C=C bonds. The graphene oxide nanofilters are able to filter out the impurities and also ability to reduce the pH level of the industrial waste water into a reusable form. Analysis provides the pH value as neutral around 7. Apart from this filtering ability, graphene oxide is used for gas sensing, energy storing, and to analyse current and voltage characteristics. Thus, graphene is one of the important and future of electronics, electrical, and various other important technologies around the world.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding publication of this article.

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