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Design, Development and Characterization of Graphene Sand Nano-Composite for Water Filtration

Shahid Hussain Abro*[a], Alidad Chandio[b] Abdulaziz S. Alaboodi[b] and, Iftikhar A.Channa[C]
[a]Department of Materials Engineering, NED University of Engineering and Technology, Karachi, Pakistan.
[b]Department of Metallurgical Engineering, NED University of Engineering and Technology, Karachi, Pakistan
[c]Friedrich University of Erlangen, Nuremberg, Germany
[d]Department of Mechanical Engineering, Qassim University, Saudi Arabia

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Abstract. Water purification and filtration is a global issue and many researchers are engaged to resolve this problem by adopting the scientific approach, graphene sand composite was prepared through bio-synthesized technique. River sand was used in this context to remove the impurities already present in the sand 0.1M nitric acid treated the sand and the product was powder black in colour, referred as GSC, graphene sand composite. SEM, XRD and FTIR characterization was used to analyze the results. SEM images showed nano sized layers or sheets of graphene extending outwards.The XRD peak represents the multi lagered graphene structure which is formed by the treatment of the composite with acid and application of the high temperature during experiment UV-visible spectroscopy results successfully reveals the filtration difference between mud water and filtered water.

Keywords: graphene, biosynthesized, sugar anchoring, sand particles, water filtration.

Introduction

Graphene is an exceptional 2-dimensional allotrope of carbon(Abdel majid *et al*., 2018; Chong yang *et al*., 2018; Chandra *et al.* 2010). The applications of graphene along with graphene based compounds composites for the removal of pollutant, filtration, environmental remediation, electronic circuits, solar cells and several chemical, industrial and medical processes are being explored.Graphene can be prepared by two distinct methods (i) Graphite is chemically transformed to GO, graphite oxide followed by reducing the graphite oxide by N_2H_4 (hydrazine) to reduce graphene oxide (ii) anchoring of graphite oxide and reduced graphite oxide upon sand particles either by applying heat treatment or by covalently bonding on silica directly as well as by applying molecular binders. Although many different chemicals can also be used to synthesize of RGO such as N_2H_4 (hydrazine), (P_2O_5) and ($K_2S_2O_8$) as a result it can generate unwanted hazardous products such as, (P_2O_3), (SO_2), etc. (Lujanienë *et al.*, 2017; Das *et al.*, 2014). This may require laborious work such as post-synthesis cleaning. (Jisoo *et al.*, 2018). Many graphene based composites have been developed so far even with and without metal oxides for water filtration applications but for success of such materials, cost is always the main criterion and therefore, it becomes compulsory that new and advanced prospective techniques should always be used for producing such products (Xiao *et al.*, 2016; Savag and Dillo 2005). Graphene sand composite is the *insitu* development of graphenic stuff material supported upon the surface of river's sand which requires additional binders. But in research process no harmful residues were left when sugars readily decomposed into carbon. (Dreyer and Sungjin, 2010). Waste water can be treated by bio-synthesized graphene process imposing the anchoring of graphene upon the river's sand and make unlikely to change the graphene as a result it more suitable for treatment of flowing water framework (Dreyer *et al*., 2012). The method used in present research work for the synthesis of composite is different from conventional composite manufacturing because it is a nano composite. (Poornima Parvathi and Umadevi, 2016; Bykkam *et al*., 2013; Yang and Chong 2010) after removing from furnace it was treated with sulphuric acid to activate it. (Peng *et al*., 2015).

*Author for correspondence; E-mail: engrabro@neduet.edu.pk

It is most desirable to develop and produce the graphene adsorbent in economical way as well as it is eco-friendly and use for water purification and filtration. A scientific approach is made in this work to design and establish the unique technique which is used for advance and traditional method to purify the drinking water. Graphene Sand Composite (GSC) was successfully developed and the results were confirmed by advanced characterization techniques. (Song *et al*., 2018; Chao *et al*., 2013).

Materials and Methods

Materials used in the process were almost easily available and purchased from the local market sugar, sulphuric acid, nitric acid, activated charcoal and de-ionized water. The sand was obtained from the sea view, having the particle size of 180 microns.The overall experimental work was performed in the following steps:

Synthesis of GSC. Sand was first washed with 0.1M nitric acid in order to remove any contaminants present in the sand. These contaminants could be different ions causing any unfavourable reaction during the process. Then sand was dried subsequently in air for one day. This washed sand was used in all the experimental titerations, performed as shown in Fig. 1 (A). The dried sample was put inside of the graphite crucible.

Preparation of sugar sand solution. Molar sugar solution was prepared by adding 342 g of sugar in 1 Liter of deionized water. This was done by mixing the solution thoroughly. Then 20 g of sand (particle size 180 micron) was added to the solution.

Mixing and drying on magnetic stirrer. The beaker containing the solution of sugar and sand was placed on the hot plate magnetic stirrer for about 6 h with continuous stirring and approximatly 85 °C to evaporate the water. The sample was grey colour of the solution as shown in Fig 2.1 and 2.2

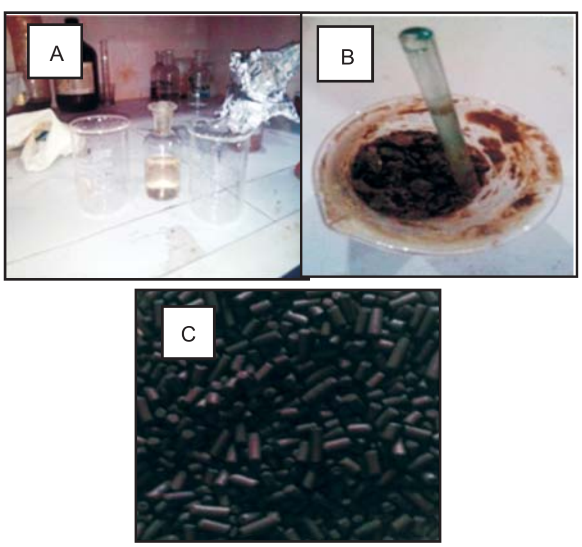

Fig. 1. (A) sand washing. (B) Sample obtained after hot plate stirring. (C) Crucible covered with charcoal.

The crucible was covered by activated charcoal dispersed from all sides to protect for the reducing environment as shown in Fig1 (C). Heat treatment was performed in a muffle furnace. Fig. (2) first it was heated to about 200°C for 1 h then it was held there for about 1 h to unformly heat all the samples and heated to 750°C for 1 h and held at this temperature for about 3 h and then furnace wash cooled. After heat treatment, black sample obtained which was graphene sand composite as shown in Fig. 2.1. The sample was treated with sulphuric acid (for every 5 g of sample 20 ml of acid was used) for about 1 h to active it and washed with deionized water and filtered by means of filter paper (Theruvak kattil Sree nivasan, 2013). The resulting sample was then dried on the hot plate for about half hour at 120°C as shown in Fig. 2.2.

Now, again followed same methodology in this titration. The particle size of sand was reduced from 180 microns to 3 microns through ball milling of the sample for about 75 h. The sample obtained from ball milling

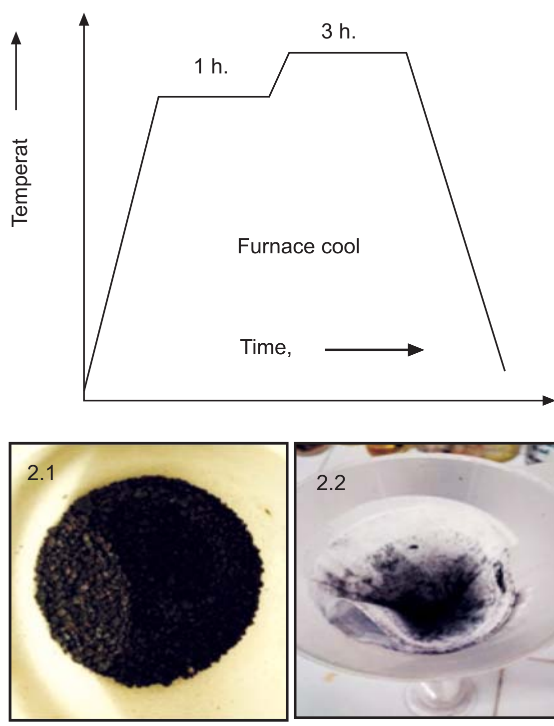

Fig. 2. Heat treatment cycle. **Fig. 2.1** GSC powder after heat treatment. **Fig. 2.2** Filtering sample

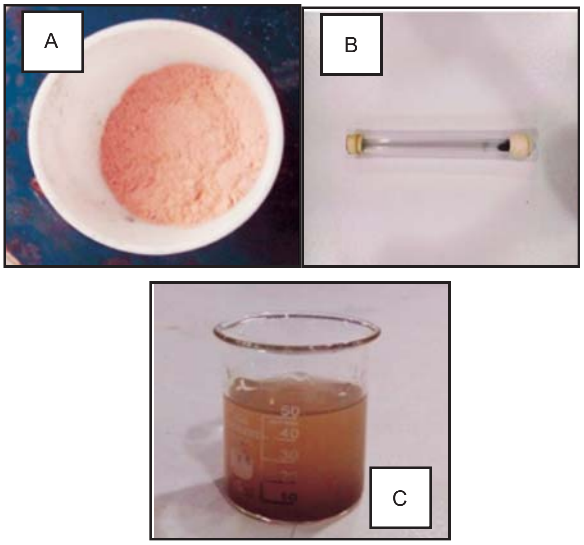

Fig. 3. (A) GSC obtained after treatment. The sample obtained was whitish brown. (B) Filter Design with simple tube covered at one end with cloth. (C) Dirty water combined with mud.

machine was very fine powder of white colour as shown in Fig. 3 (A)**.**

Water filtration is a simple filteration which was made by the glass tube closed at one end and allow only water to pass through the sample and also hold the sample in place as shown in Fig. 3 (B). The water from the mud was collected in a beaker (Fig. 3 C) and passed through the filter tube and collected in the bottles for further testing of this purified water.

Results and Discussion

Synthesis and characterization of GSC. ***X-ray diffraction.*** The XRD results of the GSC sample in the powdered form (180 micron) is shown in Fig. 4. The peak obtained at 20.93° represents the multi layered graphene structure which is formed by the treatment of the composite with acid and application of the high temperature in the procedure. The d-spacing for GSC is also higher, than the pristine graphene because of this treatment and equal to 0.402 nm.

The characteristic peaks of graphene were obtained at 26.6°, 42.4°, 44.7°, and 54. 8°.The peak for multi layered graphene was obtained at 20.9° degrees and the corresponding d-spacing is 0.402 nm. Almost similar results were obtained when the sand size was reduced to 3 microns by ball milling for 60 hours as shown in Fig. 4.

FTIR spectroscopy. The FTIR results as shown in Fig. 5 which verifies the proper and perfect graphitization of 180 micron sand. It clearly indicate the absorption

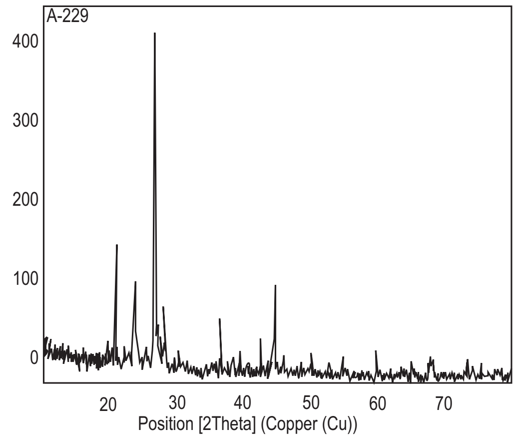

Fig. 4. XRD pattern for 180 micron GSC.

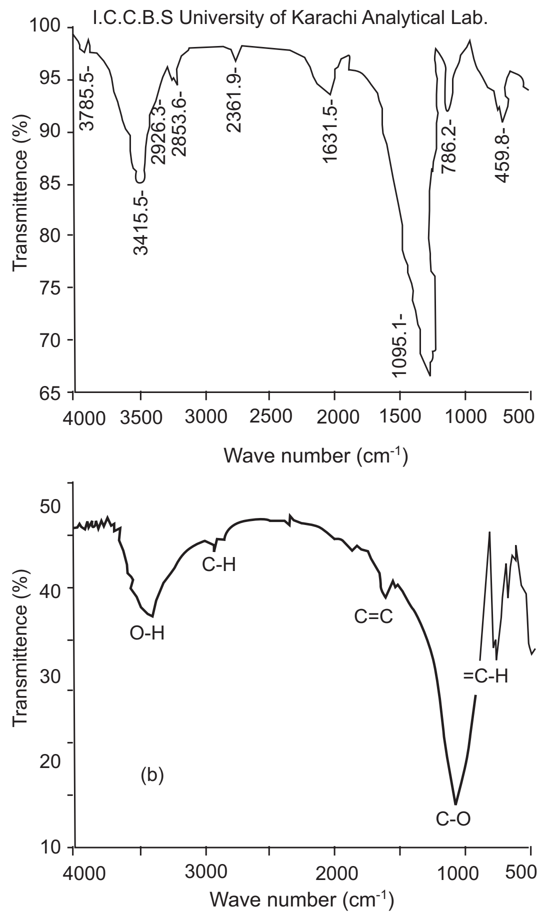

Fig. 5. FTIR of GSC sample.

band at 1631.5 cm, that was closed similarity straighten at C=C and indicated the sketchy graphene structure. An absorption band present at 1095.1 cm indicates the C=O sketchy graphene structure. However, the band straighten at 3415.5 cm indicates O-H, which represents the oxygen functionality present at that point. The band at 2925cm respresents C-H and at 778 is for C-H.

Results of filtration. ***UV visible spectroscopy.*** Two Fig. 6 (A) and (B) describes elementary UV-visible absorption spectrum for mud water and filtered mud water sample. The values on y-axis indicate the amount of light absorbed.

If the Y-axis value is greater than higher the wavelength is absorbed.The large difference was obtained between absorption of mud and filtered mud water.

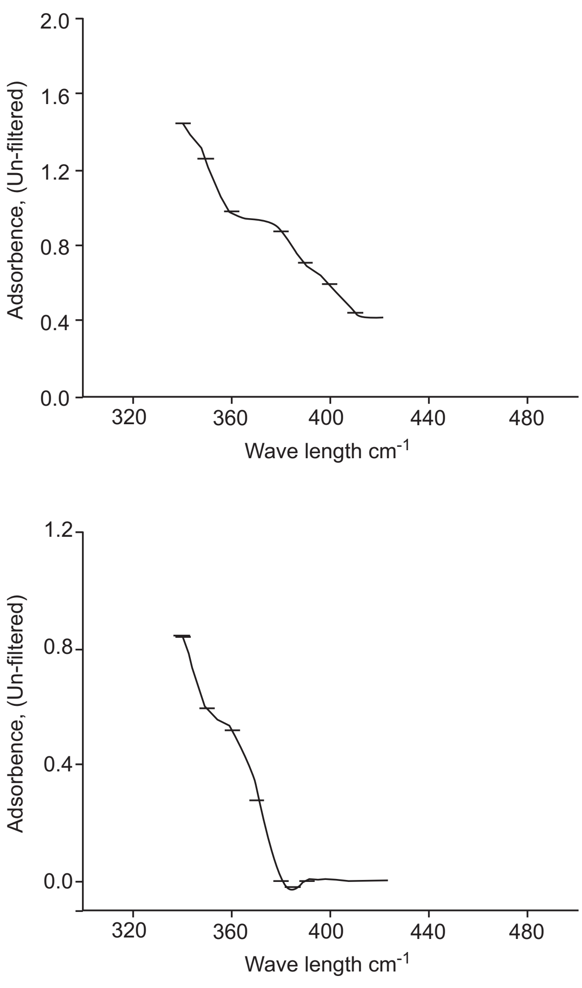

Fig. 6. (A) visible UV absorption spectrum of mud water. (B)Visible UV absorption spectrum of filtered mud water

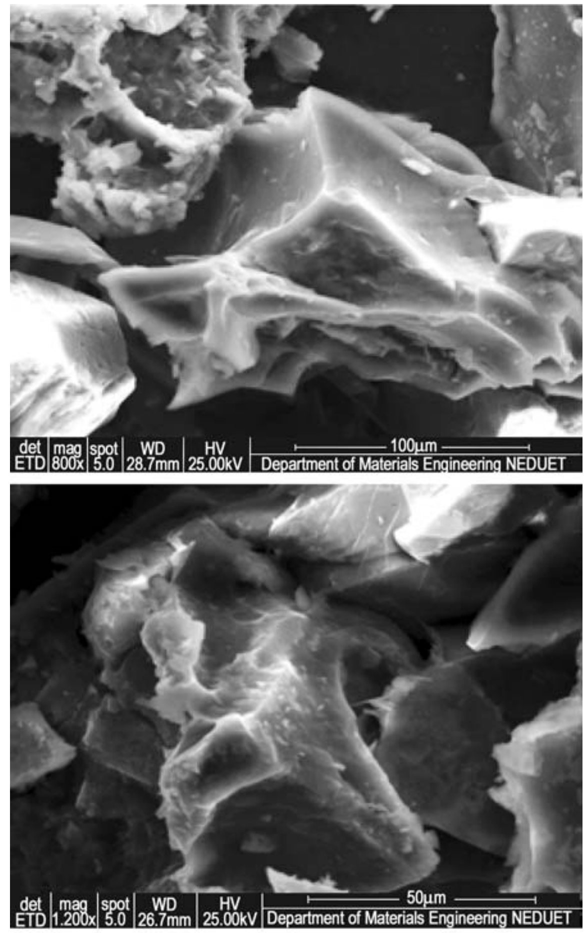

Fig. 7. (A) SEM results of GSC (B) SEM results of GSC.

Scanning electron microscopy images at different resolutions showed layers or sheets of graphene extending outwards (Gao *et at*., 2011; Sreeprasad 2011). These dimensions of layers were found to be in the range of nano meters (nm), shown in Fig 7 (A) and (B) and the presence of wide pores in the surface are seen. This may be the reason for the good adsorption properties of GSC.

Conclusion

Graphene sand composite prepared through biosynthesized technique by means of anchoring of sugar particles upon the sand with no binder, the different characterizations techniques used for the identification formation of graphene sand composite are SEM imaging, XRD analysis and FTIR spectroscopy and the adsorption test. The graphene sand composite and the classical results of this work are comparable and up to the standards, however further work can be performed as well.

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Conflict of Interest. The authors declare no conflict of interest

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