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CHARACTERIZATION OF GRAPHENIC MATERIAL COATED ON SAND FOR WATER PURIFICATION APPLICATION

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Abstract

In this research, a suitable methodology was introduced to synthesize of graphenic material on sand as graphenic material coated sand composite (GSC). Graphenic material was prepared from sugar and normal sand as a media of adhesion in order to produce graphenic material coated sand media which is well known as graphenic material coated sand composite (GSC). GSC was used to remove lead from lead solution. Physical and chemical tests were carried out for water purification applications. Structural properties of the obtained composites were analyzed by X-ray diffraction (XRD) and the morphology studied of GSC was characterized by scanning electron microscopy (SEM). And then residual lead concentration of the lead solution after filtration process were observed by using atomic absorption spectroscopy (AAS). The current study reveals the importance of water purification application using GSC.

Introduction

One of the most socially relevant aspects of nanotechnology is in the field of environmental remediation. Diverse applications of nanomaterials in decontamination of air, water and soil are intensely pursued in the recent past· The availability of large surface area and unusual electronic structure imparts new properties to nanomaterials. One of the early applications of such materials is the halocarbon decomposition and the use of this technology in pesticide removal· Numerous other applications of noble metal nanoparticles have been reported in the literature. Chemical interaction at noble metal nanoparticle surfaces often led to charge transfer and subsequent cleavage of chemical bonds, the most often encountered is reductive dehalogenation. Enhanced surface chemistry leading to faster kinetics is reported on noble metal nanoparticles. Carbon has been the most versatile material used for water purification in history. Very early account of the use of charcoal in water purification is found in the Vedic literature. It is believed that people of Indus valley civilization used carbon and porous materials, such as earthen vessels, for filtering and storing drinking water. The most widely used material for water purification today is activated carbon (AC) derived from plant sources. It has the best possible surface area and could be produced at low cost, making it the most affordable adsorption medium in diverse applications. A number of other forms of carbon have appeared with very large adsorption capacities. Advanced techniques such as membrane filtration, reverse osmosis and ion-exchange can be used in treatment and removal of contaminants from water. However, higher cost limits the large scale application of such treatment techniques in developing countries. One of the fascinating new additions into the carbon family is graphene' the one-atom thick sheets of carbon. Carbon materials, such as activated carbon, charcoal, carbon nano-tubes, have been used extensively in water purification and, hence, are indispensible components of all commercial water technologies. Materials derived from plant sources may even be more eco-friendly than those from fossil source such as petroleum. Among the simplest of natural sources of carbon are

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sugars, which upon dehydrogenation get converted completely to elemental carbon, leaving only water to escape. Similar reactions are applicable to decomposition of sugars of various kinds. This transformation is simple and effective. The carbon so obtained could be anchored on inorganic surfaces, and a subsequent chemical treatment could transform it to graphenic carbon (GC). Activation of newly formed surfaces may produce highly effective adsorbents. In this research, was observed in situ creation of graphenic material anchored onto the surfaces of river sand without the need of any additional binder. And also studied the application of this material in water purification

Materials and Methods

Materials

The raw materials used for the synthesis were common sugar, river sand, and sulfuric acid.

Methods of Characterization

X-ray diffraction patterns were recorded using X-ray diffractometer (Rigaku-Multiflex 2kW) which was operated at 30kV and 40mA with X-ray source of CuKα radiation having wavelength 1.5406° A. The XRD patterns in the 2θ range of (10°-70°) were recorded at room temperature. The surface morphology of GSC was imaged using a high resolution scanning electron microscopy JEOL JSM-5610LV model scanning electron microscope (SEM). And then residual lead concentration of the lead solution after removing process were observed by using atomic absorption spectroscopy (AAS).

Preparation of the Composite

Common sugar (sucrose crystals) was used as the carbon source. At first, the (160g) of sugar was dissolved in (100mL) distilled water and then, the solution was mixed with (40g) of sand (riversand). The mixture was dried at∼95°C on a magnetic stirrer for about 6 h with constant stirring. The sugar-coated sand was then placed in a ceramic crucible and heated in a furnace. The furnace temperature was programmed as follows: (a)from room temperature to 100°C in 30 min, (b) 100−200°C in 30 min(c), held at 200°C for 1 h (to melt sugar to form a uniform coating; melting point of sucrose is around 186°C), (d) ramped to 750°Cin1h,and (e) held for 3 h at 750°C (to ensure complete graphenic material of sugar). The furnace was switched off and the material was cooled to room temperature. The temperature of 750± 5°C was chosen as the final temperature after optimization through several experiments. No special care was taken in controlling the cooling rate. The black sample was named graphenic material coated sand composite (GSC). For activation, 5 g of the composite was treated with 10 mL of concentrated sulfuric acid and kept undisturbed at room temperature for 30 min. The mixture was then filtered and dried at 120°C. The activated GSC is labeled as GSC. The Figure (1) shows the preparation of graphenic material coated sand composite GSC.

Preparation of Pb^{2+}solution and Commercial Soft Drink with GSC Filtration

(1000 mg/L) stocks solution were prepared for $Pb^{2+}$by dissolving (1.5985g) of $Pb(NO_3)_2$ in one liter of distilled water then diluted to (50 mg/L) concentration to be used in subsequent experiments. Firstly, (3g) of GSC were packed in a tubular column of 20mL capacity with 8mm diameter and poured (15mL) of Pb^{2+}solution above the tubular column as shown in the following Figure(2). After that were made filtering process. The residual Pb^{2+} concentration of the Pb^{2+} solution after filtering process were observed by using atomic absorption spectroscopy (AAS). And then were calculated removal efficiency by using following equation.

$$\%\, Removal\ Efficiency = \frac{C_0 - C_e}{C_0} \times 100$$

Where C_0 *and* C_e is the initial and final concentration of solution (mg/L) respectively.

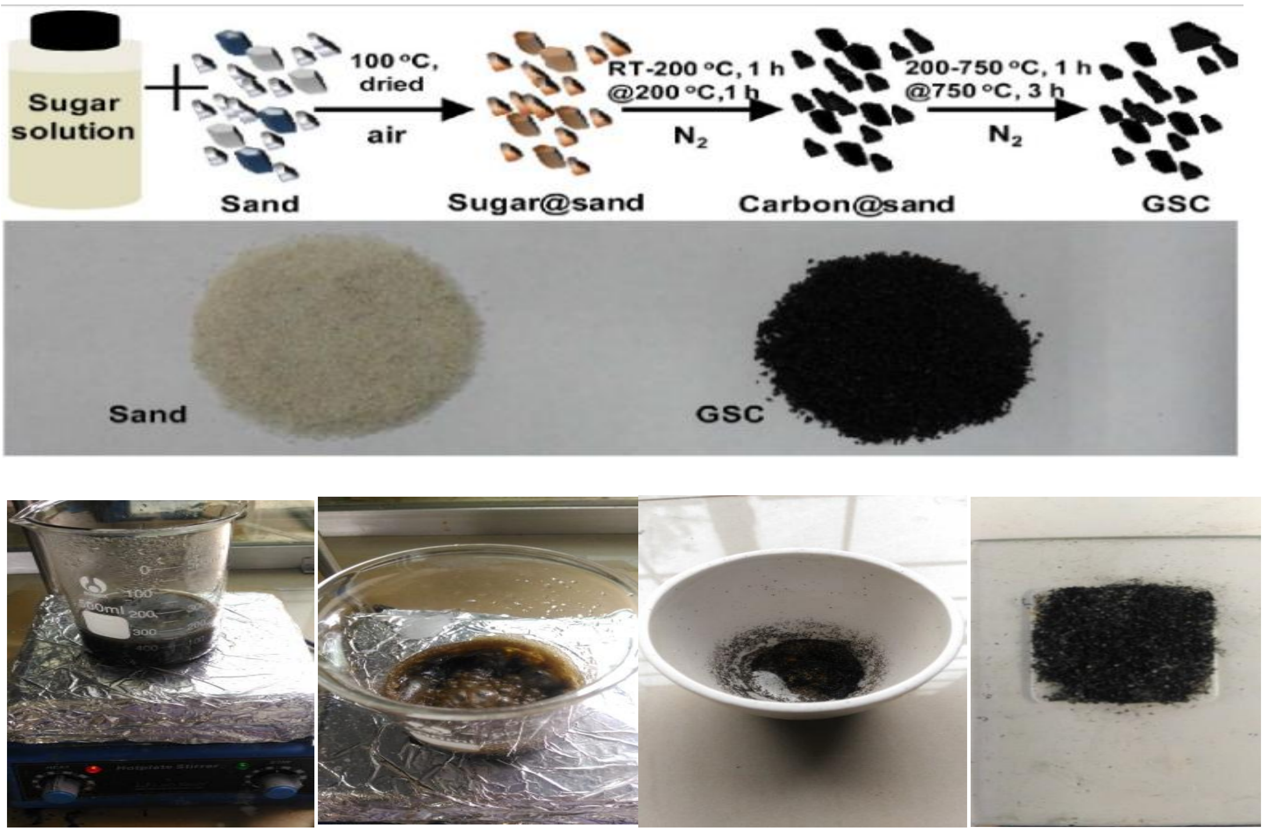

Figure 1 Photograph of preparation of graphenic material coated sand composite GSC

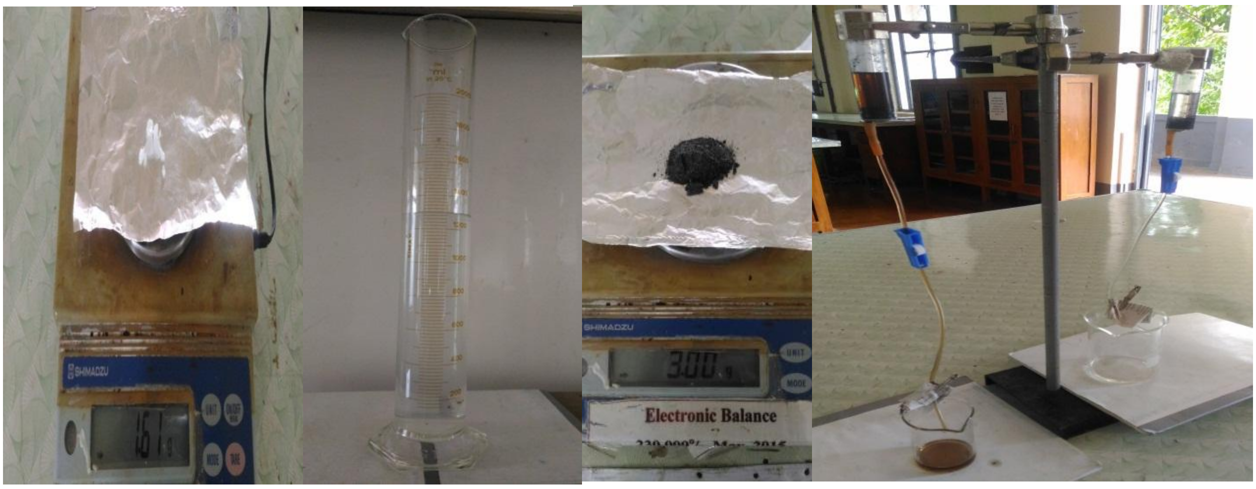

Figure 2 Photograph of preparation of Pb^{2+}solution and Filtration with GSC.

Results and Discussion

XRD Measurement

Structural studies of the GSC with heat-treated at 750°C for 3 hours were done with X-ray diffraction (XRD) technique. The crystalline sharp peaks in the diffraction pattern were identified by using the International Centre for Diffraction Data (ICDD). The crystalline size was calculated by using Scherer's equation; $D = (k\lambda)/(\beta \cos\theta)$ where, β is the peak width measured at half intensity (radian), λ is the wavelength measured in Å, k is the particle shape factor or Scherer constant (k= 0.9) and D is the crystallite size of the crystallites (Å).

The XRD spectra for GSC at750°C are depicted in Figure 3. XRD diffraction peaks belonging to (100), (101), (110), (102), (111), (200), (201), (112), (202), (103),(210) and (211) were observed in all these GSC which are well matched with the powder diffraction data of " *00-003-1161> Quartz, syn-SiO2* and *00-023-0064> Graphite* " were also well matched with diffraction peaks (002), (110), (101), (004). "*01-080-3905>syn-Carbon"* were also well matched with diffraction peaks (100). The diffraction peak at Quartz in (101) plane was pronounced sharper indicating that the crystallinity of GSC was improved at this processing condition. Agreement of lattice constant values ($a=b\neq c$) of GSC proved that quartz (SiO_2) has trigonal structure and carbon (C) has hexagonal structure.

Surface Morphology of GSC

Surface morphology of GSC sample was examined by scanning electron microscopy (SEM). SEM images of GSC layers heat-treated at750°C for 3 hr are shown in Figure 4. According to the images, it was observed that the graphenic materials coated on the sand in the form of flakes pattern. The graphenic materials were uniformly spread over the sand surface and it reveals the micro-grain structure with small crystallite sizes. The micron size grains are visualized on the surface of GSC.

AAS Measurement

The residual lead concentration of the lead solution after removing process were observed by using atomic absorption spectroscopy (AAS) is shown in Table 2. After filtering process with GSC sample, the initial (50mg/L) concentration of lead solution slightly decrease to (4.3 mg/L) concentration. Percentage of removing efficiency of GSC is (91.4%).The results prove that GSC has efficiently removed the lead concentration present in the initial (50mg/L) concentration of lead solution.

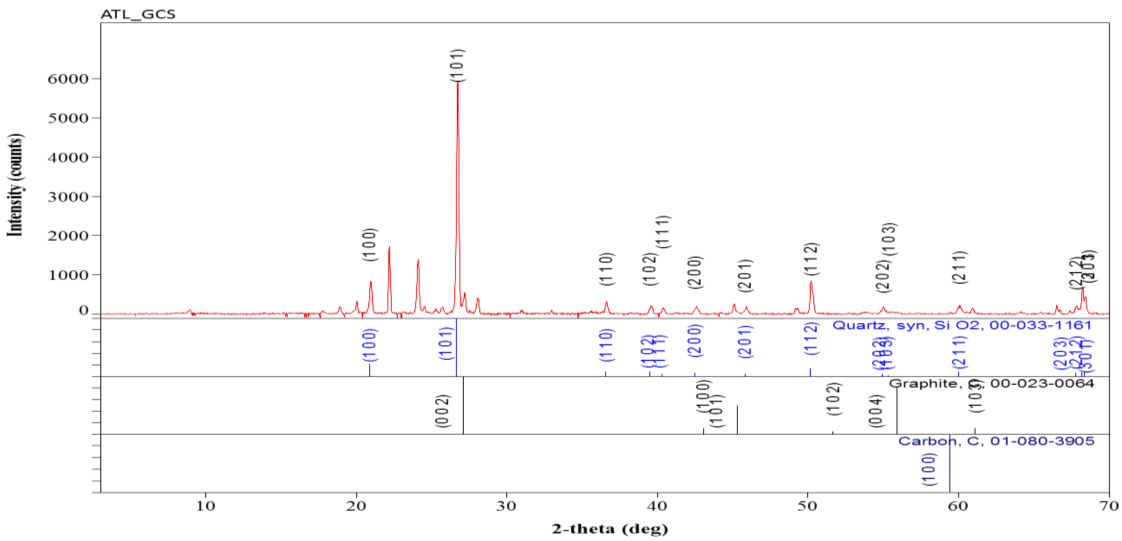

Figure 3 The XRD pattern of Graphenic material coated sand composite (GSC).

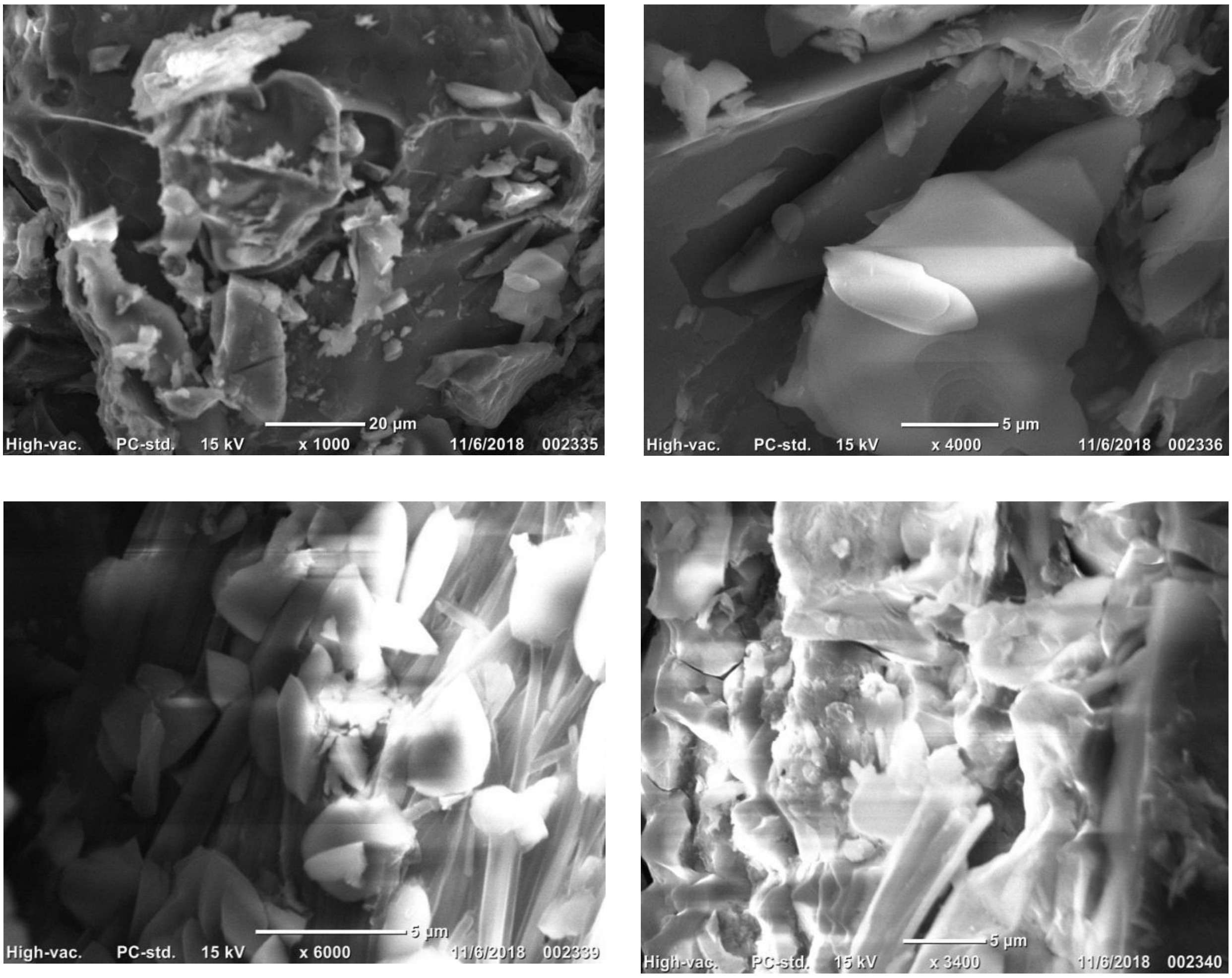

Figure 4 The SEM image of Graphenic material coated sand composite (GSC).

Table 1 The XRD result data of Graphenic material coated sand composite (GSC).

Sample	2-theta (deg)	d (Å)	Phase name	FWHM (deg)
GSC	26.7229	3.3333	Quartz, syn(1,0,1)	0.1593
	27.176	3.2787	Graphite(0,0,2)	0.169
	59.476	1.5529	Carbon(1,0,0)	0.105

Table 2 The residual lead concentration of lead solution before and after filtration process with GSC.

The concentration of Lead Solution before filtering with GSC	The concentration of Lead Solution after filtering with GSC	% Removal Efficiency
50 mg/L	4.3 mg/L	91.4%

Conclusion

Graphenic material was prepared from sugar and normal sand as graphenic material coated sand composite (GSC) with slow carbonization at 200°C. In this research, the synthesized GSC was used to remove lead from lead solution. The XRD pattern of the sample GSC exhibited a stong peak for loading ratio of (160 g) sugar and (40g) sand (river sand) which corresponds to an interlayer spacing of about 0.333 nm, 0.327 nm and 1.552 nm, indicating the presence of SiO_2, graphenic material and carbon functionalities. The peak around 26.72˚, 27.17˚, and 59.47˚ are responsible for the presence of SiO_2, graphenic material and carbon and all other peaks corresponds for the elements present in the natural river sand and trace impurity of sand. The morphology of GSC was evident in the SEM images. Thin sheets of carbon are protruding outward and are visible as composites layers of graphenic material and sand mixture. It was observed that the synthesis of sugar-derived graphenic material supported on sand. The utilization of this material for water purification is evident from the data presented. The large percentage of removing efficiency, the availability of the raw materials and cost effective and environmental friendly synthesis method for preparing GSC are high potential to use in water purification and water treatment applications.

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