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Research Paper

Green Synthesis of Silver Nanoparticles Loaded With Activated Carbon and Its Characterization

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Abstract: *In this study, a new adsorbent, the greener synthesis of silver nanoparticles loaded with activated carbon (Ag-NP-AC) was synthesized and characterized. This novel material was characterized and identified by different techniques such as FTIR,Scanning Electron Microscopy(SEM),XRD analysis. Surface functional groups were detected by Fourier transformation infrared (FTIR) spectroscopy techniques. The surface morphology, porosity of silver nanoparticle loaded activated carbon was visualized via scanning electron microscopy (SEM) analysis .The nature of the particles determined by X-ray diffraction method.*

Keywords: Silver nanoparticles, Activated carbon, FTIR, SEM.

Introduction

Nanotechnology provides the tools and technology platforms for the investigations and transformations of biological systems, and biology offers inspiration models and bio-assembled components to nanotechnology. Nanobiotechnolgy is defined as a field that applies the nanoscale principles and techniques to understand and transform biosystems (living and non-living) and which uses biological principles and materials to create new devices and systems integrated from the nanoscale[1].

Hazards can be either physical, chemical, biological, medicinal, or microbiological agents of disease. Activated carbon a product of popularly agricultural waste such as coconut husk[2], bamboo tree [3] is widely used for solving physical and chemical problems due to the fact that activated carbon (AC) possesses a large surface area, so that high adsorption ability. However, to obtain a material which can solve not only physical, chemical but also microbiological problems as well is an interesting issue. Carbon materials are biocompatible with bacteria and good supports for their development [4].

An activated carbon material with antibacterial activity can be obtained by impregnated with silver or metallic oxides. There are several ways to produce silver nanoparticles (AgNP) supported on activated carbon matrix. The technique we applied here in which AgNP are directly loaded inactivated carbon[5]. Silver nanoparticles are commonly utilized nanomaterials due to their antibacterial properties, high electrical conductivity, and unique optical properties that could be used in various applications[6]. The properties allow the incorporation of AgNP in to various matrix such as activated carbon, polymer networks, textiles, and wound dressing materials[7].

This technique benefits from unique properties such as simple design, using nontoxic, low cost adsorbents and high efficiency. Characteristics and appropriate selection of adsorbents are based on remarks such as removal capacity, treatment cost and operating conditions[8]. Nanoscalematerial benefit from advantages such as high surface reactive atom, large surface area with porous structures. Silver nanoparticles due to their ordered structure, high aspect ratio, ultra light weight, high mechanical strength and high surface area are suitable for adsorption[9-12].

In the present study, we have reported a green method for the synthesis of silver nanoparticle in which the water is utilized as an environmentally benign solvent throughout the preparation. This study reports on the feasibility of applying silver nanoparticles are then directly loaded on activated carbon Ag-NP-AC as low cost adsorbent produced by activation of activated carbon.

Material and Methods

Preparation of silver nanoparticles loaded Activated carbon

The procedure for the preparation of nanoAgAC was as follows: 100 mL of the freshly prepared Ag nanoparticles solution (6.8×10^{-2} mg/L) was mixed with AC (5.0 g) in a 250 mL Erlenmeyer flask under magnetic stirring for upto 12 h. After deposition of the Ag nanoparticles onto activated carbon, the nanoAgAC mixture was filtered. The nanoAgAC was later dried at 110^{o}C in an oven for 10 hr. A mortar was used to homogeneously ground the nanoAgAC powders. The nanoAgAC was stored at room temperature and it was found that the shelf life of nanoAgAC was at least 1 year.

Characterization of silver nanoparticles loaded activated carbon

Fourier Transform Infrared Spectroscopy (FTIR)

FTIR is perhaps the most powerful tool for identifying the types of chemical bond (functional groups). The wavelength of light absorbed is characteristic of the chemical bond and can be seen in this annotated spectrum. Chemical bonds in a molecule can be determined by interpreting the infrared absorption spectrum. The spectra of the samples were recorded between 400 cm^{-1} and 4000 cm^{-1} using (IR Affinity-1Shimadzu FTIR spectrometer)to analyze the functional groups of the silver nanoparticles loaded activated carbon. About 0.1 g of sample was mixed with 1 g of KBr powder, in a mortar and pressed in to a pellet for measurement.

X-ray diffraction measurement (XRD)

X-ray scattering techniques are a family of non-destructive analytical techniques which reveal information about the crystallographic structure, chemical composition and physical properties of materials and thin films. These techniques are based on observing the scattered intensity of an X-ray beam hitting sample as a function of incident and scattered angle, polarization and wavelength or energy. The activated carbon were grinded to form fine powders and then pressed lightly on a stainless steel holder using a carbon conducting tape. XRD was performed at D8 Advanced XRD, Bruker and the spectra were analyzed using Origin 6.0 software. The crystallite domainsize was calculated from the width of the XRD peaks, assuming that they are free from non-uniformstrains, using Scherrer's formula.

$$D = \frac{0.94\,\lambda}{\beta\ \mathrm{Cos}\ \theta}$$

where D is the average crystallite domain size perpendicular to the reflecting planes, λ is the X-ray wavelength, β is the full width at half maximum (FWHM) and θ is the diffraction angle. To eliminate additional instrumental broadening the FWHM was corrected, using the FWHM from a large grained Si sample.

$$\beta \text{ corrected} = (\text{FWHM}^2 \text{ sample- FWHM}^2\text{si})^{1/2}$$

The above modified formula is valid only when the crystallite size is smaller than 100 nm (Cullity, 1978).

Scanning Electron Microscopy (SEM)

Scanning Electron Microscopic (SEM) is a type of electron microscope that images a sample by scanning it with a high-energy beam of electrons in a raster scan pattern. Morphology, size and structures of the particle were examined using scanning electron microscopy (SEM) (Model 6093, JEOL).

Results and discussion

FTIR analysis of silver nanoparticles loaded activated carbon

Figure 1 shows FTIR results of silver nanoparticles loaded activated carbon. The peaks at 3410.15cm^{-1} are characteristic stretching vibrations of alcohol -OH group,1608.63 cm^{-1} characteristic of C=C stretching vibrations, 1379.10 cm^{-1} characteristic of C-H bending vibrations, 1701.22cm^{-1} characteristic stretching vibrations of C=O group.

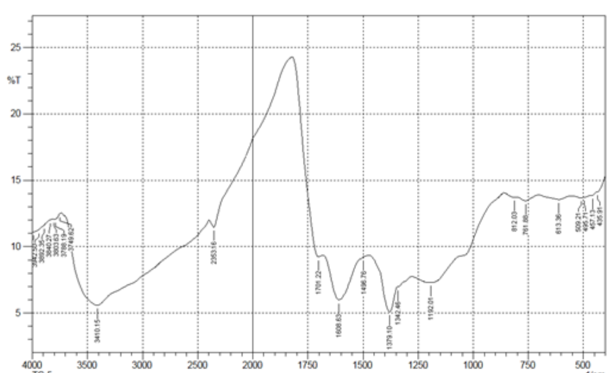

Figure 1: FTIR analysis of silver nanoparticles loaded activated carbon

XRD analysis of silver nanoparticles loaded activated carbon

The X-ray diffraction patterns of silver nanoparticles loaded activated carbon are shown in Figure 2. The XRD pattern of silver loaded activated carbon did not reveal any diffraction pattern observed in the 2θranging from 10º to 79 ºindicating that it is disordered. An amorphous peak was observed at 2θ = 24.1 it is due to activated carbon.

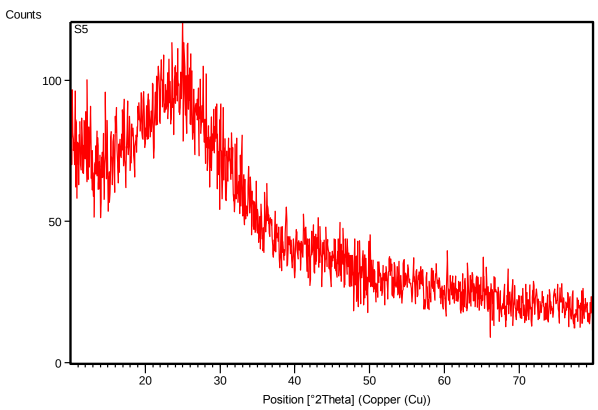

Figure 2: XRD analysis of silver nanoparticles loaded activated carbon

SEM analysis of silver nanoparticles loaded activated carbon

The Scanning Electron Microscope (SEM) analysis was carried out for the silver nanoparticles loaded activated carbon for determining the surface morphology. It was noticed that the SEM analysis indicated the presence of irregular and highly porous structure of the sample studied shown in Figure 3.

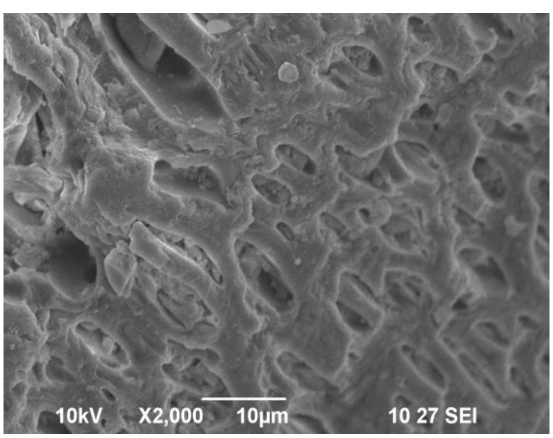

Figure 3: SEM analysis of silver nanoparticles loaded activated carbon

Conclusion

In the present work, we have reported the potential usage of silver nanoparticles loaded activated carbon(Ag-NP-AC) ,as a new ,renewable, inexpensive, green and environmental friendly adsorbent. (Ag-NP-AC) shows good efficiency of adsorbent compared to the other adsorbents .The present study concludes that the Ag-NP-ACcould be employed as low cost activated carbon instead of commercial activated carbon.

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