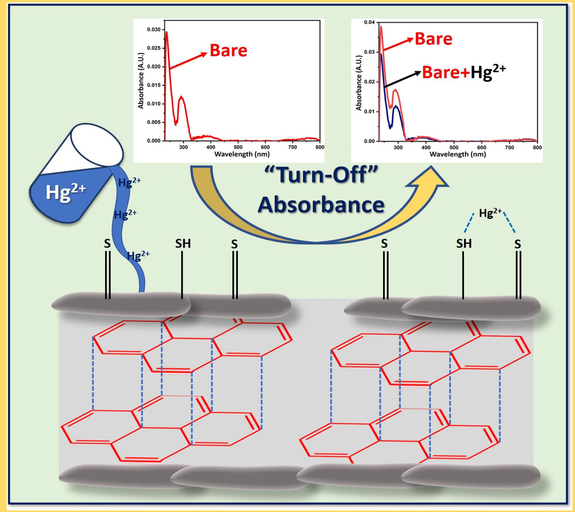
A new "turn-off" adsorption probe based on modified coconut shell activated carbon for the optical sensing of mercury in waste water

Vishal Bharati Jaryal[1]; Dilbag Singh[2]; Neeraj Gupta[1]*

[1]Department of Chemistry and Chemical Sciences, Central University of Himachal, India; [2]Department of Environmental Sciences, Central University of Himachal, India

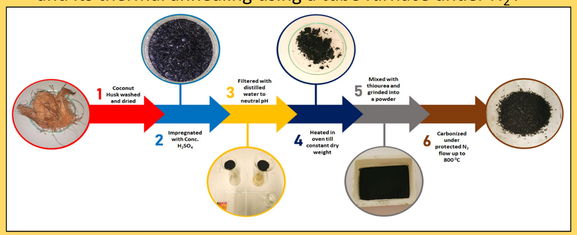
Abstract



Methodology

The AC was prepared from coconut husk by the following steps that involved the pretreatment of raw husk followed by its carbonization.

1. Pre-treatment of coconut husk.
2. Impregnation with the activator (Conc. H_2SO_4).
3. Homogenization of the impregnated material with thiourea and its thermal annealing using a tube furnace under N_2.



Results

- ✓The XPS spectrum of g-SFCSs displayed 90.4% carbon proving that the material is rich in carbo content. The presence of sulfur is confirmed by the S_{2p} peak obtained at 164.19 eV with an atomic percentage of 2.08%.
- ✓X-ray diffraction pattern of g-SFCSs shows that a major portion of the material is amorphous. The crystallinity of the material was recorded to be 45.54% with 54.48% amorphous content.
- ✓The FESEM analysis of the material exhibited flat sheets stacked over one another and small flakes deposited on the surface are also seen. The presence of N and S in the EDX spectrum confirmed that the precursor thiourea is incorporated into the carbon matrix.
- ✓The BET surface area of g-SFCSs was higher than that of other related carbon materials.
- ✓The synthesized material was further used for selective adsorption of Hg^{2+}. It was observed that in the absence of Hg^{2+}, the material displayed a strong absorption peak at 237 nm. Conversely, the presence of Hg^{2+} causes a significant reduction in the absorption intensity.

Table 1. Comparison of the Hg(II) adsorption capacity of g-SFCSs with other carbon-based adsorbents

Adsorbent	Detection Limit (μM)	Linear Range (μM)	Reference
TFIC MNPs[a]	5.04	4-16	1
Carbon dots	1.3	0-2.69	2
Functionalized carbon dots	2.69	0.1-2.69	3
g-SFCSs	10.4	-	Recent Study
Polymer sensor	0.728	1-30	4

[a]TFIC MNPs: TSRH6G-b-cyclodextrin fluorophore/adamantanemodified inclusion complex magnetic nanoparticles.

Table 2. Determination of Hg^{2+} in natural water samples

Samples	Added (μM)	Measured (μM)	Recovery (%)
River Water	0.72	0.67	93.05
Underground Water	0.4	0.37	92.5
Tap Water	0.18	0.17	94.44

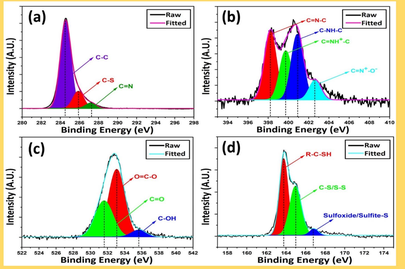


Figure 1. The deconvoluted XPS spectra of AC: (a) C 1s spectrum, (b) N 1s spectrum, (c) O 1s spectrum and (d) S 2p spectrum.

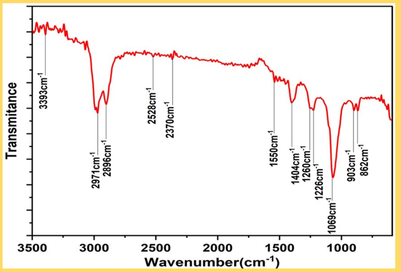


Figure 2. The FTIR spectrum of AC prepared at 800 °C

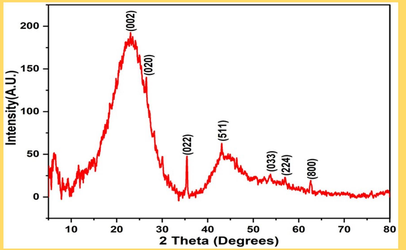


Figure 3. The XRD pattern of AC prepared at 800 °C

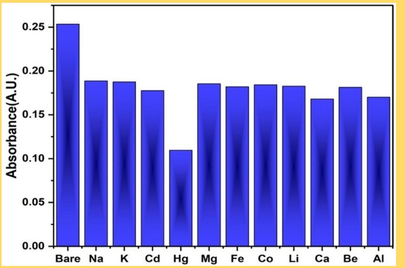


Figure 5. The response of AC and Hg^{2+} in the presence of other cations.

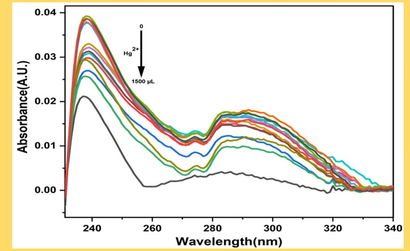


Figure 4. Effect of Hg^{2+} concentration on the UV-Vis absorbance spectrum of AC.

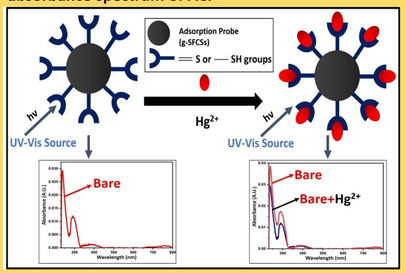


Figure 6. A plausible mechanism for the detection of mercury by AC

Discussions

- ✓ The UV analysis of the material shows a remarkable decrease in absorption signal with increasing Hg^{2+} concentration. The variation of the absorption intensity with the concentration of Hg^{2+} **(3.06–12.25 μM)** was linear and the limit of detection (LOD) was found to be **10.4 μM**.
- ✓ UV-Vis absorption decreased drastically after Hg^{2+} addition. However, the addition of other metal ions to the g-SFCSs dispersion did not lead to a significant reduction in absorption.
- ✓ The real samples (river water, underground water and tap water) had similar results, with good recovery rates ranging from **92.5% to 94.4%**. The LODs obtained for the g-SFCSs probe for Hg^{2+} detection were also compared with those of previously reported fluorescent probes, and the results are shown in Table 1.

Conclusion

In the present study, graphitic sulfur functionalized carbon sheets used as an adsorption probe to remove a hazardous pollutant (Hg^{2+} ions) from water were prepared successfully by a simple, eco-friendly, and economical method. The affinity of the material towards Hg^{2+} ions was determined by UV-spectroscopy, where quenching of the absorption signal was observed in the presence of Hg^{2+}. The current research has the potential to reduce the pollution caused by the widespread use of disinfectants. The stability of the sensing material in the presence of other competing ions, as well as its cost-effectiveness and environmentally friendly production approach, will expand the possibilities of its use for detecting harmful ionic species in aqueous solutions, thereby making the water better suited for humans and other living organisms.

References

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Contact:

Vishal Bharati Jaryal (Research Scholar), vishaljaryal.cuhpchem19@gmail.com
Dr. Neeraj Gupta* (Asst. Prof.), gupta_nrj@hpcu.ac.in
Department of Chemistry and Chemical Science
Academic Block – Shahpur, Central University of Himachal Pradesh,
Dharamshala, Distt. – Kangra (H.P.) - 176206