Nano-size copper oxide encapsulated urea – formaldehyde resin film for arsenic (III) removal from aqueous solutions

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The nano-size copper oxide with 40-50 nm dimensions was prepared through KNO\textsubscript{3}: NaNO\textsubscript{3} eutectic melt and encapsulated in urea – formaldehyde (UF) resin during polymerisation. Particle size of CuO was determined by XRD and SEM techniques. CuO encapsulated in urea – formaldehyde resin in the form of film (~5 mm thickness) was used to remove As (III) content from aqueous solution. The process of As (III) removal was found to be efficient and cost effective.

Keywords: Copper oxide, Nanoparticles, Arsenic, Urea-formaldehyde, XRD, SEM

Arsenic is one of the major pollutants in ground water and responsible for number of diseases related to lungs, bladder and skin cancer.\textsuperscript{1,2} The toxicity of arsenic varies greatly according to its oxidation state. As (III) has been reported to be more toxic than As (V). This can be removed by chemical and physical methods. The techniques used are less effective and costly. Further, adsorption and membrane filtration processes are also widely used as an effective method for water decontamination from toxic substances. Activated carbon is the potential sorbent materials because of its high surface area and porous morphology but its re-use is limited by the material loss during recovery.\textsuperscript{3-5} Nanostructured material based technologies are promising in removing toxic chemicals because they have large specific surface areas which are useful for impurity removal. Recently it is reported that nanosize CuO can remove toxic chemicals like As (III) from water.\textsuperscript{6} However the properties of the prepared CuO samples strongly depend on its morphologies and structures such as crystal sizes, orientations, stacking manners, aspect ratios and crystalline densities.\textsuperscript{6} One drawback of nanomaterials is their agglomeration which greatly limits their utility. In order to avoid agglomeration, CuO embedded urea-formaldehyde resin is used to remove As (III) from water and the results discussed in this paper.

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Experimental Procedure

Materials and methods
KNO\textsubscript{3}, NaNO\textsubscript{3}, CuSO\textsubscript{4}. 5H\textsubscript{2}O (all E. Merck), urea and formaldehyde (NOVA chemical, AR Grade) were used without further purifications. Doubled distilled water was used throughout the investigations.

The chemical characterizations have been made using: Rigaku Rotaflex (RAD/Max-200B) X-ray diffractometer and JEOL-840 (JEOL Corporation Japan) scanning electron microscope and UV-2501 PC, Shimadzu Corporation Japan UV spectrometer.

Preparation of CuO nanoparticles

CuO nanoparticles were prepared in a similar way described earlier.\textsuperscript{7,8} 3 g anhydrous cupric sulphate was mixed with 5 g NaNO\textsubscript{3}-KNO\textsubscript{3} (45:55) eutectic . The mixture was heated at 425°C and a black coloured product was obtained. This was washed with distilled water and then dried at 120°C in a vacuum oven.

Preparation of CuO encapsulated UF film

20 g of formaldehyde and urea were mixed in 2:1 molar ratio in 200 mL round bottom flask and stirred magnetically at 60°C. In this mixture 100 mg of CuO and 0.5 mL concentrated H\textsubscript{2}SO\textsubscript{4} were added under stirring. After some time (~15 min) a white precipitate with blackish spots settled down. The precipitate was washed with distilled water and in semi solid sate pressed between two ordinary glass plates where a thin film (thickness ~ 0.5 mm) was formed. This film was CuO encapsulated UF resin. A similar film without CuO was also made as a reference sample.
Removal of As(III) from aqueous solution

A saturated solution of $\text{As}_2\text{O}_3$ in 1% NaOH aqueous solution was prepared and 100 mL of this solution was taken in two different beakers separately. In one beaker 1 sq cm UF film was dipped which acted as a reference and in the second beaker nanosize CuO encapsulated UF film of 1 sq cm dimension was placed. 5 mL solutions from both the beakers were taken out at an interval of 0, 10, 20 and 30 min and UV-visible spectra were recorded in the wavelength range of 200-300 nm with the help of UV-visible spectrophotometer. From the absorbances at the $\lambda_{\text{max}}$, the concentrations of As (III) were calculated using a calibration curve. It was found that there was no change in the case of reference.

Results and Discussion

Powder X-ray diffraction patterns of CuO, UF and CuO encapsulated UF are shown in Figs 1a, 1b and 1c, respectively. Fig. 1a confirms the formation of CuO. The diffraction pattern given in Fig.1c shows...
the presence of most intense peaks of CuO (111 and 110 plane) and that of UF indicating the encapsulation of CuO by UF resin. The full width half maxima of 111 peak of CuO was used to calculate the particle size by using Scherrer equation. The crystallite size of CuO was found to be ≈40 nm.

SEM photographs of nanosize CuO and CuO encapsulated UF resins are shown in Figs 2a and 2b, respectively. Fig. 2a confirms the formation of nanosize CuO and Fig. 2b shows homogeneous encapsulation of nanosize CuO by UF resin.

Figure 3 shows UV spectra of As (III) solution in the presence of CuO encapsulated UF resin at different intervals of time. It is seen that the peak intensity is decreased with time. This clearly indicated that CuO encapsulated UF resin removes the As(III) ions from the solution. The concentration changes at different time intervals are given in Table 1. It is seen that CuO encapsulated UF resin removes As(III) ions from the solution in an effective way.

### Conclusions

Results showed that nanosize CuO encapsulated UF resin is a cost effective adsorbent for the removal of As(III) ions from the solution.

### References