Drinking Water Treatment by Using Polymer Nanocomposites

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Introduction

In this research, we synthesized PU foam nanocomposite adsorbent based on modified magnetic iron-oxide nanoparticles (Fe3O4@APTES) via in-situ polymerization method for the removal of heavy metal ions (Arsenic) from drinking water. The chemical structure and surface morphology were characterized using SEM analysis and TEM analysis. ICP-MS analysis was used to measure the concentration of the heavy metal ions from solutions. Sorption isotherm model was used to indicate the adsorption mechanism. The removal capacity of the PU nanocomposite was at its highest during a contact time of four hours (95% As removal).

Methods

For modification of nanoparticles, Iron oxide was added in ethanol solution and stirred then APTES was added in the solution and the mixture was stirred at room temperature. Then, the modified magnetic nanoparticle was collected by magnet and washed and dried in oven. The modified nanoparticles were dispersed in the polymer raw matrix. Finally, the sample was mixed with Isocyanate in a mold was kept at room temperature. Then, batch sorption experiment was done. Modified PU nanocomposites-sample (20 % of nanoparticles) was soaked in 100 ppb arsenic solution for 1,2,3,4,5 and 6 h. Then the tubes were shaken at 200 rpm After each batch test, treated solution was filtered for ICP-MS analysis.

Results and Discussion

TEM image of synthesized Fe3O4@APTES NPs are shown in Figure. 1. By modification of magnetic nanoparticles, you could see less aggregation in TEM image and the average size of NPs is below 100 nm.

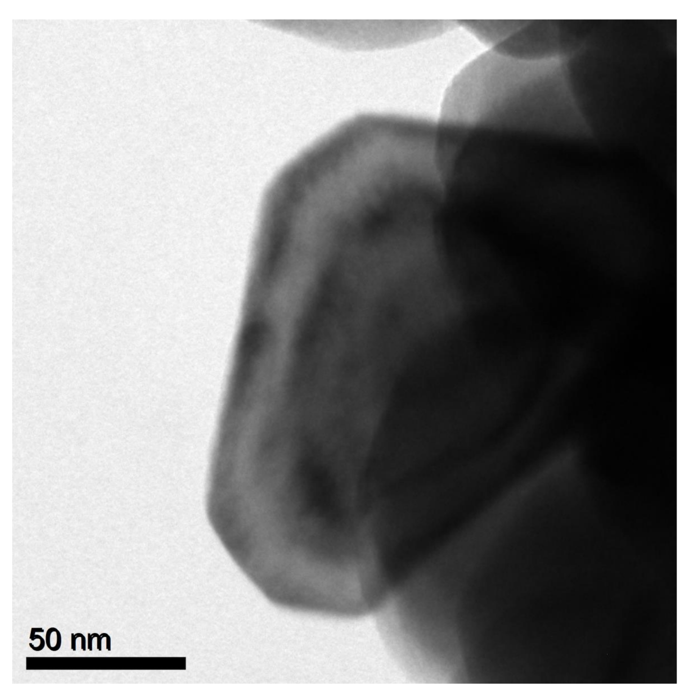

Fig 1. TEM image of modified Fe3O4@APTES nanoparticles

SEM image is used for Surface morphological analysis of the modified magnetic PU Foam nanocomposites, as shown in Figure 2 the modified magnetic nanocomposites (20 wt%) shows smaller cell size. This result indicates that cell size is controlled by the competitive process between cell nucleation, growth, and distribution, which indicate the foam structure [1-2].

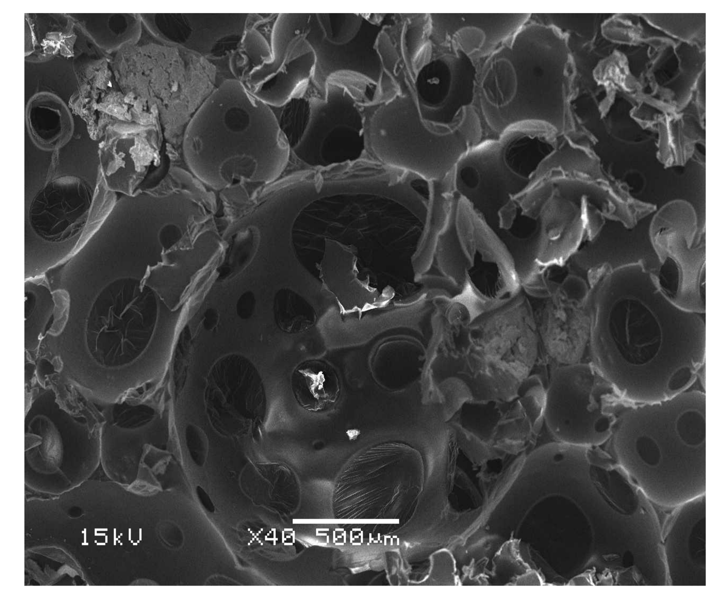

Fig 2. SEM image of modified magnetic PU foam (20 wt%)

By increasing the contact time, the number of arsenic ions attached to the nanoparticles improved. The adsorption reached equilibrium after 4 h, and increase had no effect on the adsorption capacity since we see the decrease in arsenic concentration and also the number of available active sites decrease (Figure 3) [1-4].

Langmuir and Freundlich isotherm models applied on the equilibrium the modified foam nanocomposites. The results showed that the Langmuir model was suitable for the adsorption behavior of arsenic based on the value of regression coefficients (R^2). Maximum adsorption was from the Langmuir equation to be 0.099 mg/g for arsenic

The results showed that the modified nanocomposite was effective in arsenic removal from drinking water Figure 4).

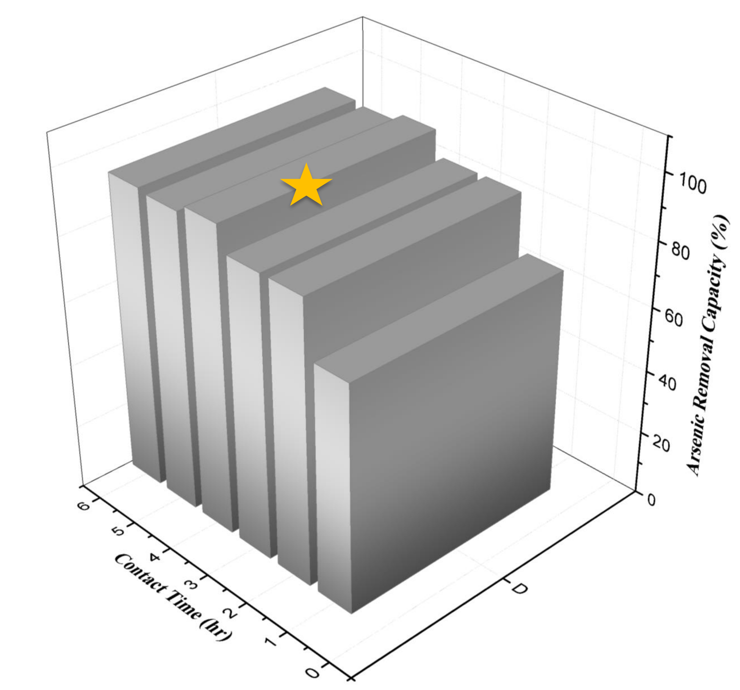

Fig 3. Effect of contact time on Arsenic removal percentage

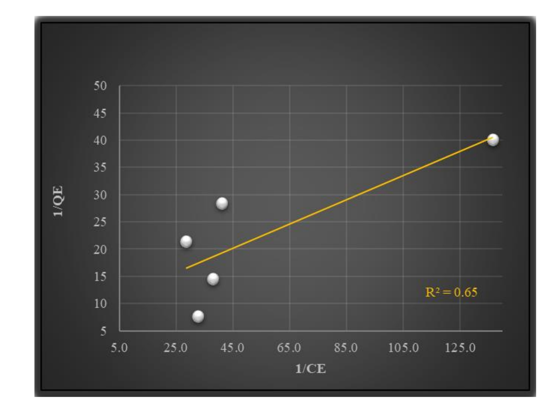

Fig 4. Langmuir isotherm for Arsenic adsorption on the nanocomposites adsorbents

Conclusions

A PU nanocomposite incorporated with 20 wt% magnetic nanoparticles was prepared for the removal of arsenic ions from drinking water. The magnetic foam showed a strong adsorption capacity with a removal of 95% (4 h). Also, Langmuir isotherm showed a good fit for the experimental data.

Literature cited

[1] Abu-Zahra, N. and S. Gunashekar, Structurally Functionalized Polyurethane Foam for Elimination of Lead Ions from Drinking Water. Journal of Research Updates in Polymer Science, 2014. 3(1): p. 16-25.

[2] Hussein, F.B. and N.H. Abu-Zahra, Adsorption Kinetics and Evaluation Study of Iron Oxide Nanoparticles Impregnated in Polyurethane Matrix for Water Filtration Application. Journal of Minerals and Materials Characterization and Engineering, 2017. 5(5): p. 298-310.

[3] Malwal, D. and P. Gopinath, Silica Stabilized Magnetic-Chitosan Beads for Removal of Arsenic from Water. Colloid and Interface Science Communications, 2017. 19: p. 14-19

[4] Sharma, M., P. Kalita, A. Garg, and K. Senapati, Magnetic nanoparticles as an effective adsorbent for removal of fluoride – a review. MOJ Ecology & Environmental Sciences, 2018. 3(3).

Acknowledgments

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For further information

https://scholar.google.com/citations?user=NjaWiY8AAAAJ&hl=en