May 2014
The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

TECHNICAL BRIEF

Mine-water treatment

Nanotechnology for the remediation of mine wastewaters

A completed WRC study successfully prepared magnetic nano-composite beads and applied it to the remediation of mine wastewaters.

WRC project results

In this project, magnetic ion imprinted polymers with high recognition for uranyl (UO_2^{2+}) and chromium Cr(VI) ions were prepared for the first time.

The prepared magnetic ion imprinted polymers were characterised and optimised in the laboratory. They were then applied to wastewaters from acid mine drainage and influent from wastewater treatment plant.

The optimum extraction parameters in batch format for magnetic ion imprinted polymers for urany ions were found to be sample pH of 4, 50 mg of magnetic ion imprinted polymers for a 25 mℓ sample volume.

The optimum contact time was found to be 45 minutes at a stirring speed of 1500 rpm. The lower maximum extraction time implies that the magnetic ion imprinted polymers have fast binding kinetics.

Under these optimum conditions, the recovery of urany ions was found to be above 80%. The binding of urany ions on the magnetic ion imprinted polymers were found to follow pseudo second order kinetics with rate constant (k_2) and correlation coefficient (R^2) ranging between 0.273-0.678 and 0.9811-0.9992 respectively.

This implied a chemisorptions interaction of the uranyl ions with the magnetic polymers. The adsorption of uranyl ions onto the polymers fitted both Freundlich and Langmuir models. The maximum adsorption capacity was found to be around 1.2 mg g^{-1} which is in the same range as other magnetic ion imprinted polymers but lower than other ordinary polymers or imprinted polymers without magnetic ions. Despite low binding capacity, the prepared magnetic ion imprinted polymers when tested for selectivity were found to have superior selectivity for uranyl ions compared to major competitors of Fe^{3+}, Pb^{2+}, Ni^{2+} and Mg^{2+} that have similar ionic radius. The selectivity order observed was as follows: $UO_2^{2+} > Fe^{3+} > Pb^{2+} > Ni^{2+} > Mg^{2+}$.

The same selectivity and recovery was observed when the magnetic ion imprinted polymers were applied to wastewaters from acid mine drainage and influent from wastewater treatment plant.

The optimum extraction conditions for the prepared magnetic ion imprinted polymers for Cr (VI) were found to be as follows; sample pH of 4, adsorbent amount of 20 mg for a 25 mℓ sample volume. The extraction time was 40 minutes at stirring speed of 1500 rpm.

The low extraction time indicates fast binding kinetics of Cr(VI) to the prepared polymers. At optimum conditions, the recovery of Cr(VI) was above 80%. The maximum adsorption capacity for the magnetic polymers was found to be 6.20 mg g^{-1}.

The optimum time for the adsorption of the Cr (VI) analyte was determined as 40 minutes at stirring speed of 600 rpm. The binding of Cr(VI) on the magnetic ion imprinted polymers were found to follow pseudo second order kinetics. This implied a chemisorptions interaction of the Cr(VI) ions with the magnetic polymers.

The adsorption of Cr(VI) onto the polymers fitted neither Freundlich nor Langmuir models. The prepared magnetic ion imprinted polymers were found to very selective towards Cr(VI) compared to other ions such as SO_4^{2-}, F^- and NO_3^-. The order of selectivity of anions followed the trend: $Cr_2O_7^{2-} > SO_4^{2-} > F^- > NO_3^-$.

Conclusion

The prepared magnetic materials may not be suited for remediation of polluted wastewater for uranyl and Cr(VI) ions on a large scale because of high cost of preparing them but are very good as sample extraction materials before final quantification.

This is very important because direct analysis of these metal ions from wastewaters is a huge challenge because of other interfering ions. Since the materials can be reused more than six times, this makes them cheap materials for sample extraction purposes.

Besides, in sample extraction, only few mg of material is used ranging from 25-500 mg depending on the sample volume.

Further reading:
*Preparation of magnetic nano composite beads and their application to remediation of mine wastewaters (***Report No. 2014/1/13).**
To order the report, contact Publications at Tel: (012) 330-0340, Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a free copy.