SYNTHESIS, CHARACTERIZATION AND APPLICATION OF A NOVEL ZINC(II) ION IMPRINTED POLYMER

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Introduction

Zinc plays an important role in human organism. It is a component of over 300 enzymes. zinc is involved in the synthesis and the breakdown of carbohydrates, lipids, proteins and nucleic acids, and in the metabolism of other trace elements [1]. Both its excess and deficiency can cause a damage to human body systems. Zinc excessive intake may result in a number of adverse health effects including vomiting, fever, nausea, stomach cramps and diarrhea [2]. It is worth mentioning that it may also lead to copper deficiency which is the major consequence of the chronic ingestion of zinc [3].Additionally, studies in rats revealed that a high-zinc diet induces hypocalcaemia and bone resorption [4].

As a result it is really important to control the level of Zn in body fluids. The aim of this work was the synthesis of a zinc (II) ion imprinted polymer which is hydrophilic and can be applied to detect zinc in urine samples by wavelength dispersive X-ray spectrometry.

Materials and Methods

ZnIP (FIG. 1) was prepared by thermal polymerization. ZnSO4·7H2O (1 mmol) was mixed with 1-vinylimidazole (4 mmol) in methanol (20 ml). The mixture was shaken for 1 hour to allow the prepolimerization complex to form. This solution was then mixed with EDMA (15 mmol), HEMA (5 mmol) and AIBN (25 mg). To avoid any side reaction, the oxygen present in the solution must be removed. It is done by bubbling of argon through the mixture for 15 min. The polymerization reaction was performed in an oil bath at 60°C for 24 h. After completion of polymerization, the solid polymer was rinsed with 400 ml methanol followed by 100 ml deionized water, crushed and ground. In order to remove the zinc(II) ions from the polymer matrix, the particles were treated with 17% hydrochloric acid. This process was controlled by the WD XRF analysis of the polymer particles and lasted until no Zn could be detected in the material. The excess of hydrochloric acid was washed by deionized water. Finally the particles were dried in a vacuum oven at 60°C.

Non imprinted polymer (NIP) was also prepared under similar conditions except for adding the template ion.

Results and Discussion

This polymer has been characterized on the basis of FTIR, TGA, TEM and surface area measurement. The imprinted Zn(II) ions were completely removed from the polymer by leaching it with 17% HCl. The optimum pH for the adsorption of Zn(II) on to the polymer was 7. The selective performance of the Zn(II)-IIP polymer was compared to non imprinted polymer (NIP) for the binary mixture Zn^{2+}/Cu^{2+}, Zn^{2+}/Ni^{2+} and Zn^{2+}/Co^{2+}. The relative selectivity of ZnIP was 22.57, 5.440 and 46.17 times greater than that of NIP as compared with the Cu^{2+}, Ni^{2+} and Co^{2+} ions, respectively. At optimal pH value, the maximum static adsorption capacity of ZnIP and NIP was found to be 5.2 mg/g and 0.22 mg/g, respectively. The proposed ZnIP sorbent was applied to determine the zinc ions in urine samples by WD-XRF.

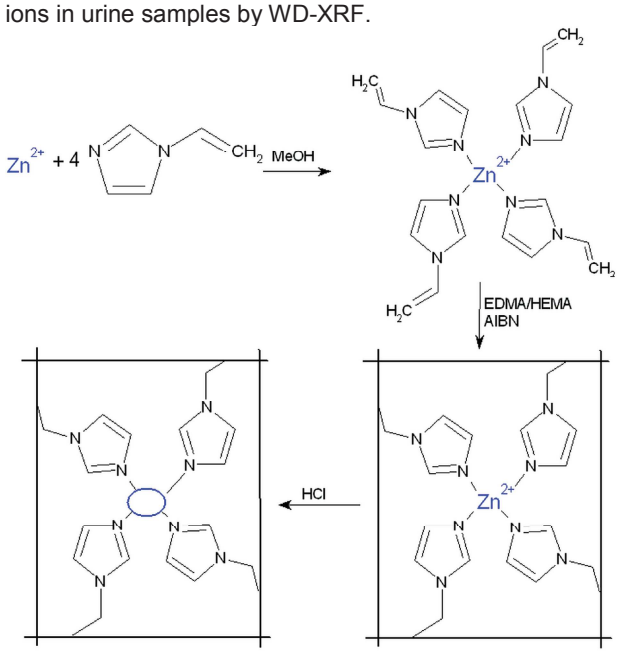

FIG. 1. Schematic illustration of imprinting process for the preparation of zinc (II) imprinted polymer.

Conclusions

The synthesized sorbent exhibits relatively high adsorption capacity and good selectivity towards interfering ions such as: Cu^{2+}, Ni^{2+} and Co^{2+}. Results from the analysis of urine samples have shown that the developed method can be successfully applied for the zinc determination in urine by the WD-XRF method.

It should be noted that the selectivity towards the cobalt(II) ions is the best among the polymers reported in the literature. Although the adsorption capacity of the polymer characterized in this work is lower than some other zinc(II) –ion imprinted polymers its properties seem to be a compromise between sorption capacity and selectivity.

There are research papers which describe molecularly imprinted polymers as drug delivery systems, which can release the therapeutic agent in a controlled way [5-8]. Further analysis of the release of zinc ions from the ZnIP matrix are promising.

Acknowledgments

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References

[1] Human Vitamin and Mineral Requirements. Report of a joint FAO/WHO expert consultation Bangkok, Thailand. Food and Agriculture Organization of the United Nations. World Health Organization. Food and Nutrition Division FAO Rome. 2001.

[2] C.G. Elinder, In: Handbook on the toxicology of metals; L. Friberg, G.F. Nordberg, V.B. Vouk, Eds.; Elsevier Science Publishers: Amsterdam, 1986; 2nd ed., 664-679.

[3] R.J. Cousins, J.M. Hempe In: Present knowledge in nutrition; M.L. Brown Eds.; International Life Sciences Institute: Washington, DC, 1990; p. 251.

[4] M. Yamaguchi, K. Takahashi et al Toxicol. Appl. Pharm. 67 (1983) 224-228.

[5] F. Puoci, F. Iemma et al. Curr. Drug Deliv. 5 (2008) 85-96.