Heavy metals removal from water with functionalised silica sorbents

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Toxic heavy metals in air, soil, and water are global problems that are a growing threat to the environment. There are various methods for removing heavy metals from aqueous media, such as chemical precipitation, reverse osmosis, ion exchange, and adsorption [1]. These suffer from a range of limitations including cost, high energy inputs, low efficiencies or large waste footprints. Recent alternative methods based on nanomaterials are highly promising however in the water purification process due to their unique properties such as higher surface area, the ease with which they can be anchored onto solid matrices and the ability to functionalize with different functional groups to enhance their affinity towards target molecules.

The research outlined here is devoted to the elaboration of methods of synthesis of hydride silicas and polyhedral oligomeric silsesquioxanes (POSS), and studying their properties and application in the sorption of mercury and some noble metals, in particular silver and palladium, from aqueous solutions. Hydride silicas were produced via direct co-condensation and post-synthesis grafting methods using organoalkoxysilanes. The physicochemical characteristics of the developed materials have been studied as follows: silica pore structure by low-temperature nitrogen adsorption; thermal stability of the silica/POSS with TGA; surface reaction dynamics with IR spectroscopy; and characterization of silsesquioxane species by ^{1}H and ^{29}Si NMR.

Mercury adsorption onto hydride silica composites is a fast (within a few minutes) and efficient process, allowing the loading of up to 44 mg of Hg per g of modified silica, at concentrations between 0.001 and 1.6 g/l Hg, and over a wide pH range. Initial experiments have also been performed on the effectiveness of removing Hg with POSS composites, allowing a loading of up to 111 mg of Hg per g of POSS hybrid materials. Coupled with their inexpensive and facile assembly, this indicates their potential usefulness as effective materials for mercury decontamination in natural waters and industrial effluents.

POSS composites were also successfully used for the removal of noble metals from water solutions, allow-

ing the loading up to 50 mg of Pd or 70 mg of Ag per g of POSS. Ions of Pd and Ag are reduced by POSS materials from water solution, and are incorporated as metal nanoparticles in nanocages of silsequioxanes, allowing their potential re-use in catalysis applications.

References

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Acknowledgments

This work has been supported by FP7-PIIF-GA-2009-255635-HYREM project.

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