Silica-based aerogels/xerogels with nitrogen-containing functional groups for heavy metal adsorption

João P. Vareda [1] *, Artur J.M. Valente [2], Luísa Durães [1]

[1] University of Coimbra, CIEPQPF, Department of Chemical Engineering, Rua Sílvio Lima, 3030-790 Coimbra, Portugal
[2] University of Coimbra, CQC, Department of Chemistry, Rua Larga, 3004-535 Coimbra, Portugal

*Presenting author: jvareda@eq.uc.pt

Heavy metals are common inorganic pollutants found in the environment, due to natural and anthropogenic activities, that have to be removed from wastewaters and drinking waters [1]. Environmental applications of aerogels are more frequent nowadays [2-4], due to their properties such as porosity and high surface area. Thus, their application for heavy metal removal comes as a natural fit. Different co-precursors with Lewis bases functional groups based on amines were used to produce silica-derived aerogels and xerogels that can be applied as heavy metal adsorbents, namely for copper, lead, cadmium and nickel. The impact of the presence of these functional groups on the microstructure and other macroscopic properties of the materials was investigated. The drying step also contributed to the preparation of materials with vastly different properties. These changes affect the adsorption performance and, in general, adsorbents with low porosity were not good adsorbents. The sorption performance was evaluated and the usefulness of different functional groups and drying procedures is discussed. The in-depth study of the best samples suggests that, in most situations, the cations are removed by chemisorption. Thermodynamic tests reveal that the process can be endothermic, exothermic or athermic, depending on the cation. For the best adsorbent, resultant from the combination of aminopropyl and propyl diethylenetriamine groups, the adsorption performance at 20 °C is dependent on the cation, ranging from 56 $mg.g^{-1}$ for copper to 172 $mg.g^{-1}$ for lead.

Acknowledgments. J.P. Vareda acknowledges the PhD grant SFRH/BD/131280/2017 funded by Fundação para a Ciência e Tecnologia (Portugal). Consumables for the syntheses and characterizations performed at CIEPQPF and CQC research units were funded by national funds through the FCT and when appropriate co-funded by FEDER under the PT2020 Partnership Agreement under the projects POCI-01-0145-FEDER-006910 and POCI-01-0145-FEDER-007630 (FCT Refs. UIDB/EQU/00102/2020 and UIDB/QUI/00313/2020, respectively).

References

1. Vareda, J. P., Valente, A. J. M., and Durães, L. (2019) J Environ Manage 246, 101-118.
2. Maleki, H. (2016) Chem Eng J 300, 98-118.
3. García-González, C. A., Budtova, T., Durães, L., Erkey, C., Del Gaudio, P., Gurikov, P., Koebel, M., Liebner, F., Neagu, M., and Smirnova, I. (2019) Molecules 24, 1815.
4. Gan, G., Li, X., Fan, S., Wang, L., Qin, M., Yin, Z., and Chen, G. (2019) Eur J Inorg Chem 2019, 3126-3141.