Structural modifications induced in ZIF-8 by interaction with Cu^{2+} ions in water remediation applications

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Metal-organic frameworks have strong potentialities in a large variety of different promising applications like gas separation, catalysis, sensing, and drug delivery [1]. Among them, one of the most intriguing, consists in water remediation [2]. In this field, ZIF-8 have gained an important role due to its strong capability to efficiently capture large quantities of Cu^{2+} ions from polluted water [3]. However, the actual applicability of water remediation processes by ZIF-8 strongly depends on the possibility to reuse the filters after the treatment. Furthermore, a permanent capture of Cu^{2+} ions has to be obtained, with negligible undesired release of metallic ions back to solution. To obtain such relevant information, a detailed characterization of the interaction process of ZIF-8 with Cu^{2+} in water solutions with significantly different concentration of polluting metal ions has to be obtained.

Here we present a study on the structural effects induced in ZIF-8 by exposure to water solution with concentration of Cu^{2+} ions ranging from 0 to 300 mg/l. The experimental characterization was performed by XRD, Raman, TGA, Electron Paramagnetic Resonance, Atomic Force Microscopy measurements and by estimation of the specific surface with the BET method. Our results prove that for concentration of copper ions in solution up to about 100 mg/l, Cu^{2+} are absorbed by the materials and the integrity of the crystalline structure is preserved. In this stage, a small fraction of the adsorbed ions undergoes an exchange process: Cu^{2+} ions from the solution are incorporated into the crystalline structure of ZIF-8 in place of the preexisting Zn^{2+} ions that are consequently released. For concentrations larger than 100 mg/l, more significant structural changes are induced. In fact, our data indicate that Cu^{2+} ions promote the structural decomposition of the material: the crystalline

order is lost and the Cu^{2+} ions may be released back to the solution, making potentially ineffective the overall water remediation process.

Our results have strong impact both in fundamental and applicative fields, as they shed new light on the process of ions exchange in one of the most important MOF, ZIF-8, and because they put forward that a threshold value of concentration of copper ions in water solution exists for the applicability of water remediation process involving ZIF-8 filters and Cu^{2+} pollutant.

References

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