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Extended Abstract

Immobilization of Metal Selective Ligands upon Polymer Nanofibers: Successes and Challenges †

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† Presented at the 16th International Symposium "Priorities of Chemistry for a Sustainable Development" PRIOCHEM, Bucharest, Romania, 28–30 October 2020.

Published: 13 November 2020

Keywords: nanofibers; ligands; immobilization; adsorption

Modifying nanofibers with specific ligands for metal chelation or adsorption purpose is no doubt a great idea. Several nanofibers have been modified via different mechanisms for various applications. For example, polyacrylonitrile (PAN) in the form of nanofibers has been modified for adsorption and separation of metals ions. Ndayambaje et al. [1] was able to chemically modify the surface of polyacrylonitrile nanofibers with 2-2′-pyridylimidazole ligand to generate PAN–pim nanofibers for adsorption of Ni(II). Pereao [2] developed a nanofiber-based adsorbent containing glycolic acid functional groups for the recovery of rare earth elements (REEs). The surface modification of nanofiber-based adsorbents has been reported in the literature [3,4]. In surface modification, surface chemical compositions and characteristics are altered either for general purposes or for specific purposes [5]. There are two main approaches for the surface modification of nanofiber materials. The first focuses on direct modification (chemical, radiation and plasma treatment) of the surface of the material while the second intends to immobilize (grafting; attachment) the active ligand onto the surfaces of the material. An understanding of the selectivity of the immobilized ligand–metal ion interaction is important, as well as the coupling of the ligand to the nanofiber. In addition to these two approaches, blending, which is done by mixing two or more materials, is found to be the easiest technique; however, getting the desired active functional groups to the surface of a material is not adequately achieved.

Cross-linked nanofibers with functional groups capable of binding metal ions offer potential advantages such as ease of operation, regeneration and reuse and environmental compatibility. Crosslinking is used for improving the chemical and/or mechanical properties of nanofibers for the removal of metals from aqueous solutions [6]. Stripping and recovery of the metal ions from the ligand is crucial to nanofiber-based adsorption processes; regeneration and reuse of the nanofibers are also important to the economics of the application. The fate of the nanofiber adsorbent after the modification process should be considered so that the resolution of one problem does not lead to a new problem, since control of the surface properties of an adsorbent are essential for its adsorption efficiency and selectivity. Care should be taken that the surfaces of the modified nanofibers exhibit similar morphologies when compared to the pristine nanofiber mats by showing little signs of fusion, degradation or cracks. The fibrous structure of the nanofiber membrane should not be distorted or over swelled. Many modification processes may be too harsh to maintain delicate nanofiber integrity. The nanofibers should be handled properly to ensure that the porous and large surface areas are not compromised during modifications and applications [5].

The nanofiber support should be physically and chemically stable, with ample inter-fiber porosity to allow access of reagents for the surface functionalization reaction and, subsequently, for the metal ion's interaction with the ligand. The stability of the attached ligand upon the nanofiber should also be confirmed before use to ensure that the ligand is not leached during application or regeneration by washing in acid or alkaline solution [5]. Thus, the nanofiber adsorbent can then be reused successfully over several cycles, especially during the regeneration of the adsorbent. Many research studies failed to report nanofiber stability, reuse and regeneration. Nanofibers with functional ligands are complex and expensive to make and, therefore, they will not be commercially viable unless they are highly durable, stable, and highly selective for extraction of metals that have commercial value. The nanofiber adsorbents may not be very useful for low value, or toxic metal recovery unless there is a specific demand for high-purity metal [6].

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