Loofah-based materials for pH-driven selective adsorption of multi-dyes solutions

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Abstract

Nowadays, the release of dyes in water matrices represents a global worry, owing to their wide use in several industries. Even small amounts of these pollutants can drastically affect the quality of water bodies due to their influence on light penetration reduction. In addition, the typical high toxicity of this pollutants class is well known [1]. Over the years, several technologies have been proposed for dyes abatement. Among them, adsorption on solids achieves very fast and cost-effective removal of water pollutants [2]. As generally required, most sorbent materials are characterized by low selectivity. However, from a circular economy perspective, industrial wastewater should be considered a potential source of valuable chemicals to save raw materials. Therefore, today the possibility of developing easily recoverable materials that selectively adsorb and desorb dyes represents an unavoidable challenge that must be faced. Recently, conducting organic polymers (COPs) have emerged as interesting alternatives to traditional adsorbents thanks to their unique chemical/physical properties. Among them, polyaniline (PANI) is unique for its interesting multifunctionality, easy synthesis, high chemical and environmental stability, porosity, and high surface area. For this reason, it has been extensively investigated in several applications, including the removal of water pollutants [3]. In addition, loofah sponge and its composites have also been exploited to develop eco-friendly alternative adsorbents for removing dyes from aqueous solutions [4]. Herein a two-step, pH-driven, fast, reversible, and selective adsorption process for removing dyes selectively from aqueous mixtures by combining the natural loofah sponge (LS) and PANI-modified loofah sponge (P-LS) is presented. Several techniques properly characterized both materials. Figure 1a depicts a micrograph of P-LS, showing the PANI discontinuous growth on the LS surface in the form of mixed rod-like and globular-like aggregates. Then, a thorough batch of adsorption experiments was conducted for the selective removal of rhodamine-B (RHB), methylene blue (MB), and methyl orange (MO) in single-dye solutions and their mixtures. Based on these preliminary results, a two-step process consisting of the fast and selective removal of MO by P-LS at spontaneous pH followed by the selective removal of cationic dyes carried out by replacing P-LS with LS and correcting the pH at 3 was realized. The obtained results indicate that during the first 30 min, P-LS leads to the complete MO removal from the solution, whereas the amount of cationic dyes removal is below 20% (Figure 1b). The successive adsorbent replacement with LS and the lowering pH promotes the quantitative recovery of the cationic dyes (100% MB and 70% RHB). The separation of multi-dye mixtures (RHB, MB, and MO) in consecutive cycles and the possibility of quickly regenerating the adsorbent systems for their reuse and selectively recovering the adsorbed dyes were eventually explored. Results demonstrated that a simple post-treatment of the materials permits, on the one hand, the recovery of much of the initial adsorbing capacity and, on the other, the selective recovery (50%) of both adsorbed MB and RHB, respectively, unlike MO, which is wholly held back.

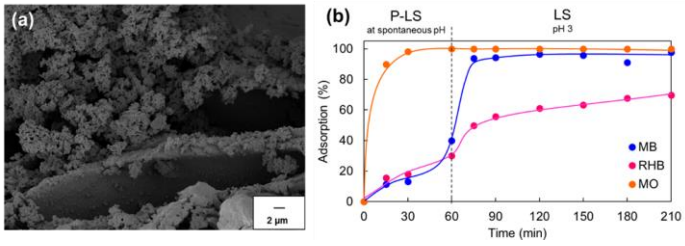

Figure 1. (a) SEM micrograph of PANI-loofah sponge; (b) Selective adsorption of MO, MB, and RHB in mixture by a two-step pH-driven approach using P-LS and LS [4].

References

1. A. Nasar, F. Mashkoor, *Environ. Sci. Pollut. Res.* **2019**, *26*, 5333.
2. K. Jahan, S. Tyeb, N. Kumar, V.J. Verma, *Polym. Environ.* **2021**, *29*, 1257.
3. C. Della Pina, M. A. De Gregorio, L. Clerici, P. Dellavedova, E. Falletta, *J. Hazard. Mater.* **2018**, *344*, 1.
4. M.G. Galloni, V. Bortolotto, E. Falletta, C. L. Bianchi, *Polymers* **2022**, *14*, 4897.