EFFICIENT REMOVAL OF SAFRANINE DYE FROM WATER USING 3D GRAPHENE-BASED MATERIALS

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Due to its solvent properties and its ability to transport particles, water incorporates various impurities, which define its quality. The presence of dyes in effluents is of great concern due to the negative effects they cause on the ecosystem, both for toxicological and aesthetic reasons, as the textile, paper, leather tanning, food processing, cosmetics and plastics industries, among others, consume large volumes of water and generate large amounts of colored wastewater. As the public perception of water quality is mostly influenced by the color of the water, dyes are the first to be recognized in wastewater, as very small amounts in the water can be highly visible and undesirable. Thus, it is required that safe techniques for the production of water for human consumption be developed. One of the ways to remove dyes and other contaminants is through adsorption, which can be performed using nanomaterials such as those based on graphene. Graphene-based three-dimensional macrostructures are ideal structures for removing pollutants from water, with excellent sorption capacity due to their unique structure with large surface area and high porosity, in addition to their high stability in aqueous environments. Thus, the objective of this work was to evaluate the removal efficiency of the cationic dye safranin using three-dimensional materials based on graphene with different degrees of oxidation. For this, four materials were synthesized using an environmentally friendly, fast and low-cost thermochemical route developed and previously patented by the Materials Chemistry Group (GQMate)[1]. The materials were named 3D-rGO-0, 3D-rGO-5, 3D-rGO-10, and 3D-rGO-25, so the higher the number that accompanies the 3D-rGO prefix, the greater the amount of agent reducer added in the synthesis. These materials were characterized by FTIR-ATR and indirect potentiometric titration, for qualitative and quantitative determination of the present oxygenated functional groups. In addition, the pH of the zero charge point (pH_{PZC}) of the materials was determined. The adsorption study was carried out using 20 mL of 25 mg/L safranin dye, which was added to a beaker containing 0.0497 ± 0.0015 g of each material. After 24 h, the final concentration of the solutions was determined by UV-Vis spectroscopy and the adsorptive capacity was determined in mg of adsorbed dye per g of added material. The results showed that through this synthesis route it is possible to efficiently obtain a high number of monoliths in less than 2 hours, while the processes described in the literature show syntheses that can take even days to obtain a single monolith. The characterizations by FTIR-ATR and indirect potentiometric titration show that the greater the amount of reducing agent added, the more reduced is the structure, that is, the fewer functional oxygenated groups are found in the material. These results highlight the efficiency of the proposed method. The pH_{PZC} value for all four materials was determined as $pH_{PZC} < 2$, that is, as long as the pH of the solution is greater than 2, the material will preferentially adsorb cationic species. Thus, we tested the efficiency of the materials in removing the cationic dye safranin, and we found that the materials 3D-rGO-0, 3D-rGO-5, 3D-rGO-10 and 3D-rGO-25 have, respectively, the adsorptive capacities 9.29 mg/g, 10.38 mg/g, 10.07 mg/g and 9.73 mg/g. For all materials, the removal efficiency was 100% within 24 h of exposure, so that the variation in adsorptive capacity values is a result of the small mass variation between the materials tested. Due to the high efficiency of dye removal by the materials, new experiments must be conducted with higher concentrations of safranin in the initial solution, so that there is saturation of the materials. From these experiments, it will be possible to determine the real adsorptive capacity of the materials. Allied to this, the adsorption isotherms must still be constructed and kinetic studies carried out so that it is possible, mainly, to predict the type of interaction that occurs in the adsorptive process. Despite variations in the amount of reducing agent used in the process, which allows obtaining materials that can be produced according to the application need, all materials obtained were applied very efficiently in the removal of a cationic dye. Finally, we verified that the proposed synthesis process is efficient and allows to obtain materials with potential environmental applications. In addition, obtaining numerous monoliths in a short period of time brings us closer and closer to the possibility of producing this type of material on a large scale.

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References

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