THREE-DIMENSIONAL GRAPHENE MACROSTRUCTURE DECORATED GOLD NANOPARTICLES FOR CATALYSIS IN THE DEGRADATION OF METHYLENE BLUE

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Methylene blue (MB) is a dye widely used by textile industries, and its incorrect disposal via industrial effluents compromises the quality of water bodies providing risk to human health and biota. One method that can be explored to reduce or eliminate the toxicity of this contaminant is through its adsorption followed by catalytic degradation, which can be done through a carbon nanocomposite with metallic nanoparticles. Graphene is an allotrope of carbon, a sheet of atomic thickness, the bonds between carbon form a network similar to a hexagonal fence. This nanomaterial has become popular due to its unique properties, such as a high surface area and excellent thermal and electrical conductivity. However, obtaining it in a highly crystalline form is impractical on a large scale, which motivated discovering other ways to achieve similar nanomaterials. Reduced graphene oxide (rGO), obtained from the chemical exfoliation of graphite, is a graphene specie that has defects in the structure and several oxygenated groups, with equally exciting properties; however, its use in the two-dimensional form can present risks because graphene species can be easily charged to water during application. To avoid this, an alternative is to use rGO in its three-dimensional form (3DrGO), i.e., several graphene sheets rearranged and interconnected randomly, analogous to a sponge. This ensures the permanence of its qualities and enhances its surface area with its high porosity. Despite this, these qualities can be enhanced and/or specialized for specific applications by combining them with other materials in the form of a nanocomposite, rGO is an excellent receptor for metal anchoring, and gold nanoparticles (AuNPs) is one of them. The AuNPs alone present good catalytic activity but tend to agglomerate, losing their properties from their surface area; when assembling 3DrGO with AuNPs (3DrGO/AuNPs), a nanocomposite is obtained maintains and/or enhances the properties of both materials. Given this, it is sought to synthesize a 3DrGO/AuNPs nanocomposite in only one synthesis step without the use of toxic reagents, which can perform the catalytic degradation of MB. To perform the nanocomposite synthesis, graphite oxide (GO) was used, obtained through the chemical exfoliation of graphite, then the mixture of GO, chloroauric acid solution and a reducing agent the ascorbic acid was performed, using a thermochemical route in autoclave patented by our research group. For comparison purposes of the synthesis process, materials were prepared also using sodium borohydride ($NaBH_4$) as a reducing agent. The mixtures were subjected to a single-step thermochemical reduction, resulting in 3DrGO/AuNPs/AA and 3DrGO/AuNPs/$NaBH_4$. After being washed and dried, each material was submerged in a mixture with NaBH4 solution (reagent responsible for dye degradation) and MB solution under magnetic stirring. The MB concentration was monitored using Ultraviolet-Visible Spectroscopy (UV-Vis) at given times, which were 0, 1, 3, 5, 8, 10, 15, 20, and 30 min after the addition of $NaBH_4$. The synthesis of the nanocomposite with AA as a reducing agent resulted in a well-structured monolith. In contrast, the synthesis that $NaBH_4$ was used as a reducing agent resulted in a fragmented material, almost powder-like. In both samples, the 3D structure was formed but with distinct structures due to different properties of the reducing agents. In the catalytic degradation test, in only 30 minutes, the sample 3DrGO/AuNPs/AA catalyzed the degradation of 84% of the MB initial concentration, and for 3DrGO/AuNPs/$NaBH_4$ 61%. AA as a reducing agent was more efficient in degrading the dye; this was probably associated with its more porous structure. These results are very encouraging. It was possible to develop 3DrGO/AuNPs structures simultaneously reduced in only one thermochemical step by testing two possible reducing agents, AA and $NaBH_4$. Both nanocomposites synthesized with different reducing agents were able to accelerate the degradation of MB. Further studies are in progress to evaluate the effect of the amount and size of gold nanoparticles on catalysis. The partial results obtained in the initial phase of the research demonstrate that the generated nanomaterials have a huge potential for treating MB contamination in water. This potential can be improved or used for the degradation of other pollutants in aqueous media.

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