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Nanocomposite Membranes Based on Chitosan Embedded with Antimicrobial Nanoparticles for Water Purification Applications

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Extended Abstract

Due to the water problem, our attention is focused on developing innovative membranes for water purification. Among the biodegradable biopolymers, the ones based on polysaccharides like chitosan have presented great interest. After cellulose, chitosan is produced by chitin's deacetylation, the most bountiful natural polysaccharide. The reason polysaccharides such as chitosan attracted special attention was because of their availability in nature, bio-renewability, sustainability, and having low-cost and impressive performance compared to other materials used in water treatment [1]. Due to having interesting composition and structure and unique physicochemical properties, chitosan provides plenteously of prospects through physical and chemical approaches to expand the applications in removing contaminants from water sources. Chitosan, an important adsorbent material, presents significant usage for removing toxins from drinking or wastewater, including microorganisms, heavy metals, dyes, and phenols [2].

Studies have shown that embedding chitosan with different nanomaterials like silver, titanium dioxide, zinc oxide, silica, magnetite, graphene oxide and zeolite printed good antimicrobial properties to the membranes. Therefore, based on the results presented in [3], ZnO nanoparticles' antimicrobial activity against Gram-negative and Gram-positive strains has been proven. *S. aureus* bacteria were the most sensitive tested strain. Starting from the antimicrobial results presented, there is a high interest in developing nanocomposite membranes for water purification. For instance, Zhu *et al.* [4] developed TiO_2/ZnO/chitosan nanocomposite thin films (NTF_S), providing an economically feasible and environmentally friendly method for treating azo dye effluents.

Accordingly, with the presented study above [4], we synthesized nanocomposite membranes based on chitosan and nanoparticles for water purification applications. Chitosan membranes embedded with nanoparticles were prepared using the casting method described next. First, a 2% chitosan solution was prepared by dissolving 2g of chitosan in 100ml of 2% acetic acid under sonication for 5h. Subsequently, 0.2g of TiO_2 nanoparticles and 1.14g of ZnO nanoparticles were added to the previous solution and stirred for 24h. The obtained nanocomposite membranes were washed, dried, and then cross-linked for further analysis. The synthesized nanocomposite membranes were characterized by FTIR, SEM/ EDX, complex thermal analysis, and complex biological assessments.

The FTIR analysis confirmed the characteristic peaks related to chitosan and nanoparticles and the interactions developed between the components.

The SEM/ EDX analyses confirm the presence of nanoparticles in the membranes' structure and their relatively homogeneous distribution conferring the premises of using them as reproducible membranes for water purification applications.

The TG/ DSC analysis on the subjected samples illustrated the thermal behaviour and the composition very close to the theoretical ones, again confirming a good homogeneity of the samples.

Following the antimicrobial assessments, the composite membranes have inhibited the adherence of the tested microbial strains. Therefore, *E. coli* ATCC 25922 and *Citrobacter* sp. were the most sensitive to the as-developed membranes. Also, the composite membranes had moderate antimicrobial activity against Gram-positive strains resistant to antibiotics (*E. faecalis* VRE 2566 and *S. aureus* MRSA 5578), which indicates that the as-presented composite membranes showed great perspective in developing membranes for water purification applications.

Keywords: antimicrobial nanoparticles, nanocomposite membranes, water purification applications.

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