The use of nanotechnology in health care: a literature review of reduced nano graphene oxide and its applications with initial tests

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1 INTRODUCTION

Nanotechnology is a subject that is constantly on the rise and its use in the health area is extremely important, aiming at improvements in the manufacture of hospital equipment, diagnostics, treatments, and medications. Thus, the use of an extremely versatile nanomaterial that has excellent chemical, physical, mechanical, and electrical properties becomes essential. Therefore, this paper aims to demonstrate the applications of reduced nano graphene oxide (nOGr) in several areas related to health sciences.

Reduced nano graphene oxide can be considered one of the most revolutionary materials arising from nanotechnology of a later generation than carbon nanotubes. In the area of health, it can be said that the reduced graphene nano oxide presents physicochemical properties superior to those of carbon nanotubes, with the great advantage of being less toxic (FILHO *et al*., 2017).

The material visually presents characteristic of a sheet with nanometric dimensions, and thanks to the reduction process, capable of removing part of its oxygen, carbonyl and hydroxyl functional groups, it presents improvement in its properties and there is still the guarantee of maintaining its water-solubility, which can be a great advantage when applied to studies with drugs (FILHO *et al*., 2017).

Reduced nano graphene oxide (nOGr) is one of the most promising materials today, because it has excellent chemical, physical, mechanical and electrical properties, making it an extremely versatile material that can be applied in several areas, such as biomedicine, energy, development of electrical circuits, mechanics, among others. Wong (2014) and Camargos, Semmer and Silva (2017) classify two types of techniques for obtaining graphene oxide , the first based on chlorates and the second on permanganates. The first is based on methods developed by Staudenmaier, Hoffmann and Brodie, and the second by Hummers and Offeman.

2 OBJECTIVE

This work aimed to review in the literature the possible health applications of reduced graphene nano-oxide synthesized by the modified Hummers method, characterizing it to understand and confirm its physicochemical properties and, in the future, to apply it in practical studies, with primary action to reproduce the Hummers method with small modifications in the molarity of the reactants.

3 METHODOLOGY

The methodologies proposed in the synthesis of reduced graphene nano oxide that follow the modified Hummers method are basically, using as primary reagents, sulfuric acid and nitric acid in an ice bath, graphite and potassium permanganate and kept under stirring for a certain period of time. The reduction of the material is generally proposed using hydrogen peroxide, which provides the hydroxyl groups for the sheet structure of the graphene formed from the graphite. Several adaptations of this method proposed by Hummers are identified in the literature, all with very promising responses for different applications in health care.

The characterization of these nanomaterials is performed by different techniques, among them: FTIR (Fourier Transform Infrared Spectroscopy) and UV-VIS (Ultraviolet and Visible Absorption Spectroscopy) optical spectroscopy, XRD (X-ray Diffraction) spectroscopy and morphological analysis by SEM (Scanning Electron Microscopy).

In the case of the literature review, searches for articles and news in electronic databases were performed, focusing on the applications of reduced graphene nano oxide applied to medicine. To verify

the effectiveness of such synthesis, this work reproduced a methodology adapted from Hummers, with minor modifications in the molarity of the materials, but using the same primary reagents, performing the evaluations by the techniques mentioned above.

4 DEVELOPMENT

FTIR analysis observed the presence of the band 3270 cm^{-1} referring to the stretching of the OH bond associated with water adsorbed on the oxide structure, C≡C axial deformation vibrations at 2128 cm^{-1} , stretching of the C=O bonds at 1705 and 1612 cm^{-1} and stretching of the C-O bond at 1032 cm^{-1} (Yang et al., 2012 and Stankovich et al., 2006).

In the UV-Vis spectroscopy result, a band at 233 nm of C-C bonding and a band at 300 nm of C=O bonding were observed which are attributed to the $\pi \rightarrow \pi^*$ transitions, referring to the LUMO→HOMO transition.

In the XRD spectrum of the nOGr sample, the presence of peaks referring to the oxidation process of graphite was observed: there is a diffraction peak at the 2θ position equal to 25.05° for pure graphite (Wang et al., 2017), another peak at 2θ equal to 16.37° with a decrease in interlayer distance of 0.541 nm and intensity of 5690.79 a.u. indicating high crystallinity of graphite after treatment.

There are also peaks at the 2θ positions equal to 12.95º and 13.41º that correspond to interplanar distances of 0.683 and 0.660 nm, respectively, which are larger than that of graphite (0.34 nm).

The other peaks appearing at 2θ positions equal to 37.60°, 43.99°, 64.53°, and 76.85° indicate small interlayer distances ranging between 0.239 nm and 0.124 nm, as well as low crystallinity.

With SEM it was possible to observe several layers of nOGr sheets, which shows there is agreement with the XRD result, showing 8 interplanar layers.

Typical wrinkled morphology of nOGr was observed, a characteristic that justifies the cause of leaf folding and are related to the existence of flexible layers (Oliveirar, et al., 2019 and Loryuenyong, et al., 2013).

As for the applications of nOGr there are reports that the material interfaces well with the neural system, due to favorable physical and electronic properties, serving as an interface with neurons and astrocytes, as well as endothelial cells, which line the vessels of the cerebral microcirculation (FILHO *et al*., 2017).

It has been found that the material has the ability to affect the blood-brain barrier in a positive way temporarily, making it possible to use such an opening period to administer a drug, which would make it feasible to use nOGr for delivery and release of the drug at the desired site (FILHO *et al*., 2017).

Studies have shown that after being administered in the body of animals, nOGr concentrated mainly in the thalamus and hippocampus, regions affected by diseases such as Parkinson's and Alzheimer's. Such behavior will possibly allow the more efficient treatment of these diseases, even enabling the reduction of the doses of administered drugs, which may reduce the numerous side effects (FILHO *et al*., 2017).

5 CONCLUDING REMARKS

The modified Hummers method proved to be very efficient and reproducible for the synthesis of nOGr. The material produced presented excellent quality, as demonstrated by the characterization techniques used, which will guide the realization of new syntheses and characterizations to improve the results and refinement of the techniques applied, especially seeking techniques and means for its application in tests aimed at drug administration.

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