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ORIGINAL RESEARCH

Convenient method for preparation of a new absorbent based on biofunctionalized graphene oxide hydrogels using nitrene chemistry and click reaction

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Abstract

A new graphene oxide (GO)-based hydrogel was synthesized through cross-linking of biofunctionalized graphene oxide nanosheets by di-alkyne polyethylene glycol as cross-linking agent. In this respect, nitrene chemistry as a convenient and straightforward protocol was developed for biofunctionalization of GO using an azido-starch as an eco-friendly, biodegradable and cost-effective material. In the next step, 1,3-dipolar cycloaddition chemistry, a green and highly efficient approach was utilized in cross-linking of functionalized GO by PEG through click reaction between remaining azido groups of starch on the surface of GO sheets and terminal alkyne groups of polyethylene glycol. Formation of aziridine and triazole rings during functionalization and cross-linking in this method could evidently improve biological activities of the obtained hydrogel compared to the conventional methods. The antibacterial activity of the new compounds was explored. The synthesized hydrogel showed antibacterial properties against Gram-positive and Gram-negative bacteria due to the presence of triazole rings. Also, the resulting hydrogel exhibited high dye removal efficiency and it can be utilized in water treatment effectively. The adsorption kinetics was analyzed through the effects of adsorption time and the dye concentration on the adsorption capacity. Kinetic data were accurately described by a pseudo-second-order model.

Keywords Graphene oxide · Starch · Polyethylene glycol · Click reaction · Methylene blue · Nitrene chemistry

Introduction

Graphene oxide (GO), as the most abundant chemical derivative of graphene with a two-dimensional structure, has attracted much researchers' attention in recent years. GO is often decorated with epoxy, hydroxyl, carbonyl and carboxylic functional groups which can be functionalized through various covalent and non-covalent approaches to achieve desired properties and application [1]. Selecting appropriate material as well as modification method for functionalization of nanoparticles is an essential approach which can widely affect their properties and their field of application. Up to now, many covalent and non-covalent surface modifications and gelation strategies using different small molecules, ions and polymers for GO have been reported and their potential applications in different fields of applications such as waste water treatment has been explored; however, efforts in search of safe and effective materials are still continued [2, 3]. Biofunctionalization of GO due to utilization of safe and eco-friendly materials which often contain huge number of variety of functional groups could be the best choice for this purpose. Among different types of biological macromolecules for biofunctionalization, polysaccharides such as cellulose, starch, xylan, inulin, carrageenan and chitosan have gained increasing attention especially because of their low cost, availability and renewability [4, 5].

On the other hand, in covalent modification, it seems that the connecting bonds the nature may have important role in development of new materials with advanced applicability. For example, polymer-functionalized reduced GO with antibacterial properties are reported by Peña-Bahamonde et al. [6]. They utilized nitrene chemistry to functionalize reduced GO sheets with polysulfone brushes (PSU) for

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