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Review

Chitosan modifications for adsorption of pollutants – A review

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ABSTRACT

In recent times, research interest into the development of biodegradable, cost-effective and environmental friendly adsorbents with favourable properties for adsorption of pollutants is a challenge. Modification of chitosan via different physical and chemical methods have gained attention as a promising approach for removing organic (such as dyes and pharmaceuticals) and inorganic (such as metal/metal ions) pollutants from aqueous medium. In this regard, researchers have reported grafting and cross-linking approach among others as a potentially useful method for chitosan's modification for improved adsorption efficiency with respect to pollutant uptake. This article reviews the trend in chitosan modification, with regards to the summary of some recently published works on modification of chitosan and their adsorption application in pollutants (metal ion, dyes and pharmaceuticals) removal from aqueous medium. The review uniquely highlights some common cross-linkers and grafting procedures for chitosan modification, their influence on structure and adsorption capacity of modified-chitosan with respect to pollutants removal. Findings revealed that the performance of modified chitosan for adsorption of pollutants depends largely on the modification method adopted, materials used for the modification and adsorption experimental conditions. Cross-linking is commonly utilized for improving the chemical and mechanical stabilities of chitosan but usually decreases adsorption capacity of chitosan/modified-chitosan for adsorption of pollutants. However, literature survey revealed that adsorption capacity of cross-linked chitosan based materials have been enhanced in recently published works either by grafting, incorporation of solid adsorbents (e.g metals, clays and activated carbon) or combination of both prior to cross-linking.

1. Introduction

Chitosan is one of the promising organic compounds being utilized for adsorption applications. The existence of $-NH_2$ and –OH groups in its molecular structure contributes mostly to probable adsorption interfaces between chitosan and adsorbate molecules (Chang and Chen, 2005; Di Bello et al., 2017; Kyzas and Bikiaris, 2015; Li and Bai, 2005). Chitosan is advantageous for adsorption purposes (Naseeruteen et al., 2018; Vilela et al., 2019; Yaoguo Wu et al., 2017a, 2017b; Yang et al., 2016) including environmental remediation (Jawad et al., 2017; Li et al., 2016a, 2016b) due to its cost effectiveness, simpler polymerization and functionalization process, and good stability (Amouzgar and Salamatinia, 2015; Zujin Yang et al., 2019). It is a useful material for decontamination (Chen et al., 2011) of wastewaters containing pollutants of either organic (Chen et al., 2017; Vanamudan et al., 2014; Vanamudan and Pamidimukkala, 2015) or inorganic species (Demarchi et al., 2015; Geng et al., 2009).

Chitosan has been modified into multi-functional adsorbents based on the capacity it required to be applied (Copello et al., 2011; Kyzas and Bikiaris, 2015). Sequel to the assessment of chitosan for removing metallic ions from organic and sea waters carried out by Muzzarelli and Tubertini in 1969 (Muzzarelli and Tubertini, 1969), research has been intensified on chitosan composites' preparation for adsorption applications as Scopus database searched on "Chitosan modifications for adsorption application" reported 122 papers between 2015 and 2019. Chitosan modification into composites is connected with its low adsorption capacity in aqueous medium with reference to its crystalline and swelling nature, low porosity, low hydrophilic, low surface area, and poor stability in acidic medium (Essel et al., 2018; Vakili et al., 2019). Its solubility in dilute solution of organic acids such as ethanoic acid (Elwakeel et al., 2018) influenced the distribution of its acetyl groups, ionic strength and degree of intramolecular hydrogen bonding (Govindaraj et al., 2019; Guaresti et al., 2018; Guibal, 2004; Pirillo et al., 2009). Better performance of modified chitosan prepared in acetic acid for cationic dye removal could be linked to resizing of pore diameter or derivatisation of functional groups around the pores under various pH

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