

REMOVAL OF FLUORIDE FROM DRINKING WATER USING PROTONATED GLYCEROL DIGLYCIDYL ETHER CROSS-LINKED CHITOSAN BEADS

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Abstract. In this study, physically and chemically modified chitosan; protonated glycerol diglycidyl ether cross-linked chitosan beads (GDCLCB/H⁺) were prepared and characterized using FTIR and SEM. The optimum defluoridation capacity (DC) of GDCLCB/H⁺ was observed at the initial F⁻ ion concentration of 15 mg/l, adsorbent dosage of 0.6 g, contact time of 30 min and pH of the solution was in the range of 5–7 at 303 ± 2 K. The equilibrium adsorption data fitted well with Langmuir and Freundlich isotherm models. The maximum adsorption capacity (q^0), obtained from Langmuir isotherm for F⁻ adsorption was found to be 2000 mg/kg, which was significantly higher than that of unmodified chitosan (192.3 mg/kg) and most of the chitosan-based sorbents reported in the literature. Water samples collected from Medawachchiya, Sri Lanka, were treated with the adsorbents and the results suggested that GDCLCB/H⁺ could be used as an effective defluoridation agent.

Keywords: defluoridation capacity, fluoride, GDCLCB/H⁺.

1. Introduction

Fluoride (F⁻) is one of the common anions mainly found in ground water. F⁻ may enter water bodies due to the natural processes like weathering, volcanic activity, *etc.* and as an anthropogenic pollutant mainly by wastewater discharges from industries such as phosphate fertilizers (which contain an average of 3.8 % fluorine), glass, aluminium production, ceramic, brick, iron works, and electroplating [1]. Fluoride can enter human body through water, food and industrial exposure and among them drinking water can be considered as the major source of daily intake of F⁻ [2]. Depending on the total intake, F⁻ is known to have both beneficial and adverse effects on humans, as summarized in Table 1.

Water fluoridation reduces tooth decay among adults and children but dental and skeletal fluorosis are also primarily associated with the consumption of

drinking water containing elevated levels of F⁻ [3]. Therefore, a guideline value of 1.5 mg/l of F⁻ was recommended by World Health Organization (WHO) as the maximum permissible concentration level of F⁻ in drinking water [4]. Various treatment methods including ion exchange [5], chemical precipitation, coagulation [6, 7], adsorption [8, 10], reverse osmosis [9], nano-filtration [10], electro dialysis [11], *etc.* have been widely used for the treatment of F⁻ containing water. Among these methods, F⁻ removal by adsorption is the most widely used method because most other processes have significant drawbacks such as high maintenance cost, incomplete removal, high-energy requirements, generation of toxic sludge, *etc.* [12]. A wide variety of adsorbents and their modifications have been tested for the F⁻ removal from water. These include activated carbons [13], activated alumina [14], bauxite [15], hematite [16], polymeric resins [17], activated rice husk [18], brick powder [19], pumice stone [20], red soil, charcoal, brick, fly ash, serpentine [21], seed extracts of *Moringaoleifera* [22], granular ceramics [23], chitin [16], modified ferric oxide/hydroxide, hydroxyapatite [24], zirconium and cerium modified materials [25], chitosan derivatives and composites [16, 26], *etc.* As adsorption is considered to be a cost-effective, environmentally friendly, simple and efficient method for water treatment, in this study the potential of use of physically and chemically modified chitosan as F⁻ removal agent in drinking water was studied.

Chitosan, deacetylated product of chitin, is widely distributed in nature. Being a biopolymer, it is biodegradable, eco-friendly, and non-toxic. It is made up of D-glucosamine (GlcN) and N-acetyl-D-glucosamine (GlcNac) which are linked by β -(1,4)-glycosidic bonds. The structure of chitosan is depicted in Fig. 1.

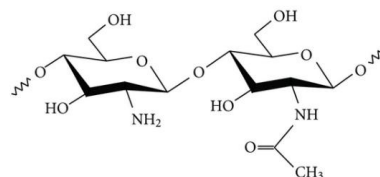


Fig. 1. The structure of chitosan (the degree of deacetylation of chitosan used in the study was 85 %)

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