



Green Synthesis of Iron Nano-Impregnated Adsorbent for Fast Removal of Fluoride from Water



Imran Ali ^{a,*}, Zeid A. ALOthman ^b, Mohd Marsin Sanagi ^{c,d}

^a Department of Chemistry, Jamia Millia Islamia (Central University), New Delhi 110025, India

^b Department of Chemistry, College of Science, King Saud University, Riyadh 11451, Kingdom of Saudi Arabia

^c Separation Science and Technology Group (SepSTec), Department of Chemistry, Faculty of Science, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia

^d Ibnu Sina Institute for Fundamental Science Studies, Nanotechnology Research Alliance, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia

ARTICLE INFO

Article history:

Received 27 June 2015

Received in revised form 10 July 2015

Accepted 12 July 2015

Available online 3 August 2015

Keywords:

Removal of fluoride

Adsorption models

Water treatment

Iron nano-impregnated adsorbent

Mechanism of adsorption

ABSTRACT

Iron nano-impregnated adsorbent was synthesized, characterized and applied for fluoride subtraction from the water. Maximum fluoride removal (90%) was at 4.0 mg/L concentration, 25.0 min. contact time, 7.0 pH, 2.5 g/L dose and 293 K temperature. Iron nanocomposite adsorbent was selective for fluoride removal. The experimental data obeyed Langmuir, Freundlich and Temkin models. The values ΔG° were -1.89 , -0.86 and -0.74 kJ/mol at 293, 298 and 303 K temperatures. ΔH° value was -7.61 kJ/mol; indicating exothermic adsorption. ΔS° value was -2.30×10^{-2} kJ/mol K; a signal of entropy decrease during adsorption. The adsorption process was in the order of $293 > 298 > 303$ K. Kinetic modeling confirmed pseudo-first-order and liquid film diffusion mechanisms. The mechanism of adsorption is also determined.

© 2015 Elsevier B.V. All rights reserved.

1. Introduction

Fluoride is one of the most harmful pollutants in the ground water. Water at some places in the world is not fit for drinking purpose due to fluoride contaminant. Geological and various anthropogenic activities are responsible for the ground water contamination by fluoride. Industries discharging fluoride are super phosphate, zinc smelters, ceramic works, aluminum smelters, brickworks, coal-fired power plants, steel mills, uranium enrichment facilities and oil refineries [1]. As per WHO, the permissible limit of fluoride is 1.0 mg/L [2]. High concentration of fluoride causes poor development of infant's brain, osteosclerosis, dental fluorosis, cancer and impairment in human beings [3]. Fluoride pollution is a global problem in various countries such as USA, Canada, Brazil, Pakistan, India, Sri Lanka, China, Thailand, Japan, New Zealand, and some countries of Africa and Europe continents. The fluoride problem is recognized globally, and Fig. 1 shows dental and skeletal fluorosis world wide.

In view of these facts, it is essential to develop, fast, selective, economic and eco-friendly method for the removal of fluoride from water. There are some techniques employed for fluoride removal, but adsorption is considered as the best one due to its unique features [4–18]. Literature survey indicates few papers on fluoride removal by adsorption [19–25]. These methods have certain drawbacks such as poor adsorption capacities, long contact time, high dose and extremely

low or high pHs. These limitations could not make these methods feasible to remove fluoride in real life problems. Therefore, the attempts were made to develop iron nano-impregnated adsorbent by green technology. The developed adsorbent was used for the removal of fluoride from water. The results of this study are discussed herein.

2. Experimental

2.1. Chemicals, Reagents, and Instruments

Sodium fluoride was obtained from Merck, Darmstadt, Germany. 1-Butyl-3-methylimidazolium bromide was purchased from Sigma-Aldrich Co., USA. Deionized water was prepared using Millipore-Q, Bedford, MA, USA system. pH meter of Control Dynamics (Model APX175 E/C) was used to measure pH of the solutions. The centrifuge of Remi (model C-30BL) was used to separate the adsorbent. Powdered X-ray diffraction was carried out on Philips PX-1830 diffractometer using Cu K α radiation ($\lambda = 1.54 \text{ \AA}$), a Cu filter on secondary optics, 25 kV voltage, 30 mA current and a proportional counter detector. The residual concentration of fluoride was determined by UV-vis. spectrophotometer (T80, P.G. Instrument Ltd., U.K.) at 570 nm wavelength as per standard procedure [26].

2.2. Preparation of Iron Nano-impregnated Adsorbent

Green technology was exploited to prepare iron nanoparticles (NPs) as per the standard procedure [27,28]. The black tea (100.0 g/L) was

* Corresponding author.

E-mail addresses: drimran_ali@yahoo.com, drimran.chiral@gmail.com (I. Ali).

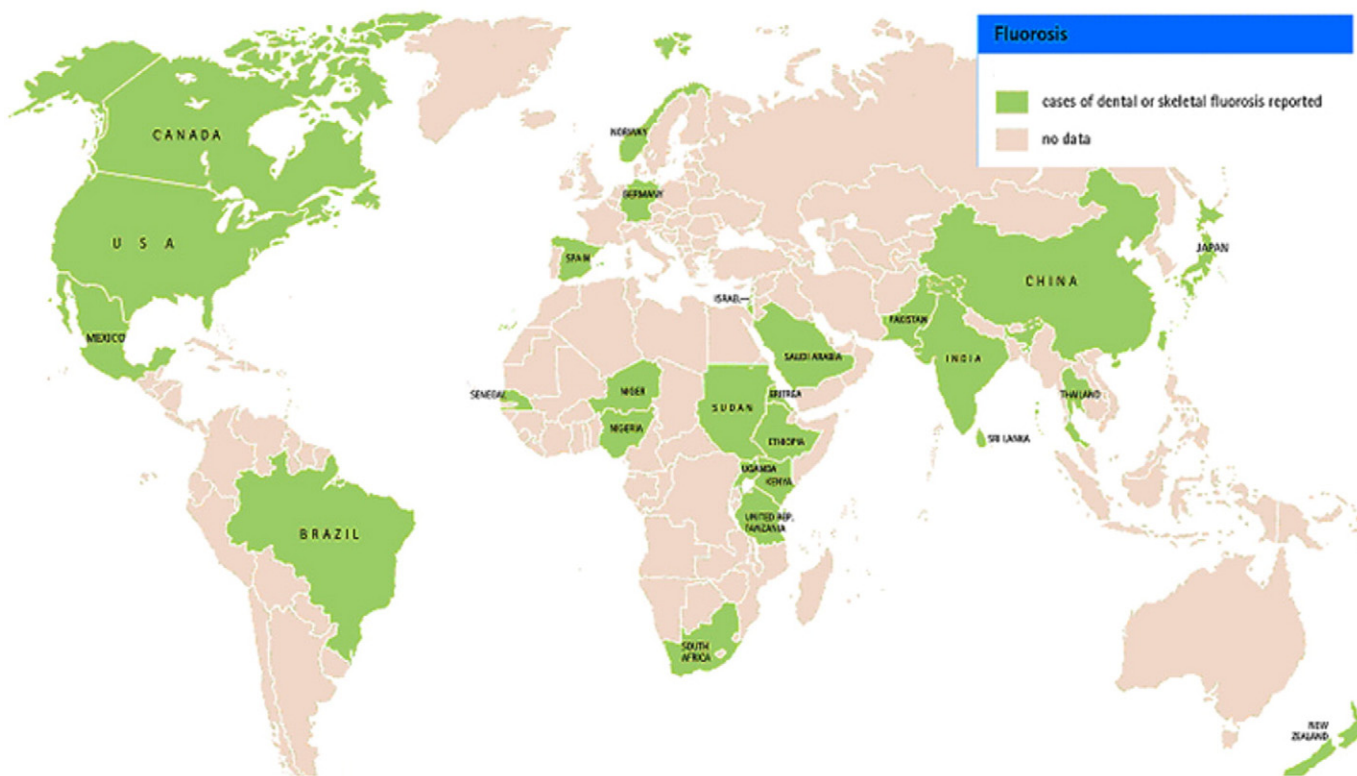


Fig. 1. The dental and skeletal fluorosis globally.

heated at 80 °C for 1 h. The extract was filtered followed by addition of 0.20 M ferrous sulphate solution in 1:2 ratio. The solution was kept for 24 h. The NPs formed were separated, washed with deionized water three times and drying in an oven at 250 °C for 24 h. 500 mg of 1-Butyl-3-methylimidazolium bromide was dissolved in 100 mL acetate buffer (0.05 M, pH 4.5). 5.0 g NPs were transferred to 100 mL solutions of 1-butyl-3-methylimidazolium bromide. It was sonicated for 24 hrs. The treated iron NPs were separated and washed with deionized water three times and dried in an oven at about 100 °C for 24 h. The prepared iron nano-impregnated particles were ready for use in adsorption experiments.

2.3. Characterization of Iron nano-impregnated Adsorbent

The synthesized iron nano-impregnated particles were characterized by UV-vis. spectrometry, field emission scanning electron microscope (FESEM) and XRD techniques. The morphology of the material was ascertained by scanning electron microscope (FESEM). Images of samples were recorded at different magnifications at 10 kV operation. X-Ray diffraction (XRD) patterns of native and iron nano-impregnated particles were obtained using Philips PX-1830 diffractometer using Cu K α radiation ($\lambda = 1.54 \text{ \AA}$), a Cu filter on secondary optics, 25 kV voltage and 30 mA current and a proportional counter detector. Iron nano-impregnated particles were scanned from 10° to 80° 2 θ at a scanning rate of 3° 2 θ per minute.

2.4. Preparation of Fluoride Solutions

The standard solution of fluoride (10.0 mg/L) was prepared in deionised water. Further dilution for UV-vis. spectrometry (0.50–5.0 mg/L) and adsorption studies (0.5–7.0 mg/L) were carried out in deionised water.

2.5. Adsorption Studies

All the adsorption experiments were carried out on thermostatic water bath shaker at a fixed temperature for a given period. After adsorption, the solid and liquid parts were separated by centrifugation. Fluoride concentrations in the solution samples were determined by UV Visb. spectroscopy. Adsorption isotherms were studied in the range of 0.5–7.0 mg/L as a concentration with 1.0–10.0 pH range, 2.5–50 min. contact time, 0.5–5.0 g/L dose and 293–303 K temperatures. The different mathematical models were used to ascertain isothermal and kinetic parameters. The data obtained in batch studies was used to calculate the equilibrium fluoride uptake capacity. It was calculated using the following equation.

$$Q_e = (C_0 - C_e) / m \quad (1)$$

where, Q_e is the amount (mg/g) of fluoride adsorbed at equilibrium. C_0 is initial concentration (mg/L). C_t is the equilibrium concentration (mg/L) at time 't'. m is the weight of adsorbent in g/L. The percentage removal of fluoride was calculated using the following equation.

$$\% \text{ Removal} = [(C_0 - C_e) / C_0] 100 \quad (2)$$

where, C_0 and C_t have the usual meanings.

2.6. Kinetics Studies

Kinetics for fluoride adsorption was analyzed by uptake of fluoride from aqueous solutions at different times. For studying adsorption isotherms, the various solutions of fluoride were stirred with a known amount of adsorbent till equilibrium. The residual fluoride concentration was determined by UV-vis. spectrometry. The batch tests were

Download English Version:

<https://daneshyari.com/en/article/5410659>

Download Persian Version:

<https://daneshyari.com/article/5410659>

[Daneshyari.com](https://daneshyari.com)