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Potential of Sri Lankan Apatite as a fluoride removal Agent from aqueous solution against Various Apatite Materials

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Abstract: As reported Sri Lanka it has a high fluoride contaminated ground water which was suspected as a cause for chronic kidney failure and there is an urgent need to treat fluoride contaminated drinking water to make it safe for human consumption by a low cost and convenient method. In this study potential of using Sri Lankan Apatite (SAp) as a defloration agent was studied and results were compared with other apatite materials. Adsorption experiments were performed on SAp, Sulphuric treated SAp (SSAp), Chicken bone char (CBC) and pre Hydroxyl Apatite (HAp). Since the raw SAp had no adsorbing capacity of fluoride, it was treated with sulfuric acid to produce HAp, however, sulphuric acid treatment for SAp did not yielded enough amount of hydroxy apatite as a fluoride adsorbent. Accordingly, higher leaching of fluoride into the solution was confirmed by the SSAp than that by the SAp. The fluoride removal capacities were in the order: HAp > CBC > SAp>SSA. The adsorption of fluoride by HAp and CBC was not well expressed by Langmuir isotherm but by Freundlich isotherm. It showed that HAp and CBC was a promising material for fluoride removal, therefore SAp should be further treated to extract phosphates to produce synthetic hydroxyapatite.
Keywords: Hydroxyl apatite, Apatite, Bone char.

1. Introduction

Various treatment technologies were proposed or applied to remove the excess fluoride from drinking water, and these technologies were based on the principle of precipitation, the ion exchange, the membrane or the adsorption processes [1-2]. Among these methods, the adsorption is a simple and attractive one having high efficiency and easy handling. In recent years, much effort has been devoted to investigate and develop new fluoride adsorbent using various synthetic, naturally occurring and waste materials from various industries and requires little processing. Hydroxy apatite is a good adsorption material of fluoride [3]. Since Sri Lanka has apatite deposit in Eppawala, this study was focused on the potential of Sri Lankan rock apatite (SAp) to remove fluoride from drinking water as a low cost material. Its results were compared with other hydroxyapatite materials.

2. Materials and Methods

2.1 Chemicals and analyses

All the chemicals used in the experiment were analytical grade purchased from Wako chemicals, Japan except pure hydroxyapatite (HAp). It was supplied from Taihei Chemical Industrial Co. Ltd. SAp was collected from Eppawala mine and chicken bone was used to produce chicken bone char (CBC). NaF solution was used for the adsorption. Anions were analysed by using anion chromatograph (DIONX-ICS 2000).

2.2 Treatment of SAp

SAp was crushed and passed through 106 µm sieve. Twenty five grams of the sieved SAp was treated with 11.1 ml of H_2SO_4 to produce H_2SO_4 treated hydroxyl Apatite (SSAp). A reaction between SAp and H_2SO_4 produce various products in addition to SSAp (Eq 1).

$$Ca_{10}(PO_4)_6(OH.F.Cl)_2 + H_2SO_4 + H_2O \xrightarrow{yields} +Ca_{10}(H_2PO_4)_2(OH)_2(s) - \boldsymbol{SSAp} + CaSO_4(s) + Ca_{10}(H_2PO_4)_2\,(OH.Cl)_{\,2}(s) + Ca_{10}(PO_4)_6(OH.F)_2(s) + Ca_{10}(PO_4)_6(OH.Cl)_2(s) + HF(aq) + HCl(aq) + H_3PO_4(aq) \quad (1)$$

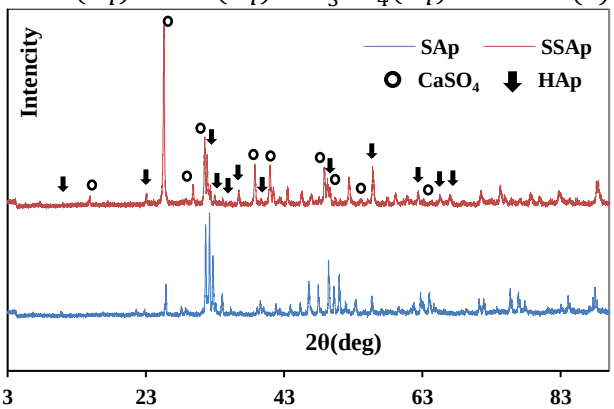

Figure 1: XRD pattern of SAp and SSAp

H_2SO_4 treated SAp was then centrifuged to separate solid portion. The separated solid was washed with excessive ultrapure water several times to remove HF, HCl, H_3PO_4 and excessive H_2SO_4. According to XRD pattern (Fig. 1), it was confirmed SSAp contains HAp and $CaSO_4$ Mixture.

2.3 Treatment of chicken bone

Chicken bone was carbonated at 600°C to make Chicken Bone Char (CBC) of which component is hydroxyapatite. It was crushed, and sieved by a 106 µm sieve for use.

2.4 Effect of sorbent dose on the Adsorbing capacity

The initial pH was adjusted to 7.0, and the initial concentration of fluoride was 10 mg/L. The contact time was 24 hr, and the temperature was kept at 25°C.

2.5 Isotherm

Pure HAp, CBC, SAp, and SSAp were put in 50 mL of NaF solution with a fluoride concentration of 10 mg/L. It was shaken for 24 hours to establish equilibrium between the adsorbent and the solution.

3. Results and Discussion

3.1 Effect of sorbent dose

Fig. 2 shows the effect of adsorbents (HAps, CBC, SAp, SSAp) dose on fluoride adsorption.

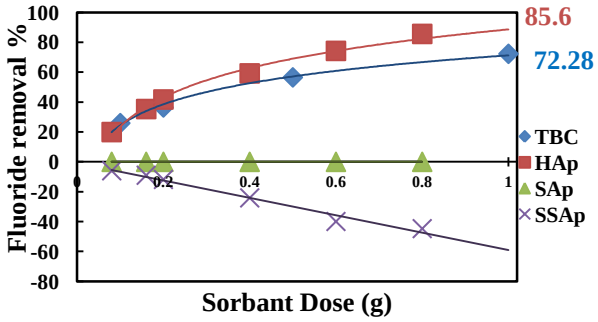

Figure 2: Effect of adsorbent dose

The adsorption capacity of CBC and HAp was significantly influenced by the dose of the materials. SAp and SSAp did not show any adsorption of fluoride. Even though HAp was present in the SSAp it exhibited negligible fluoride removal efficiency. The possible reasons are unstable fluoro Apatite forms and slow release of OH ions from HAp hence far from adsorption; SSAp leached fluoride to the solution.

3.2 Adsorption Isotherms

Fig.3 shows Freundlich isotherm and Fig.4 shows Langmuir isotherm for CBC and HAp. By comparing the results presented in Fig. 3 and Fig.4, the adsorption of fluoride by HAp and CBC was not well expressed by Langmuir isotherm but by Freundlich isotherm. SAp and SSAp did not follow both of the isotherms.

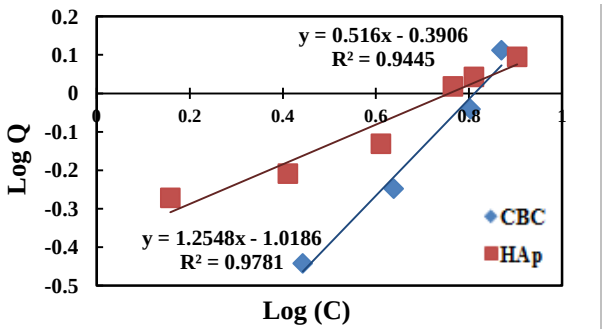

Figure 3: Freundlich Isotherm

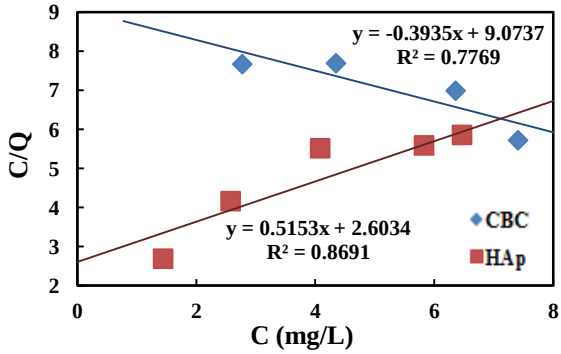

Figure 4: Langmuire Isotherm

4. Conclusion

SAp or SSAp could not remove fluoride from aqueous solution. Further treatment and synthesis are required for producing adsorbent of fluoride. CBC and HAp could be suitable precursor materials for producing high capacity adsorbents of fluoride removal from aqueous solution.

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