Magnesium oxide modified activated carbon derived from coconut shells for fluoride adsorption

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Introduction

Figure 1: Effect of extensive fluoride exposure; dental and skeletal fluorosis

Fluoride presence in water has been recognized as one of the major global problems, making the development of effective technologies for its removal, within the limits set by WHO (1.5 mg/L). Among the commonly applied technologies for fluoride removal, adsorption has gained great attention while offers a highly efficient, simple and low-cost treatment. This study was aimed to examine the performance of activated carbon modified by MgO under specific laboratory conditions, while previous studies have proved magnesium (Mg) as a suitable metal source to enhance fluoride removal

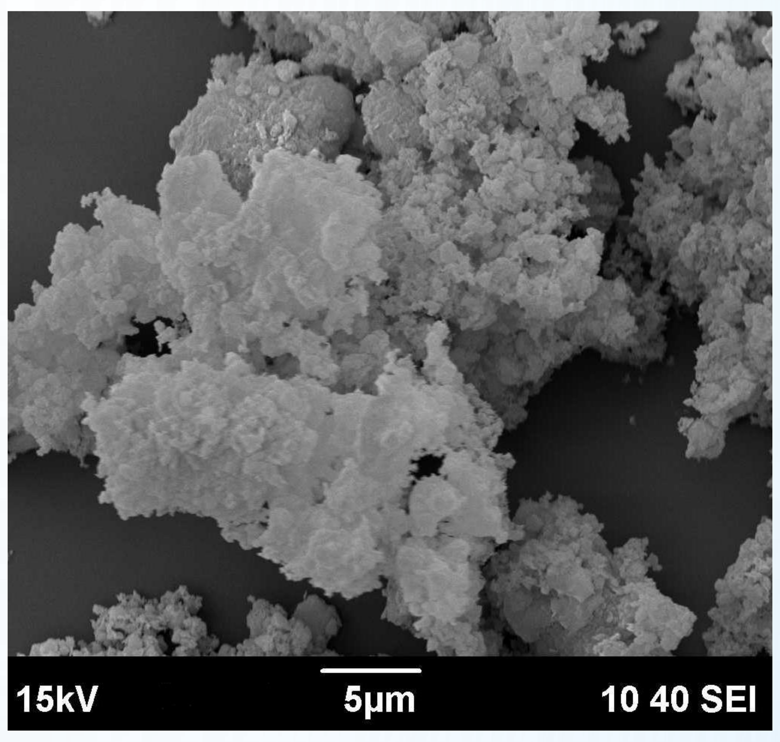

Figure 2: SEM image of AC-Mg

The structure and the morphology of modified activated carbon (AC-Mg) were studied in detail. The proposed adsorbent material applied for the treatment of simulated contaminated with fluoride water. The effects of the adsorbent's dosage, pH value, and experimental/operational conditions efficiency, were examined. According to the obtained results, the maximum adsorption was observed at pH 8, 4h as contact time and 0.2 g/L of adsorbent dose.

Results & Discussion

Activated carbon was synthesized from coconut shells (AC) and then modified with MgO. The physical properties of laboratory prepared AC-Mg adsorbent, were summarized in Table 1.

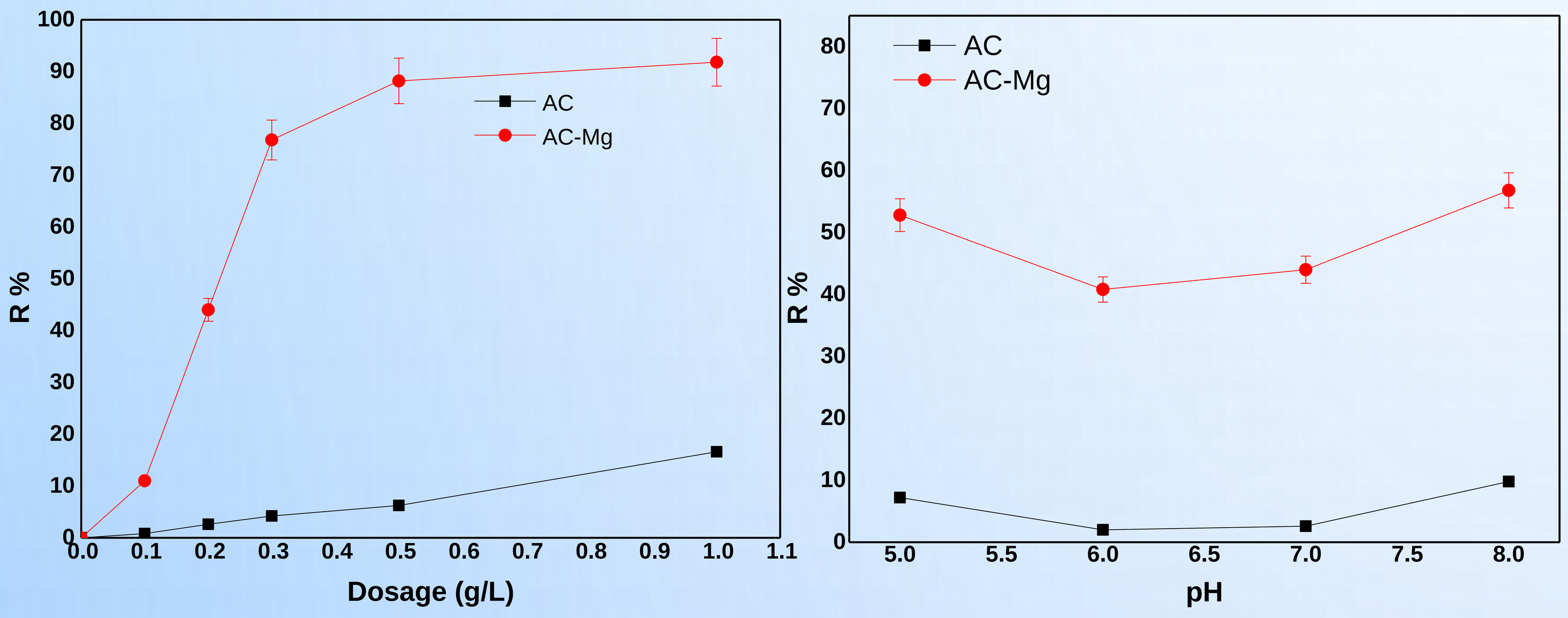

Figure 3: Effect of dosage (at pH 7) and effect of initial solution pH (at dose 0.2 g/L), T=25±1 °C, contact time 24 h, in deionized water.

The BET surface area, total pore volume, and micropore volume of AC-Mg were measured to be 42.5 m^2/g, 0.282 cm^3/g and 0.779 cm^3/g , respectively, which show that AC-Mg is practically efficient for adsorption. The morphology and structure of the modified activated carbon, were observed by SEM. As shown in Figure 2, AC-Mg has a structure with pores and cavities that may be due to the carbonization stage during preparation.

In batch experiments, the effect of the adsorbent's dosage and the initial solution pH were studied to determine the feasibility of AC-Mg for F^- removal. As illustrated in Figure 3, with the increase of the adsorbent's dosage, the percentage removal of F^- increased from 12% to 92% at pH 7. The modification of the material showed advanced adsorption capacity, when comparing the results with those obtained by the use of the unmodified activated carbon, i.e. only 15% using 1.0 g/L. The effect of pH was examined at pH range 5–8 with constant adsorbent's dose (0.2 g/L). As it can be noticed, the maximum fluoride removal was observed at the alkaline pH values (58% for AC-Mg and 11% for AC).

Figure 4 presents the effect of F^- initial concentration in the range of 5-4800 mg/L. The adsorption capacity of AC-Mg was found to increase at pH value 8, from 0.15 to 17.12 mg/g for initial F^- concentration 5 and 4800 mg/L, respectively.

Another key factor in the adsorption process is the kinetic behavior of the adsorbents, thus, the effect of contact time from 5 to 1440 (24 h) min was then studied, keeping all other parameters constant. The results (Figure 4) showed that in order to increase the removal rate of F^- and the relative cost-effectiveness of adsorption, 4h (240 min) were selected as the optimal contact time for batch experiments.

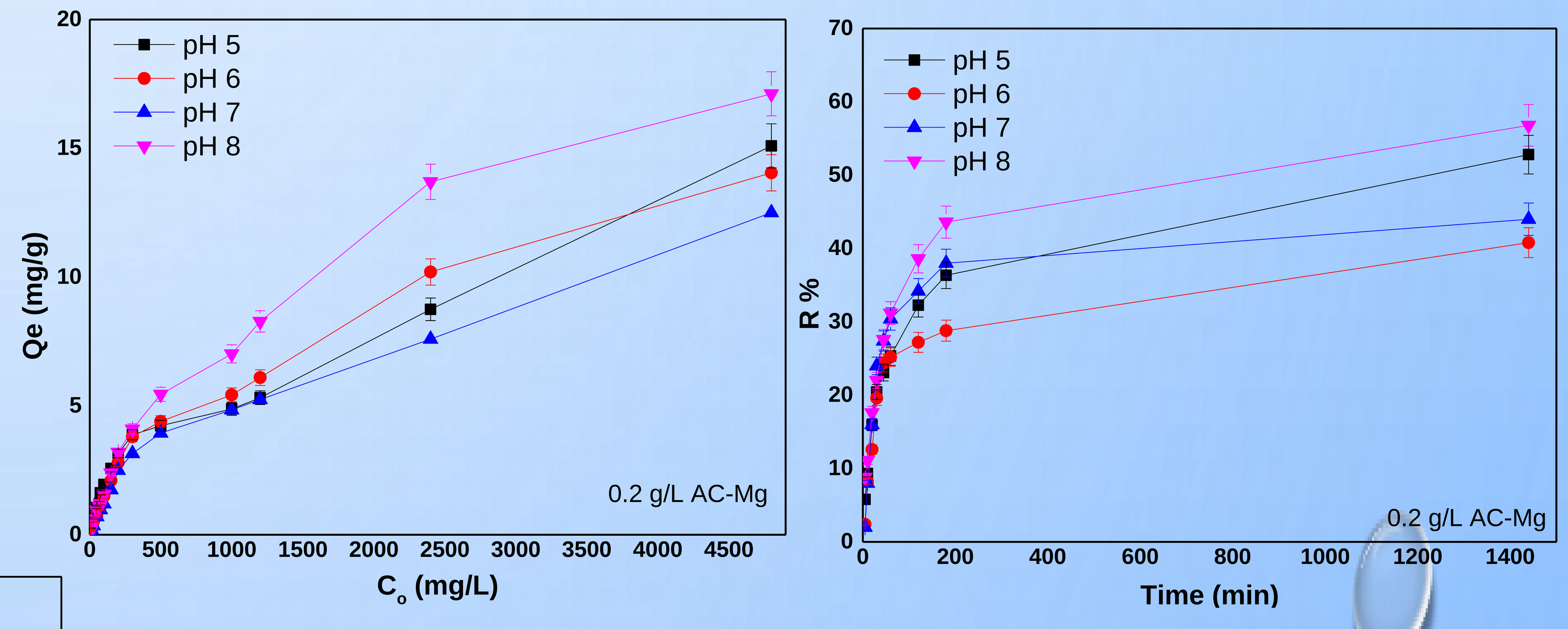

Figure 4: Effect of initial [F-] concentration, and contact time; dose 0.2 g/L, T=25±1 °C, contact time 24 h, in deionized water.

Parameters	AC-Mg
BET Surface area, S_{BET} (m^2/g)	42.5
Micropore volume, V_{micro} (cm^3/g)	0.779
Total pore volume, V_T (cm^3/g)	0.282

Table 1: Physical properties of AC-MgO

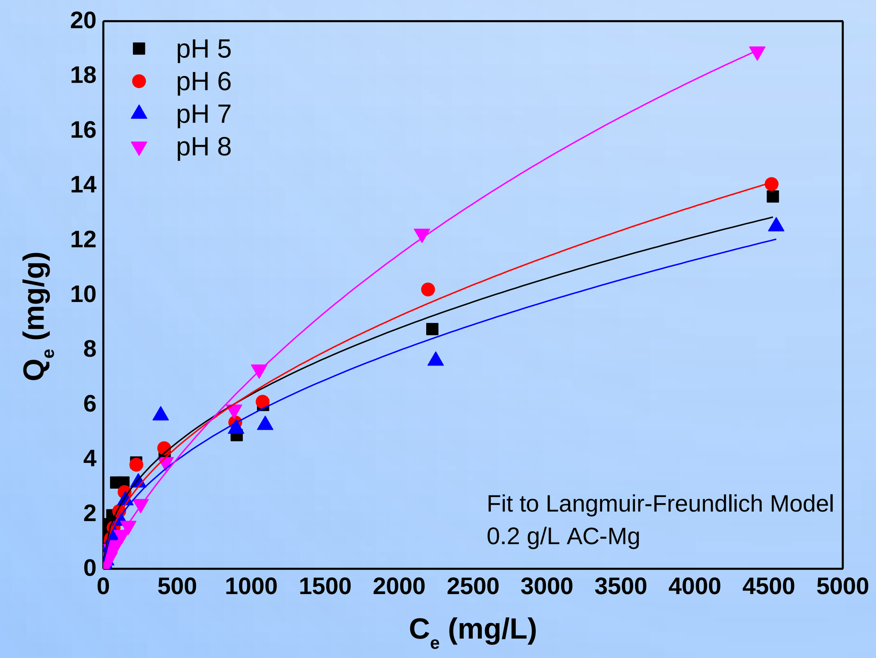

Figure 5: Langmuir-Freundlich isotherms model

In order to study the mechanism of adsorption and define the association between the concentration of F^- and the adsorption capacity of the adsorbent, the adsorption isotherms models were conducted.

As shown in Figure 5, The Langmuir-Freundlich isotherm model was found to better fit the adsorption, which describes the distribution of adsorption energy onto heterogeneous surfaces of the adsorbent. A relative high correlation coefficient (R^2 = 0.99), was found at pH 8 exhibiting a maximum adsorption capacity of 54.48 mg/g.

Conclusions

- The BET surface area, total pore volume, and micropore volume of AC-Mg were measured to be 42.5 m^2/g, 0.282 cm^3/g and 0.779 cm^3/g , respectively.
- The optimal dose of 0.2 g/L and pH 8 are selected, which leads to the residual fluoride concentration within the desired set limits.
- So as to increase the cost-effectiveness of adsorption, 4 h (240 min) of contact time were selected as optimal time for batch experiments.
- The maximum adsorption capacity was determined to be 54.48 mg/g at pH 8, according to Langmuir-Freundlich isotherm model.

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