# Supplementary Materials

*for*

## Performance and mass transfer of aqueous fluoride removal by magnetic alumina aerogel

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a) Five tables (Tables S1 – S5)

b) Five figures (Figs. S1 – S5)

**TABLES:**

**Table S1** The concentrations of the co-existing anions used in studying interferences of other species with $F^-$ adsorption by magnetic alumina aerogel.

| Co-existing anions | $HCO_3^-$ | $PO_4^{3-}$ | $SO_4^{2-}$ | $SiO_4^{4-}$ | $NO_3^-$ | $NO_2^-$ | $Cl^-$ |
|---|---|---|---|---|---|---|---|
| Concentrations (mg $L^{-1}$) | 100 | 5 | 300 | 9 | 30 | 30 | 300 |

**Table S2** BET surface areas and pore properties for alumina, magnetite and magnetic aerogel alumina samples

| Samples | BET surface area ($m^2$ $g^{-1}$) | Pore volume (mL $g^{-1}$) | Average BJH pore diameter (nm) |
|---|---|---|---|
| Alumina aerogel | 320.3 | 1.0 | 8.8 |
| Alumina aerogel (ground for 3 h) | 378.7 | 1.2 | 9.8 |
| Magnetite | 89.9 | 0.2 | 8.4 |
| Magnetite (ground for 3 h) | 92.0 | 0.2 | 8.4 |
| Magnetic aerogel | 215.1 | 0.4 | 6.1 |
| Magnetic aerogel (ground for 3 h) | 223.9 | 0.4 | 5.9 |
| Magnetic aerogel after adsorption of $F^-$ | 243.2 | 0.5 | 7.3 |
| Magnetic aerogel after adsorption of $F^-$ (ground for 3 h) | 268.7 | 0.4 | 6.0 |

**Table S3** Elemental atomic percentages of pristine aerogel alumina, magnetite and magnetic aerogel alumina samples and magnetic aerogel alumina samples before and after 3 h-grinding

| Samples | Al 2p (%) | Fe 2p (%) | F 1s (%) | O 1s (%) |
|---|---|---|---|---|
| Alumina aerogel | 34.9 | 0 | 0 | 65.1 |
| Alumina aerogel (ground for 3 h) | 35.1 | 0 | 0 | 64.9 |
| Magnetite | 0 | 62.3 | 0 | 37.7 |
| Magnetite (ground for 3 h) | 0 | 61.4 | 0 | 38.6 |
| Magnetic aerogel | 20.8 | 12.6 | 0 | 66.6 |
| Magnetic aerogel (ground for 3 h) | 20.6 | 12.9 | 0 | 66.5 |
| Magnetic aerogel after adsorption of $F^-$ | 23.7 | 8.5 | 3.1 | 64.7 |
| Magnetic aerogel after $F^-$ was adsorbed (ground for 3 h) | 24.1 | 7.7 | 2.5 | 65.6 |

**Table S4** The linear fitting parameters for $F^-$ adsorption kinetics on the MAA adsorbent

| Initial concentrations (mg $L^{-1}$) | Pseudo-second-order model | | |
|---|---|---|---|
| | $k_2$ (g $mg^{-1}$ $h^{-1}$) | $q_e$ (mg $g^{-1}$) | $R^2$ |
| 32.4 | 0.015 | 16.1 | 0.92 |
| 55.7 | 0.006 | 33.0 | 0.98 |

**Table S5** The water quality conditions of spiked well water used for $F^-$ remediation by MAA magnetic alumina aerogel

| pH | Total As (mg $L^{-1}$) | $Cl^-$ (mg $L^{-1}$) | $F^-$ (mg $L^{-1}$) | $Fe^{3+}$ (mg $L^{-1}$) | $SO_4^{2-}$ (mg $L^{-1}$) | $Na^+$ (mg $L^{-1}$) | $K^+$ (mg $L^{-1}$) | $Al^{3+}$ (mg $L^{-1}$) |
|---|---|---|---|---|---|---|---|---|

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 7.57 | 1.1 | 178 | 1.83 | 4.2 | 332 | 118 | 3 | 1.11 |

**FIGURES:**

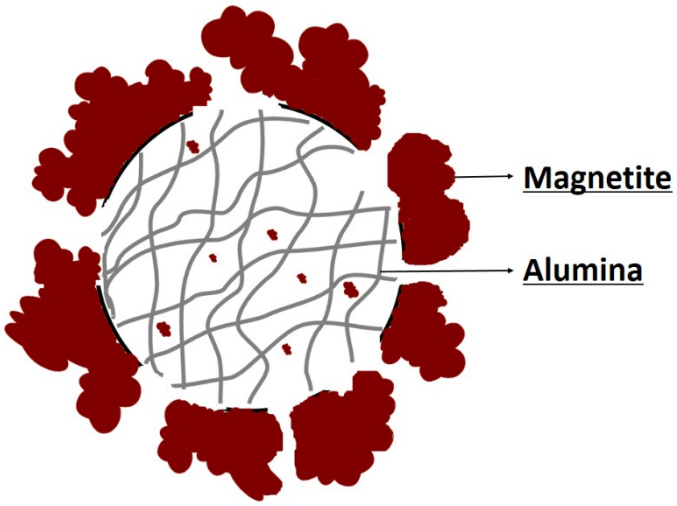


**Fig. S1** An illustration of the favored core-shell structure of the magnetic aerogel alumina adsorbent

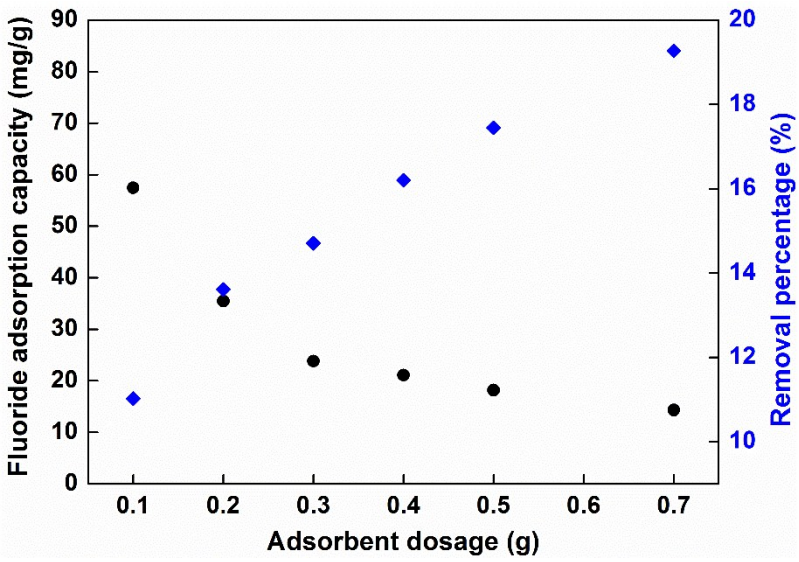


**Fig. S2** The effect of MAA dose on its $F^-$ removal performance. Initial $F^-$ concentrations, 50 mg $L^{-1}$; adsorbent dose, 0.1-0.7 g $L^{-1}$; total solution volumes, 100 mL; pH 5.0 ± 0.1; temperature, 25 ± 1 $^oC$, and shaking time, 24 h.

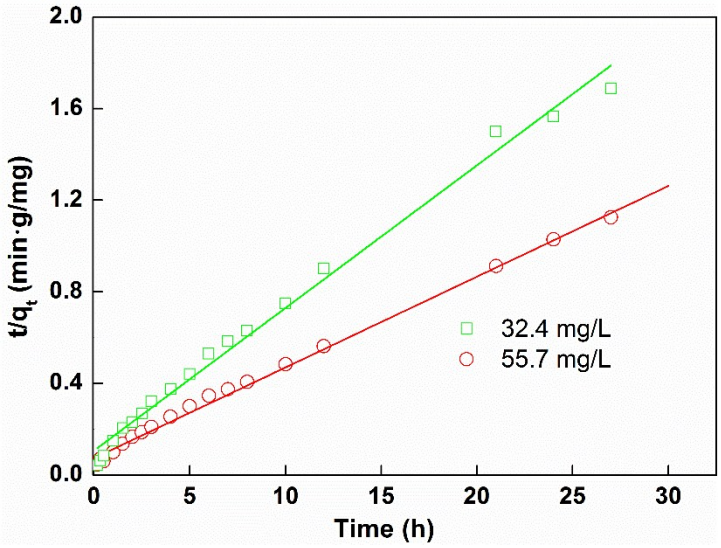


**Fig. S3** Kinetics of $F^-$ adsorption on the magnetic alumina aerogel adsorbent (MAA). The solid lines represent the linear pseudo-second order fittings. Initial $F^-$ concentrations, 32 mg $L^{-1}$ and 56 mg $L^-$; adsorbent dose, 0.3 g $L^{-1}$; total solution volumes, 1 L; pH 5.0 ± 1; temperature, 25 ± 1 °C.

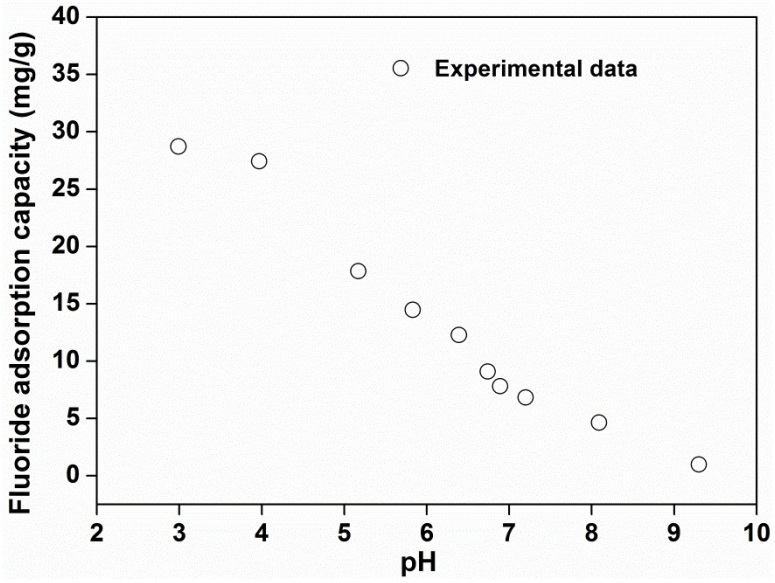


**Fig. S4** Effect of pH on $F^-$ adsorption onto the magnetic alumina aerogel adsorbent (MAA). Initial $F^-$ concentrations, 42.2 mg $L^{-1}$; adsorbent dose, 0.3 g $L^{-1}$; total solution volumes, 100 mL; pH range, 3 - 10; temperature, 25 ± 1 °C, and shaking time, 24 h.

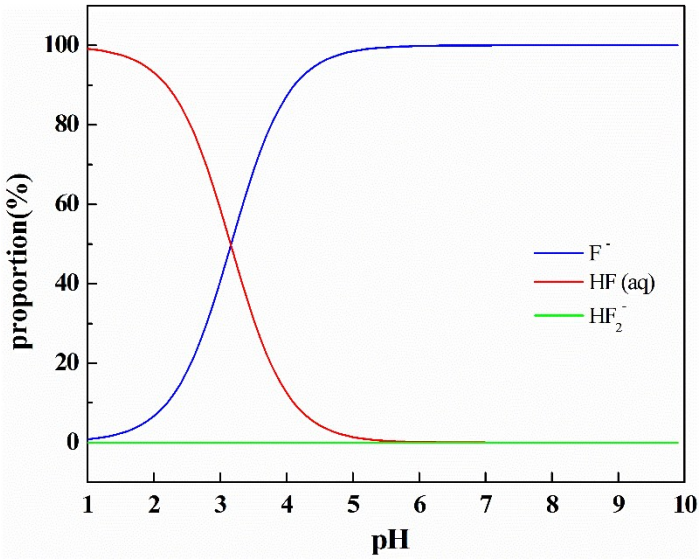


**Fig. S5** Speciation diagram for $F^-$ in water showing the relative proportions of each species. Values were calculated using Visual Minteq v 3.0 with initial $F^-$ = 10 mmol $L^{-1}$, temperature = 25 $^oC$ and ion strength was calculated at each point.

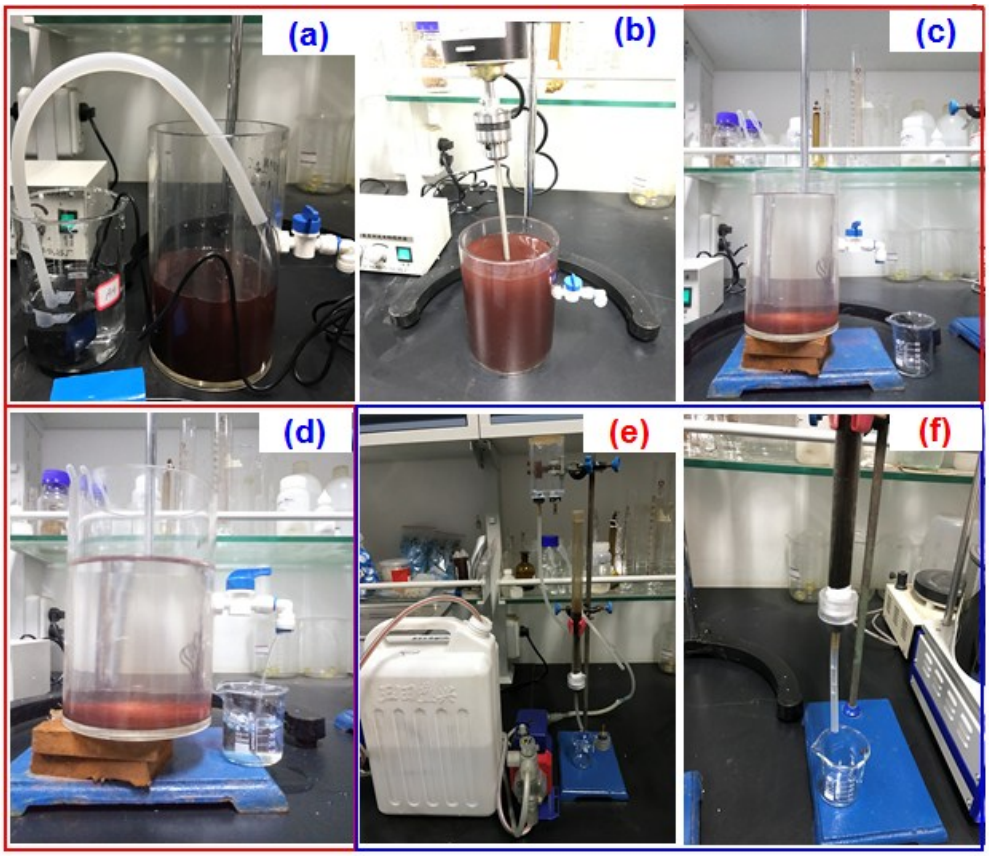


Fig. S6 The MAA adsorbent was demonstrated to be used in a magnetic separation-enhanced sequencing batch (MSES) mode including four steps, which are (1) influent fill (a), (2) adsorption (b), (3) magnetic separation (c) and (4) treated water withdraw (d), and in a packed bed mode with problems of fluent flow ((e) and (f)).