

Supporting Information for

Mn₂O₃ Hollow Spheres Synthesized Based on Ion-exchange Strategy from Amorphous Calcium Carbonate for Highly Efficient Trace-level Uranyl Extraction

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Experimental Sections

Chemicals. All chemicals are analytical grade. Calcium chloride (CaCl₂), anhydrous sodium carbonate (Na₂CO₃), magnesium chloride hexahydrate (MgCl₂), manganese sulfate (MnSO₄), potassium permanganate (KMnO₄) and ethanol (C₂H₅OH) are of analytical grade. All chemicals were purchased from Alfa Aesar and used without further purification. HCl solution (37 %) were purchased from National Medicines Corporation Ltd. of China. Distilled water (18.0 MΩ · cm⁻¹) in the experiments was prepared by using an ultra-pure purification system. Synthetic uranyl solution (8 mg/L) was prepared by dissolving UO₂(AC)₂ · 2H₂O into deionized water. Samples of salt lake water were retrieved from a salt lake in Qinghai Province, China.

Synthesis of Magnesium Amorphous Calcium Carbonate (Mg-ACC). The Mg-ACC was prepared by a typical procedure as follows: CaCl₂ (0.025 mol) and MgCl₂ (0.1 mol) were dissolved in 150 mL distilled water, and Na₂CO₃ (0.025 mol) was dissolved in another 150 mL distilled water. Then, the two solutions were fast mixed under stirring for 1 min at room temperature. After that, the mixed solution was centrifuged at 8000 rpm for 5 min. The white precipitate Mg:ACC was extracted, washed with distilled water and ethanol, and dried under vacuum condition at room temperature.

Phase Transformation of Mg-ACC to MnCO₃ and Mn₂O₃. MnSO₄ (0.01 mol) was dissolved in 50 mL water. Then as-prepared Mg:ACC (0.17 g) was added into MnSO₄ solution at room temperature, which was stirred for 0.5 h and formed the MnCO₃. After that, 50 mL KMnO₄ solution (0.03 M) was added into the above solution and kept for 5 min with stirring. Finally, the sample was centrifuged at 8000 rpm for 5 min. The precipitate was dissolved into the diluted HCl solution (3.7 %) under room temperature. The final sample was centrifuged at 8000 rpm for 5 min, washed with distilled water and ethanol, and dried under vacuum.

Adsorption Kinetics. Batch adsorption experiments were conducted by equilibrating 0.1-1 g/L Mn₂O₃ in synthetic uranyl solution (8 mg/L) or in the salt lake water sample. At pre-determined time intervals, a fraction of sample was centrifuged at the speed of 8000 rpm for 5 min. The concentration of uranyl in the supernatant was analyzed by an ultraviolet pulse trace uranium analyzer (WGJ-III).

Characterization.

XRD data were collected on a PANalyticalX'-Pert PRO diffractometer with Cu Kα radiation (40 kV, 40 mA) in the continuous scanning mode. The 2θ scanning range was from 5 to 85° in steps of 0.008° with a collection time of 50 s per step. The morphology and size of the solids were characterized with a JEOL- 6700F SEM and JEOL JEM2010 TEM coupled with an energy dispersive X-ray spectroscopy (Oxford) system. X-ray photoelectron spectrometer (XPS, PHI

5000 Versa Probe) was used in the sample surface analysis. The concentration of uranyl in the supernatant was analyzed by an ultraviolet pulse trace uranium analyzer (WGJ-III).

Table S1. Comparison of adsorption capacity of adsorbents listed in literatures (with the initial uranyl concentration around 10 mg/L).

Samples	Initial Uranyl concentration (mg/L)	Equilibrium Capacity (mg/g)	Ref.
Mn ₂ O ₃ -HHNs	8	63	This work
Mg(OH) ₂ Nanoflowers	10	<11	[1]
Layered Metal Sulfides	3.3	<4	[2]
Mesoporous Mg(OH) ₂	10	58	[3]
TiO ₂	2.4	~6	[4]
Quartz-Chlorite Mineral	1.2	~5	[5]
Polysulfide/Layered Double Hydroxide	22	~22	[6]

Table S2. Concentration of elements in Salt Lake water.

Element	g/L	Element	mg/L
K	241	Ni	1.7
Na	514	Mo	0.1
Mg	171	Zn	0.4
Ca	0.79	Cu	0.4
B	1.07	Fe	2.0
Li	0.33	U	0.26

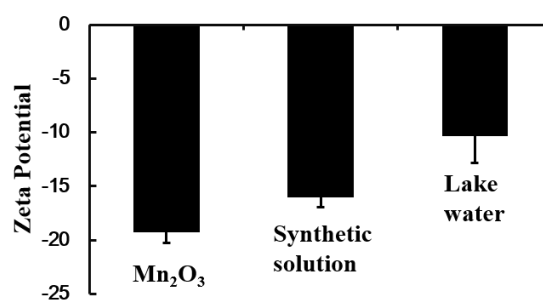


Figure S1. Zeta potential of primary Mn₂O₃-HHN; Mn₂O₃-HHNs performed in synthetic uranyl solution and a salt lake water, respectively.

References for Supporting Information

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