Supporting Information on

Core-Shell Hierarchical C@$Na_2Ti_3O_7$·$9H_2O$ Nanostructures for the Efficient Removal of Radionuclides

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Table SI-1.

Radionuclide	Cs^+ (mmol/g)	UO_2^{2+} (mmol/g)	Eu^{3+} (mmol/g)	pH	Initial concentrations	Dosage of adsorbent(g/ml)	Reference
CSTHNs	5.757	8.151	8.659	4.0	0.5-7.0mmol/L	0.5	This paper
titanate nanotubes	-	1.6	-	-	17mg/L-17g/L	1	1
$K_4Nb_6O_{17}$ nanolamina	1.25	-	-	6.0-7.0	-	1	2
$Na_2Ti_3O_7$ nanosheets	-	-	5.21	4.4-5.3	-	1.25	3
$Na_2Ti_3O_7$ nanofibers	-	-	2.24	4.4-5.3	-	1.25	3
$Na_2V_6O_{16}$ Nanofibers	2.15	-	-	6.0	-	1	4
titanate nanobelt membranes	0.48	-	-	-	0.17-6.85 mmol/L	1.25	5
multilayer titanate naotubes	-	1.40	-	5.0	10-200 mg/L	0.2	6

Table SI-2.[7,8]

Cations	Hydration energy(kJ/mol)	Absolute hardness	Radius(Å)	Hydrated radius(Å)
Na^+	-405	21.1	1.02	3.58
Cs^+	-276	9.1	1.67	3.29
UO_2^{2+}	-1614	16.3	0.73	4.96
Eu^{3+}	-864	8.9	1.12	4.52

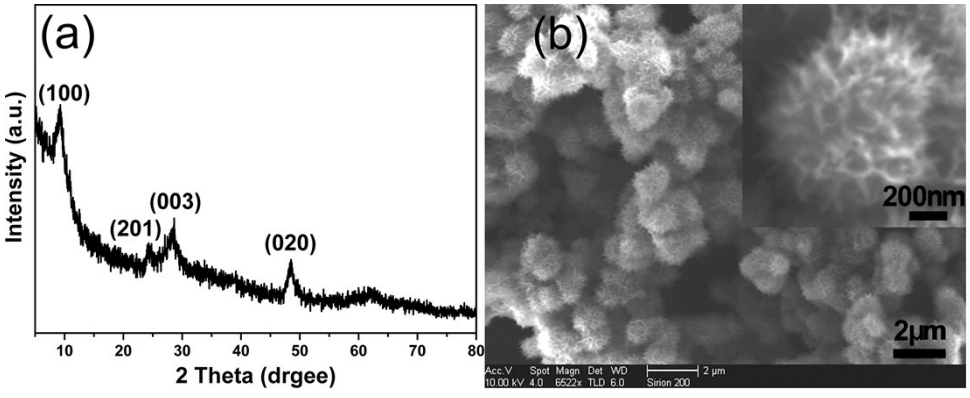

Figure SI-1.

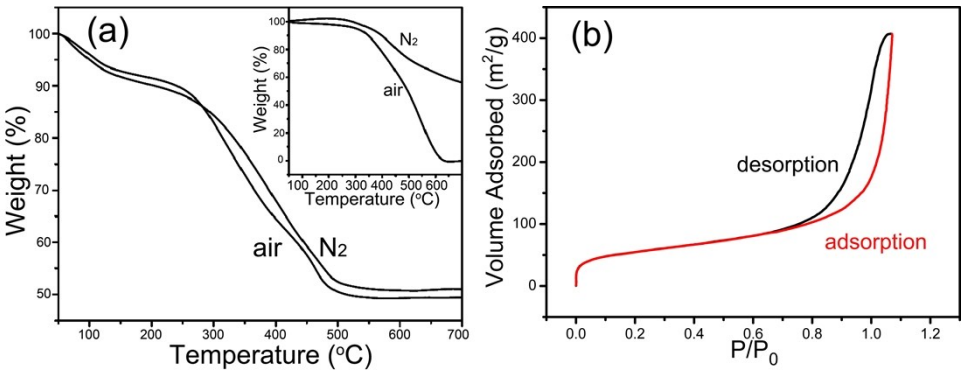

Figure SI-2.

EDS spectrum of the sodium titanate hierarchical nanostructure is shown in Figure SI-2a. Only C, O, Ti and Na elements are observed. It should be noted that the C element comes from the carbon film of the specimen holder and the carbon spheres. The product obtained by hydrothermal reaction usually contains lots of bonded water molecules, as confirmed by the thermo gravimetric analysis (TGA) (Figure SI-2b). The weight loss curve is different in different environment. In the air, the weight loss below 200 °C (approximately 8.105%) can be ascribed to the removal of surface adsorbed water molecules. As the annealing temperature is increased to 700 °C, the residual weight ratio is 49.268% and 50.803% in the air and N_2, respectively. The difference is 1.535%, which should be ascribed to the different behavior of the carbon core. Considering the inset of Figure SI-2b, we can conclude that the weight ratio of the carbon sphere is approximately 2.75%. This means that the part of weight loss that does not originate from the carbon spheres is approximately 39.7% (91.859% - 49.409% - 2.75% = 39.7%) when heating from 200 °C (91.859%) to 700 °C (49.409%) in the air. Combining the XRD result, we obtain X=9.2 (≈9). The complete chemical formula of the as prepared titanate should be $Na_2Ti_3O_7 \cdot 9H_2O$.

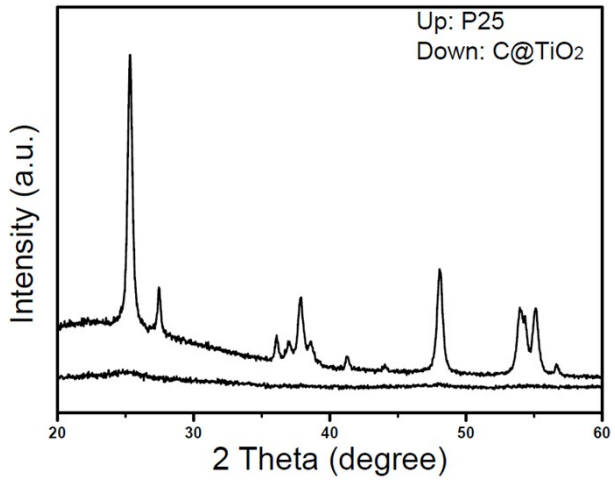

Figure SI-3.

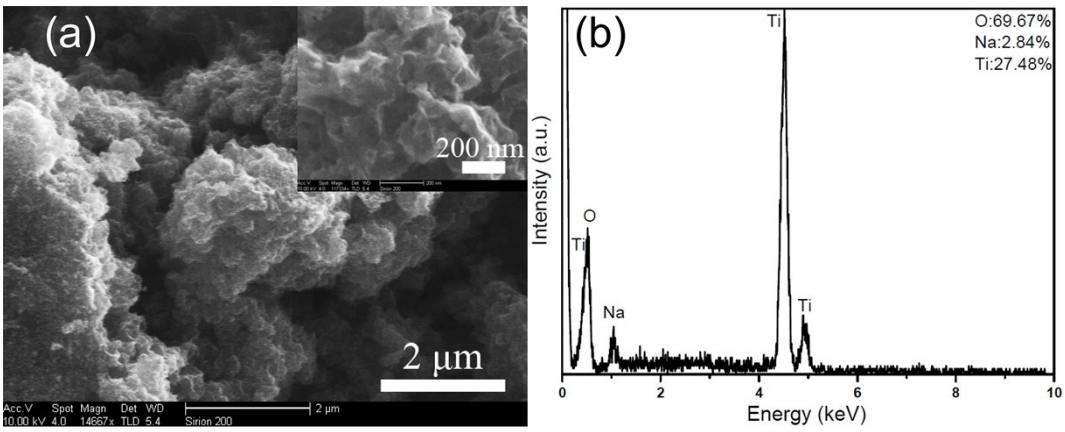

Figure SI-4.

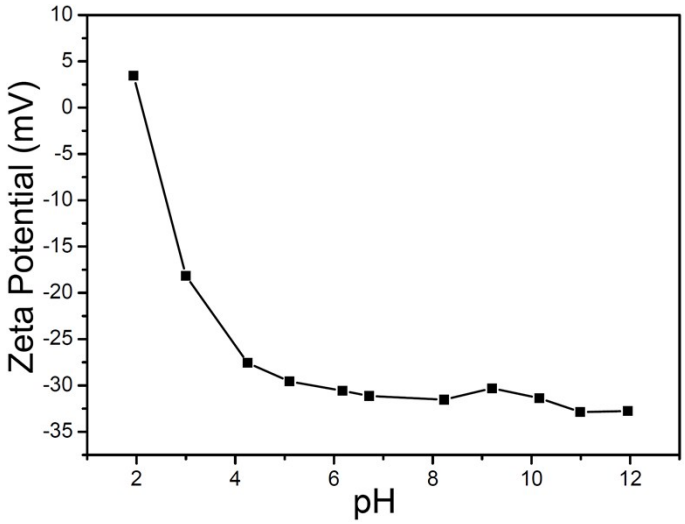

Figure SI-5

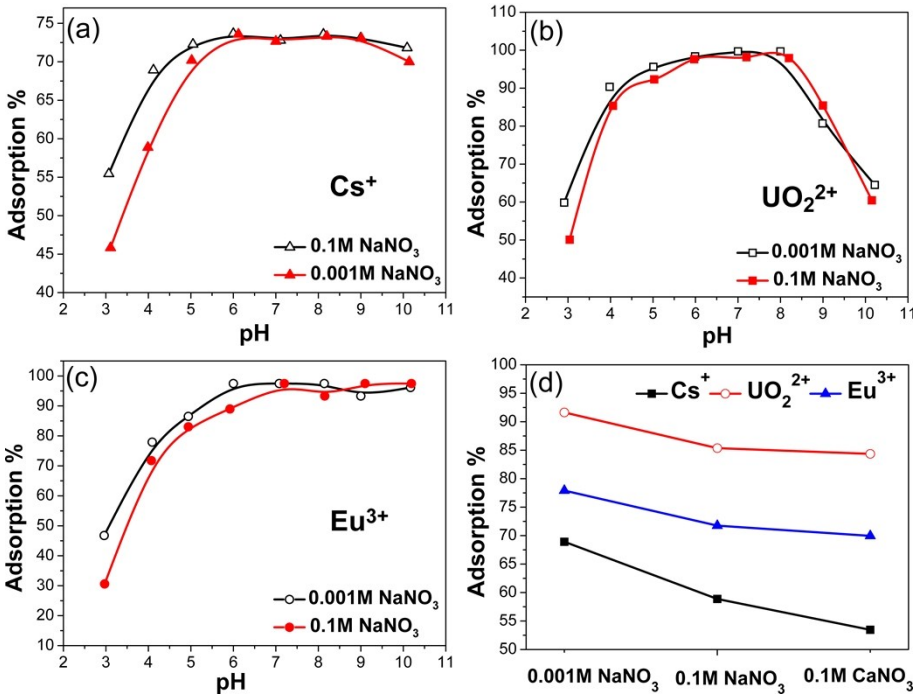

Figure SI-6.

The solution pH exerts an important influence on the adsorption of cations. Figure SI-6 a - c display the pH dependence of Cs^{+}, UO_2^{2+} and Eu^{3+} on CSTHNs. In the first pH range from 3.0-6.0, the adsorptions of cations are all increased as the pH value increases. A further increase of the pH to 10.0 resulted in the adsorption of Cs^{+} and Eu^{3+} to almost maintain a high level, which is due to the negative surface sites and positive metal ions for the formation of metal ion-ligand complexes. For U(VI), the adsorptions decreased at pH 8.0-10.0 due to an increase in the concentration of soluble negative U(VI)-carbonate complexes. The ionic-strength dependent adsorption indicates that ion exchange and inner-sphere complexation is the main adsorption mechanism at low pH. Figure SI-6 (d) presents the evolution of adsorption as the ion strength increased at pH = 4.0. It can be clearly observed that the adsorption of Cs^{+}, UO_2^{2+} and Eu^{3+} decreased as the ion strength increased, demonstrating inhibition of the competitive ions.

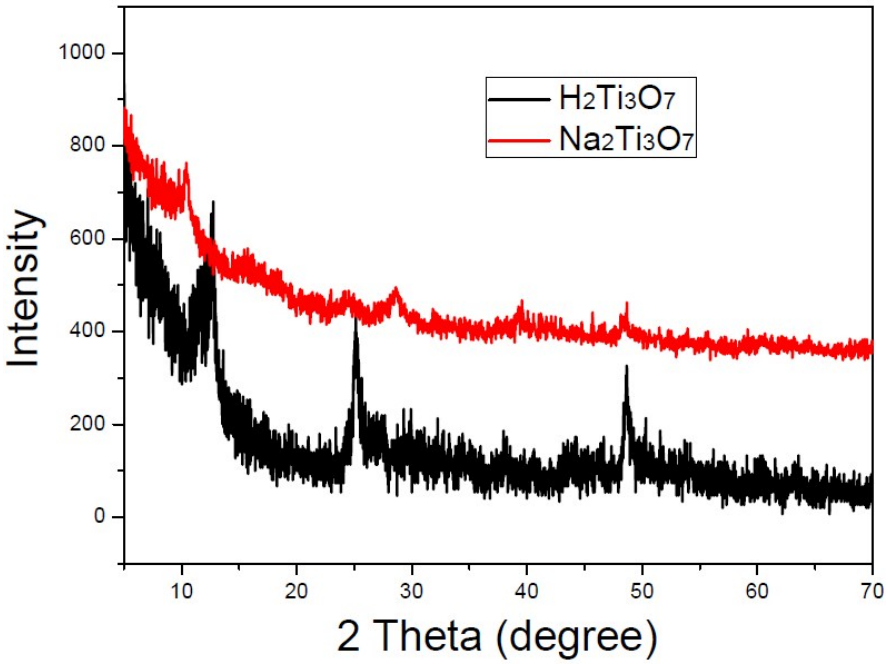

Figure SI-7.

From the previous studies, sodium titanate nanotubes are usually obtained under a relative low temperature and nanosheets under a relative high one (the critical temperature is about 150-170 ^{o}C[9]). We ascribed this to the high temperature effect on the lattice vibration. The temperature is higher, the lattice vibration becomes stronger. As the vibration energy is higher than that needed for bending a sheet to a tube, the sheet like structure will be made. To ensure the formation of nanosheet, 200 ^{o}C was selected in this experiment

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