Electronic Supplementary Information

Synthesis of low-silica CHA zeolite with exceptional selectivity for radioactive $^{137}Cs^+$

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Table S1 Low-silicon CHA zeolite synthetic methods

Synthesis formula	methods	Product Si/Al	Ref
SiO_2: 0.05 Al_2O_3: 0.2 NaOH: 0.2 $TMAda^+$: 10 H_2O	OSDA	2.8	[1]
5 SiO_2: Al_2O_3: 1.95 K_2O:1.5 NH_4F:175 H_2O	in fluoride media	2.5	[2]
5 SiO_2:Al_2O_3: 3 KOH:0.75 NH_4F:80 H_2O	in fluoride media	2.26	[3]
6.02 SiO_2: Al_2O_3: 8.23: Na_2O: 656 H_2O	add seeds	1.6	[4]
5.18 SiO_2: Al_2O_3: 0.17 Na_2O:2.0 K_2O: 224 H_2O	rotating crystal method	2.2	[5]
3.70 SiO_2: Al_2O_3: 0.095 Na_2O: 8.03 K_2O: 350 H_2O	rotating crystal method	1.58	[6]
16 SiO_2: 0.8 Al_2O_3: 9.5 Na_2O: 0.85 K_2O: 0.35 Cs_2O: 125 H_2O.	hydrothermal synthesis	2.0	[7]
0.28 $Al(OH)_3$: SiO_2: 0.66 KOH: 0.01 $Sr(NO_3)_2$: 20 H_2O	hydrothermal synthesis	2.06	[8]
3.99 SiO_2: Al_2O_3: 0.092 Na_2O: 1.067 K_2O: 171 H_2O	One-pot method	2.06	This work

Table S2 Removal performance for Cs^+ of Na-CHA zeolite and other adsorbents

Materials	Initial concentration of Cs^+	Competing ions	K_d (mL/g)	Ref.
KATS-2	17.59 ppm	Na^+: 9669.63 ppm; K^+: 367.55 ppm; Ca^{2+}: 331.62 ppm; Mg^{2+}: 1109.93 ppm	3.28×10^3	9
K-RWY	1 ppm	Na^+: 40 ppm; K^+: 5 ppm; Ca^{2+}: 25 ppm; Mg^{2+}: 5 ppm	4.9×10^4	10
K-RWY	1 ppm	Na^+: 9000 ppm; K^+: 320 ppm; Ca^{2+}: 370 ppm; Mg^{2+}: 1100 ppm	$\sim1.17\times10^3$	10
NaMT1	1.58 ppm	Na^+: 145 ppm; K^+: 230 ppm; Ca^{2+}: 25 ppm;	1.52×10^3	11
K-MPS-1	31.42 ppm	Na^+: 20.41 ppm; Rb^+: 25.43 ppm; Ca^{2+}: 9.70 ppm; Mg^{2+}: 0.29 ppm;	1.03×10^3	12
FJSM-SnS	2.056 ppm	Na^+: 77 ppm; K^+: 6 ppm; Ca^{2+}: 8 ppm; Mg^{2+}: 8 ppm	215	13
MIL-101-SO_3H	229.50 ppm	Na^+: 2371 ppm; K^+: 3744 ppm;	203.46	14
10S-CHA	18780 Bq/L 5.87 ppt	Na^+: 10000 ppm; K^+: 500 ppm; Ca^{2+}: 500 ppm; Mg^{2+}: 1500 ppm	1.85×10^4	15
Na-CHA	**1587.22 Bq/L 0.496 ppt**	**real nuclear wastewater**	**2.17×10^5**	**This work**

Table S3 The maximum adsorption capacity (q_m) for Cs^+ of various adsorbents.

Materials	q_m (mg/g)	Ref.
KMS-2	531.7	16
hf-TiFC	454.54	17
MIL-101-SO_3H	453	14
FJSM-SnS	408.91	13
KATS-2	358	9
KMS-1/r-GO	338.18	18
GP-CuFC	328.28	19
K-MPS-1	337.5	12
Zinc ferrocyanide	372	20
K-RWY	310	10
NaMT1	290.7	11
$Na_2V_6O_{16}\bullet 3H_2O$	285.735	21
KTS-3	280	22
Sulfonated Hyper-cross-linked polymer	273	23
Commercial CST (UOP)	266	24
KMS-1	226	25
Zeolite A	207.47	26
FJSM-InMOF	198.63	27
$K_4Nb_6O_7$	166.125	28
FJSM-GAS-1	164	29
Cu-BTC/KNiFC	153	30
Hollow PB nanoparticles (190 nm)	131	31
Ca-Phl	91.7	32
AMP–PAN	81	33
Natural clinoptilolite	168.9	
Natural chabazite	275.3	34
Natural mordenite	256.7	
Na-mordenite (MOR)	222.1	35
Commercial NaX	308	
Na-CHA	**442.48**	**This work**

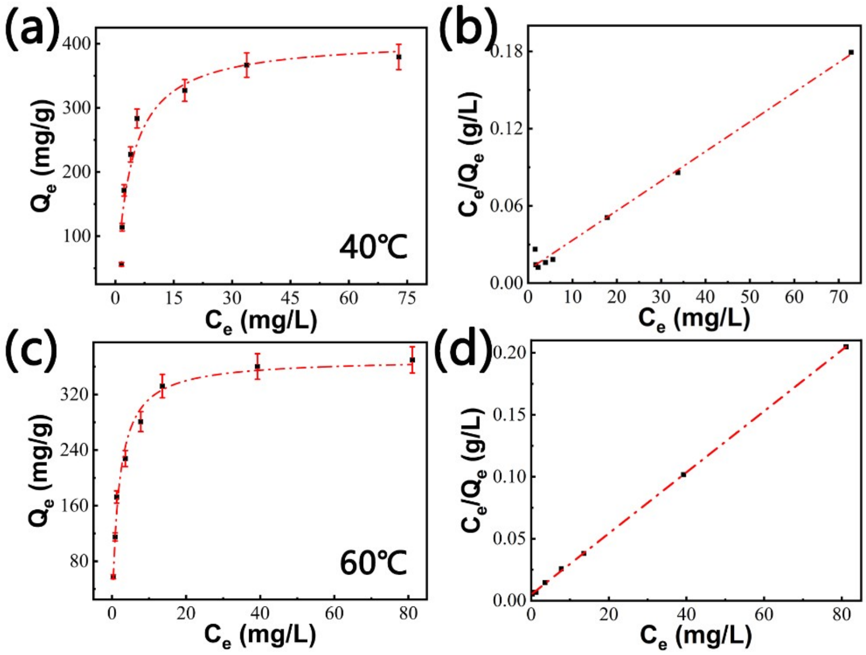

Fig. S1 (a) (c)Adsorption isotherms of Cs^+ adsorption in Na-CHA zeolite at 40 and 60 °C respectively, (b) (d) Linear fitting with the Langmuir model of Cs^+ adsorption in Na-CHA zeolite at 40 and 60 °C respectively.

Table.S4 Langmuir isotherm parameters for Cs^+ adsorption in Na-CHA zeolite at 40 and 60 °C.

Langmuir isotherm parameters			Langmuir isotherm parameters		
40 °C			60 °C		
R^2	Q_m mg/g	b L/mg	R^2	Q_m mg/g	b L/mg
0.991	434.78	0.223	0.999	406.50	0.491

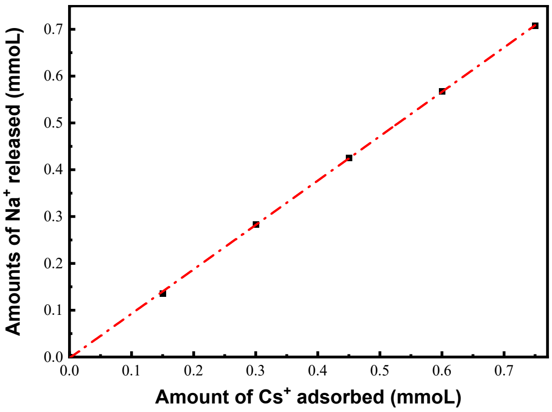

Fig. S2 Relationship between the adsorption amount of cesium and the release amount of sodium

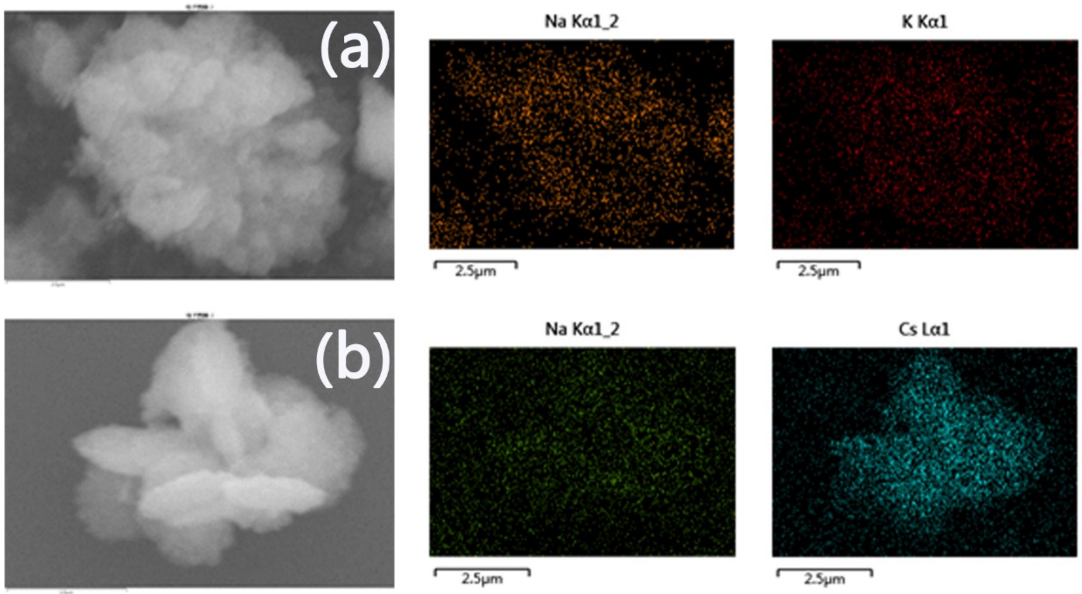

Fig. S3 (a) SEM elemental mapping images of Na-CHA zeolite, and (b) Cs-loaded Na-CHA zeolite

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