SAND2013-10795C

Sandia Materials for the Capture, Storage or Purification of Cs, Sr and Fission Gases

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Areva - SNL Visit
December 19, 2013

Separations and waste forms research is currently funded under the DOE/NE-FCR&D Separations and Waste Form Campaign.

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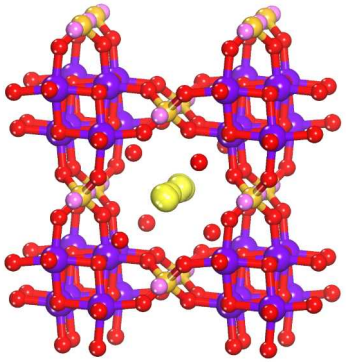
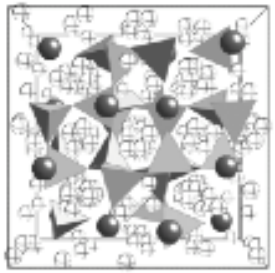
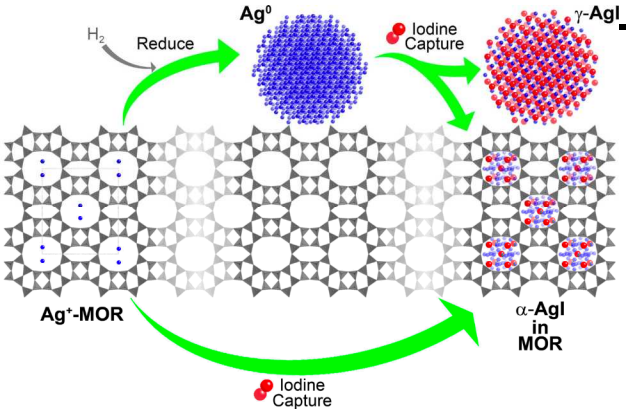
Nenoff, et.al., Portfolio of NE related Technologies: Novel Separations and Waste Forms



CST, Cs^+ removal from water to Pollucite Waste Form



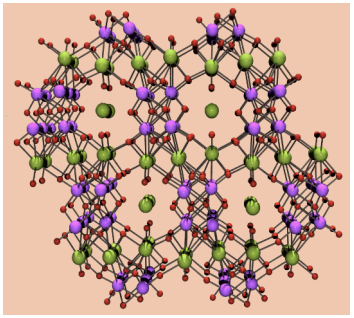
R&D100 1996
JACerS, **2009**, *92(9), 2144*
JACerS, **2011**, *94(9), 3053*
Solvent Extr. & Ion Exch, **2012,** *30*, 33

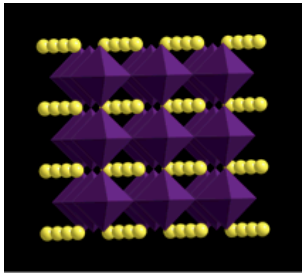


Ag-MOR $I_2(g)$ capture & mechanisms

JACS, **2010**, *132*(26), 8897
J Phys Chem Letters, **2011**, *2*, 2742

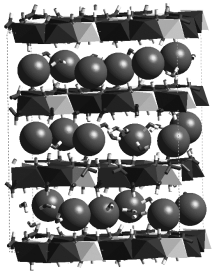
Fundamental Research to Applied to Commercial Products
Design the Separation Material To Develop the Waste Form

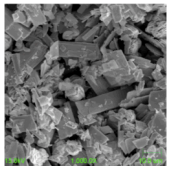




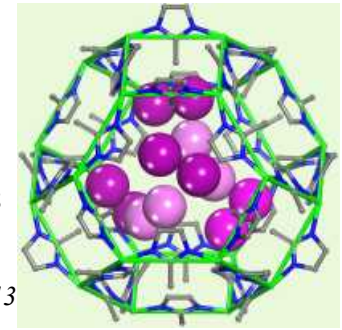
Sr^{2+} getter, 1-step to Perovksite waste form
JACS, **2002**,*124(3),* 1704

Applied Geochem, **2011**, *26*, 57

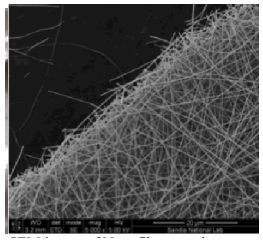




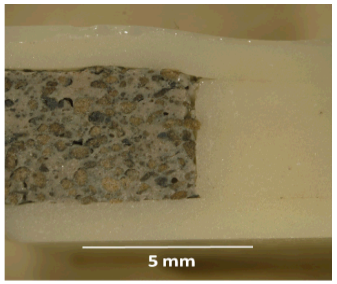
In-situ Iodine removal from water



I_2/MOF, Isolation to Waste Form
JACS, **2011**,*133(32),*12398
Ind.Eng.Chem.Res, **2012**, *51*(2),614
Provisional Patent Oct 2013



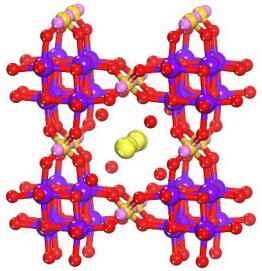
Nanoporous Nanofibers Volatile Gas Removal
US Patent Application, 2011



Universal Core-Shell Glass Waste Form Iodine & Getter
JACerS, **2011**, *94*(8), 2412
US Patent 8,262,950

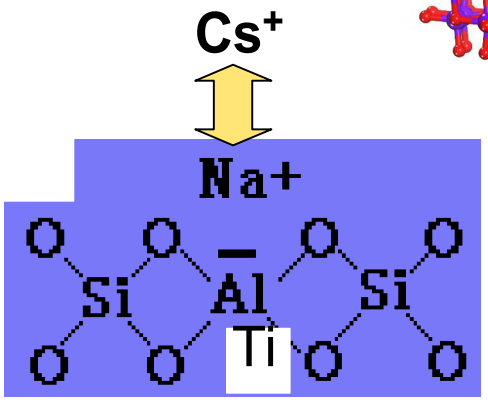
Removal of Rad-Cs^+ from Pooled Seawater (heat treat to Pollucite WF or add into SNL GCM)

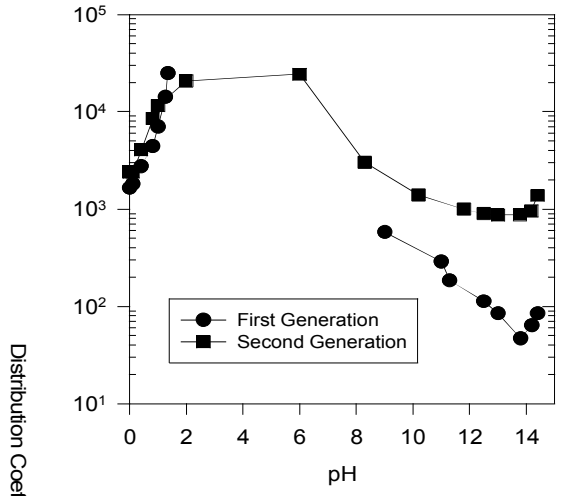
Crystalline Silicotitanates (CSTs)
With exceptional Cs^+ selectivity, and mechanical, thermal and radiological stability

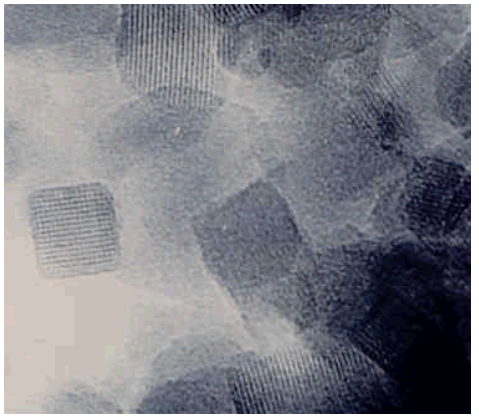


CST properties:

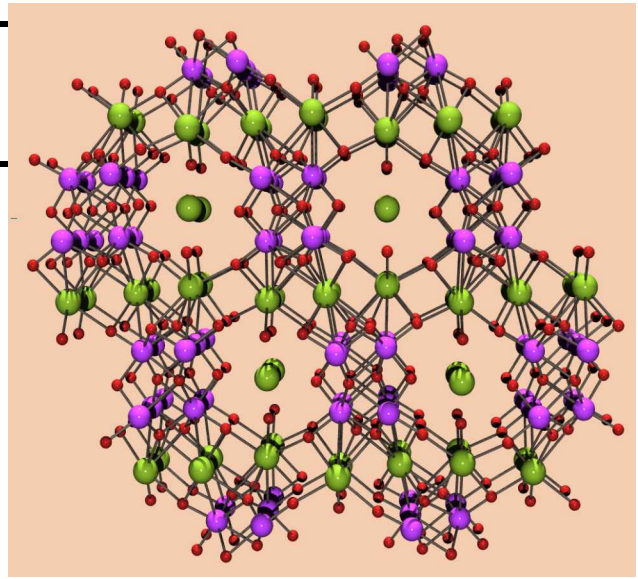
- Removes 1 part Cs per 100,000 parts Na
- Stable over entire pH range
- Stable in extreme environments
- *Commercially available as IONSIV™ IE-910 & IE-911*







Sandia Octahedral Molecular Sieves (*SOMS*) Selectivity (heat treat to perovskite WF)



	metal ion	Ti-niobate phase Nb:Ti = 1:4	Zr-niobate phase Nb:Zr = 1:6
Radionuclides	Ba^{2+}	> 99,800 *	> 99,800 *
	Sr^{2+}	> 99,800 *	> 99,800 *
High concentration in natural systems	Ca^{2+}	2,300	2,657
	Mg^{2+}	226	458
Industrial Waste Metals	Pb^{2+}	66,467	22,022
	Cr^{3+}	> 99,800*	> 99,800 *
	Co^{2+}	> 99,800 *	> 99,800 *
	Ni^{2+}	> 99,800 *	> 99,800 *
	Zn^{2+}	> 99,800 *	> 99,800 *
	Cd^{2+}	> 99,800 *	> 99,800 *
	Cs^{+}	150	169
	K^{+}	95	153
	Li^{+}	8	35

Instead use CST: high selectivity

$K_d = [M]_{ie} / [M]_{sol}$

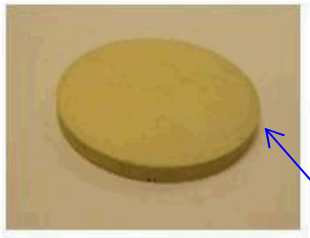
** 0.1 ppm detection limit*

K_d obtained from 50 ppm metal ion solutions (no competing ions)

Long Term Storage of I_2 Capture Materials: Waste Forms

Homogenous Glass GCM: for
AgI or AgI-MOR off-gas capture and storage

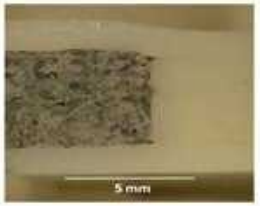
50 wt% AgI/50 wt% Glass
500°C for 3 hr



50 wt% AgI/50 wt% Glass,
500°C for 3 hr

Core-Shell GCM Glass Waste Forms

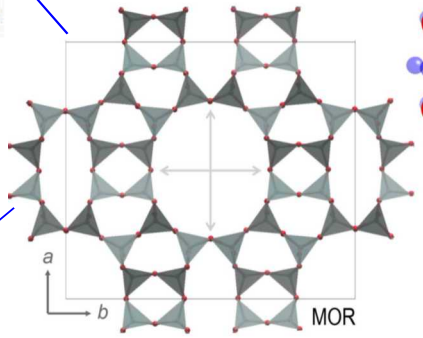
Glass shell, AgI/glass core,
75/25

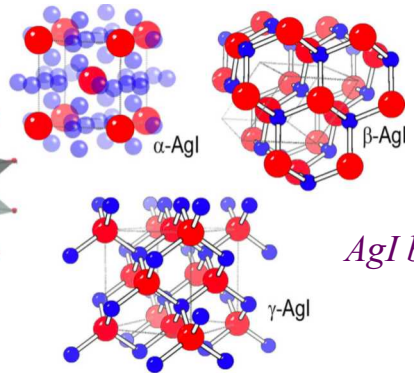


Glass shell,
AgI-MOR/Ag/Glass core 80/20/5

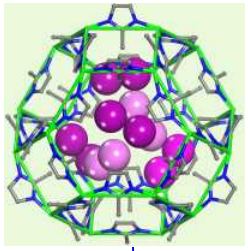
JACerS, **2011**, *94*(8), 2412

All These waste forms have been made with the SNL Low Temperature Sintering Oxide Glass
No HIP-ping needed: Sintering 550°C
Accepting of all types of rad-loaded getters:
zeolites (AgI-MOR), Metals (AgI), MOFs (I_2-MOF), and Cs-CSTs
Durability studies: equal to better performance than basalt glass



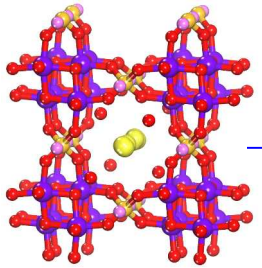


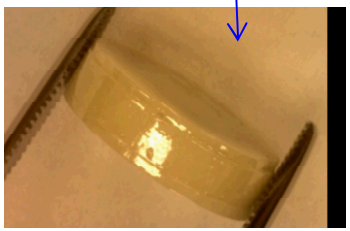
AgI bp 556°C



I_2/MOF, Isolation to Waste Form
JACS, **2011**,*133(32)*,12398
Ind. Eng. Chem. Res (Invited Article)
2012, *51*(2), *614*

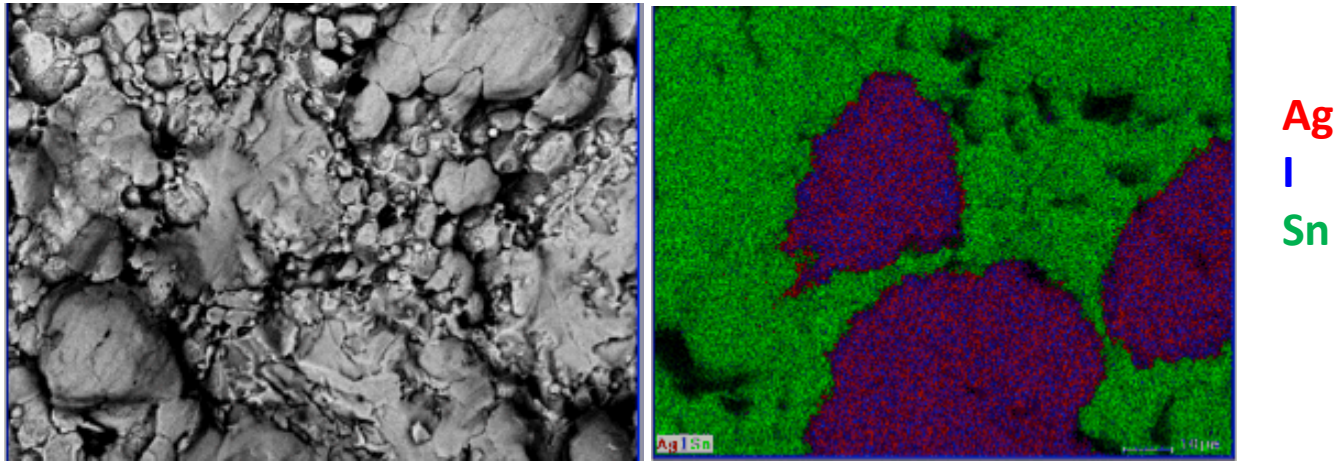
Cs-CST in Low Temp Glass Waste Form, No Cs Loss in Sintering





Metal Matrix Waste Form

- Highly attractive to encapsulate iodine-loaded zeolites and MOFs due to low temperature processability.
- This methodology prevents the use of expensive Ag for both the getter material and the waste form.
- Potential to incorporate a very high capacity of iodine into a final waste form.
- Waste form durability testing procedures need to be established.



SEM-EDS image of Sn with 25% AgI waste form

Nenoff, et. al., Patents Awarded and Pending Related to Nuclear Fuel and Legacy Waste

U.S. PATENTS
Awarded/Filed
- Cesium Silicotitanates for Ion Exchange and Waste Storage, 6,482,380, November 19, 2002.
- Niobate-based octahedral molecular sieves, 6,596,254, July 22, 2003.
- Niobate-based octahedral molecular sieves, 7,122,164, October 17, 2006.
- Low Sintering Temperature Glass Waste Form for Sequestering Radioactive Iodine, 8,262,950, September 11, 2012
- Mixed-Layered Bismuth-Oxygen-Iodine Materials for Capture and Waste Disposal of Radioactive Iodine, 8,383,021, February 2013

Applications
- An Inexpensive Method for bulk synthesis and Commercial Scale up of SOMS: Sandia Octahedral Molecular Sieves (2006)
- Pelletized Molecular Sieves and Method of Making Pelletized Molecular Sieves (Nonprovisional Patent Application, SD11971), 11/07/12.
- Metal Matrix Waste Forms for Fission Products. (Aug 2013)

Working with Dan Jenkins and Brooke Garcia for Tech Transfer Possibilities in (1) waste forms and (2) engineered/ pelletized getter materials, along with others