SAND2013-7202P

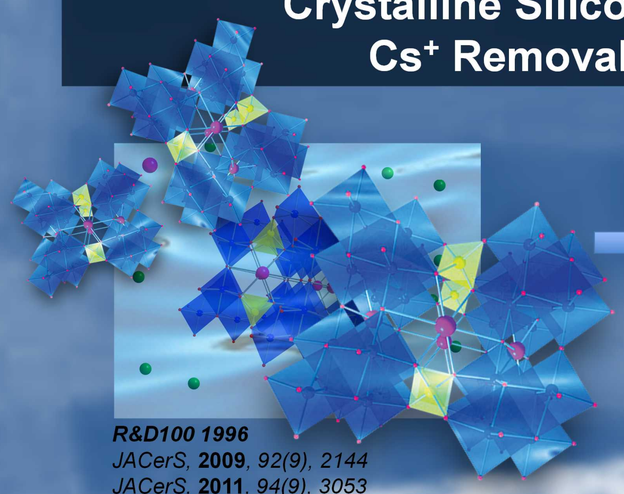
Exceptional service in the national interest

Sandia National Laboratories

Nanoporous Materials and Sensors

The ***Nanoscale Sciences Department at Sandia National Laboratories*** is implementing complementary strategies to effectively address significant challenging needs in various areas: hazardous waste remediation, water treatment, sensing/detection, gas storage/separations, catalysis, biomedicine. Emphasis is placed on the rational design and synthesis of novel functional nanoporous materials and sensors, with the focus on the fundamental understanding of the structure-property relationship at the nanoscale. Ultimately, the goal is to transition this knowledge to applied technologies. We have successfully demonstrated the effectiveness of this synergistic approach by partnership with industry for the development of commercial products.

Crystalline Silicotitanates (CSTs) Cs^+ Removal from Water



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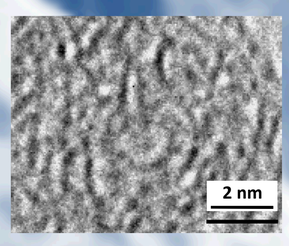
R&D100 1996
JACerS, **2009**, *92(9), 2144*
JACerS, **2011**, *94(9), 3053*
Solvent Extr. & Ion Exch, **2012**, *30*, 33

US Patents 6,479,427 (2000) and 6,110,378 (2002), 6,482,380, (2002)

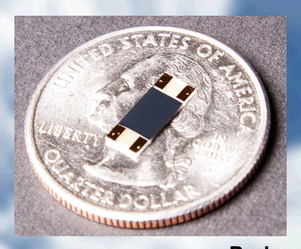
- CSTs are inorganic, molecularly engineered ion exchangers with exceptional Cs^+ selectivity, and mechanical, thermal and radiological stability
- Extended portfolio of novel materials and waste forms technologies developed at SNL:
  - Sr^{2+} getter, one-step to perovksite waste form by niobate-based octahedral molecular sieves (US Patent 7,122,164, 2006)
  - In-situ iodine removal from water with mixed-layered bismuth oxygen-iodine materials (US Patent 8,383,021, 2013)
  - Universal Core-Shell Low sintering temperature glass waste forms for sequestering radioactive iodine (US Patent 8,262,950, 2012)

Sandia National Laboratories technology has been used to remove radioactive material from more than 43 million gallons of contaminated wastewater at Japan's damaged Fukushima Daiichi nuclear power plant.

Nanoporous Carbon (NPC) Coated SAW Device for Sub-Nanogram Detection of Hazardous Chemicals in Water



US Patent application (2010)



Parker THM Analyzer, Parker Hannifin Corporation

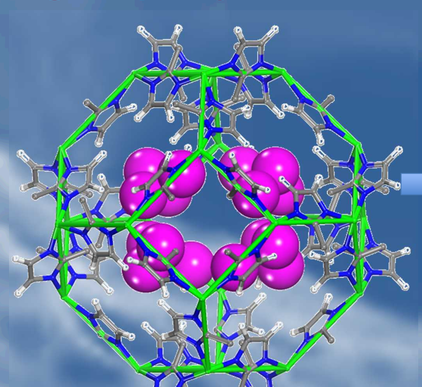
- Low density NPC provides nanopores and intercalation pathways for chemical sorption and detection
- NPC was used as a sorbent coating on surface-acoustic wave (SAW) detectors for the Parker THM (trihalomethanes) Analyzer, a tabletop tool which allows water system operators easily measure potentially dangerous disinfection by-products (DBPs) in less than 30 minute at their own facilities
- The technology can be readily modified as a vapor-phase sensor to detect volatile organic compounds, toxic industrial chemicals, chemical warfare agents, and explosives-related compounds for first responders

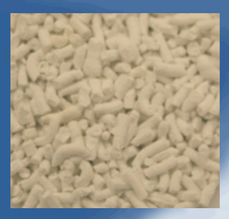
Sandia is using its research to keep public drinking water supplies safe, while simultaneously lowering the costs of chemical treatments

Fundamental Research to Applied Technologies to Commercial Products

Metal-Organic Frameworks (MOFs)

High Capacity Volatile Gas Capture

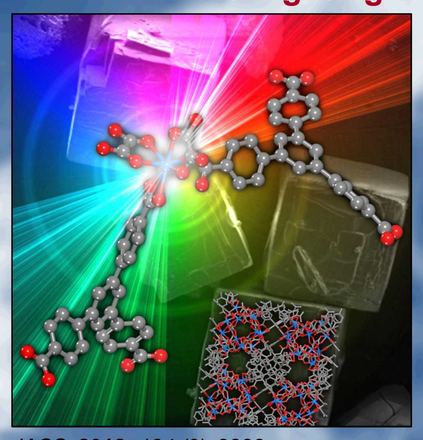




US Patent application #PCT/US12/64698 (2012)

JACS, **2011**,*133(32)*,12398.
JACS, **2011**, *133*(46), 18583.
Ind.Eng.Chem.Res, **2012**, *51*(2),614 .

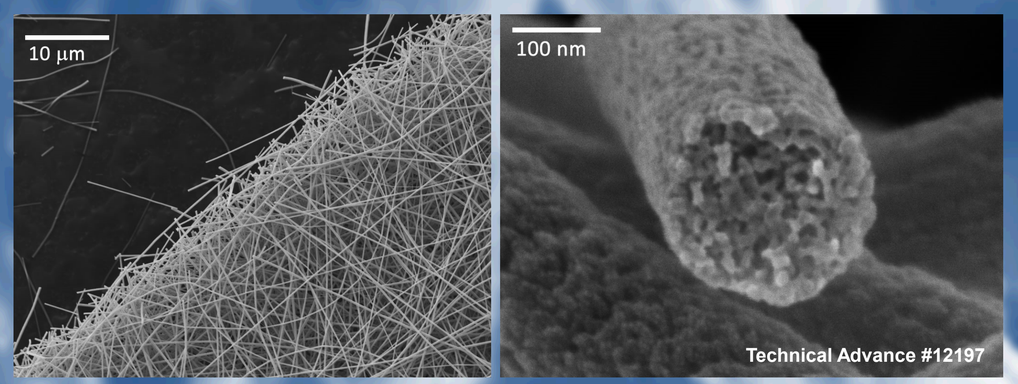
Single Component Phosphors for Solid State Lighting



JACS, **2012**, *134 (9)*, 3983.
US Patent application (2013)

- MOFs are crystalline hybrid materials having the highest reported surface areas to date. They are *highly tunable* and *highly modular*, having intricate pore sizes and volumes, amenable for modifications, and supporting diverse chemistry
- Demonstrated very high I_2 sorption capacity; additionally, contamination is eliminated by capture and temporary storage via pressure-induced amorphization
- Recently developed MOFs platform with ranging color properties from white to red by systematic metal-ligand alteration for enhanced photoluminescence properties
- Ongoing and proposed MOFs projects in our group include: efficient materials to separate oxygen from air for oxyfuel combustion, phosphors for solid-state lighting, non-linear optics, and biomedicine related applications

Ultra-Porous Nanofibers: One Step Nuclear Waste Separation and Sequestration Scaffolds



Scanning electron microscopy (SEM) images of the TiO_2 nanofibers show the typical achievable porosities: (a) inter-fiber microporosity, (b) intra-fiber nanoporosity.

- Ceramic nanofibers with intrinsically high surfaces and high flux characteristics are produced through a modified sol-gel technique in conjunction with coaxial electrospinning, with fiber diameters of a few hundred nanometers and internal pore sizes ranging from 2~10 nm.
- Adapted electrospinning with engineering versatility for large-scale fabrication of ultra-fine long nanofibers
- Controllable pore size and pore distribution by altering the ratio of the precursor components
- Amenable to support surface chemistry modifications with various functional groups to capture target compounds in applications of nuclear waste sequestration, sensors, ultrafiltration, etc.
- Cost effective and readily scalable approach suitable for commercialization

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U.S. DEPARTMENT OF ENERGY
National Nuclear Security Administration

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