Materials for the Immobilization of High Level Radioactive Waste

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MSE 395-0: Materials for Energy Efficient Technology

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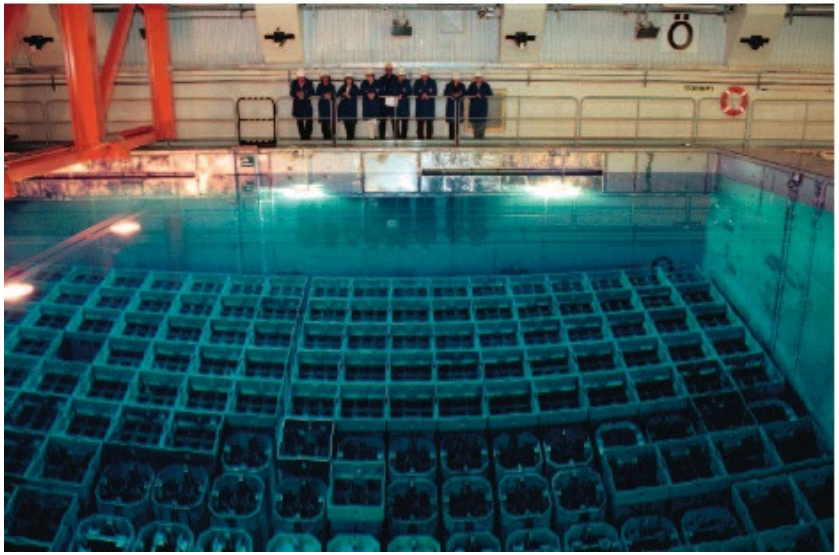
- Waste, or energy resource?
  - "We need another Manhattan Project to figure out what to do with all the spent fuel."
    - Senator Tom Carper, Chair of Senate Subcommittee on Clean Air and Nuclear Safety
  - Current operating U.S. reactors can produce 105,000 metric tons of high-level waste in operating lifetimes (2 times area of Central Park)

Problem

- 3000 new plants
- No good long-term solutions for HLW
- Idea: Geological Repository

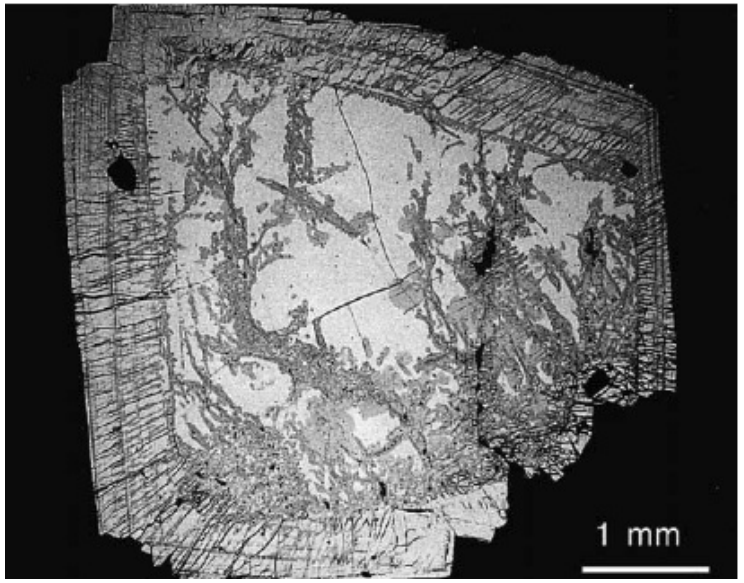


- "The Yucca Mountain program will be scaled back to those costs necessary to answer inquiries from the Nuclear Regulatory Commission (NRC), while the administration devises a new strategy toward nuclear waste disposal."

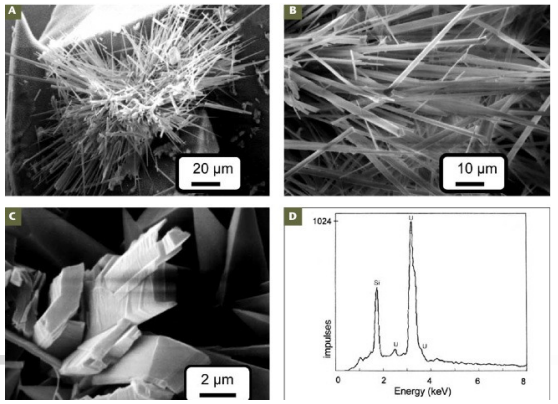
  - Department of Energy, Feb. 2009

Current Research Challenges

- Inability to incorporate radionuclides
- Volatile radionuclides
- Short-fission and long-fission
- Radiation damage



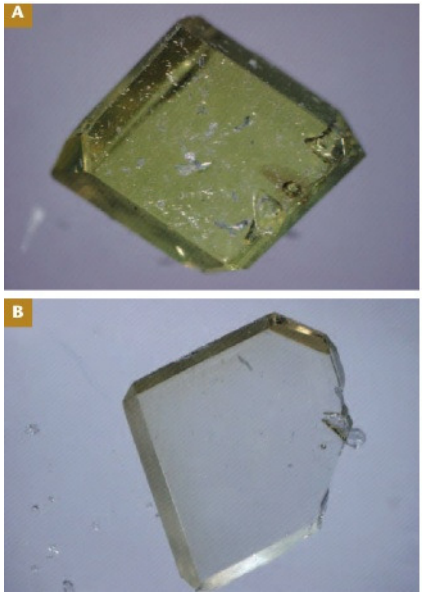
Borosilicate Glass



- Incorporation into specific structural sites
- Currently the industrial standard
- Can accommodate many compositions
- Easy to scale up
- Stable against thermal, radiative, and chemical perturbations
- Demonstrated technology with 40 years of processing experience
- However, high T processing and some radionuclides have low solubility

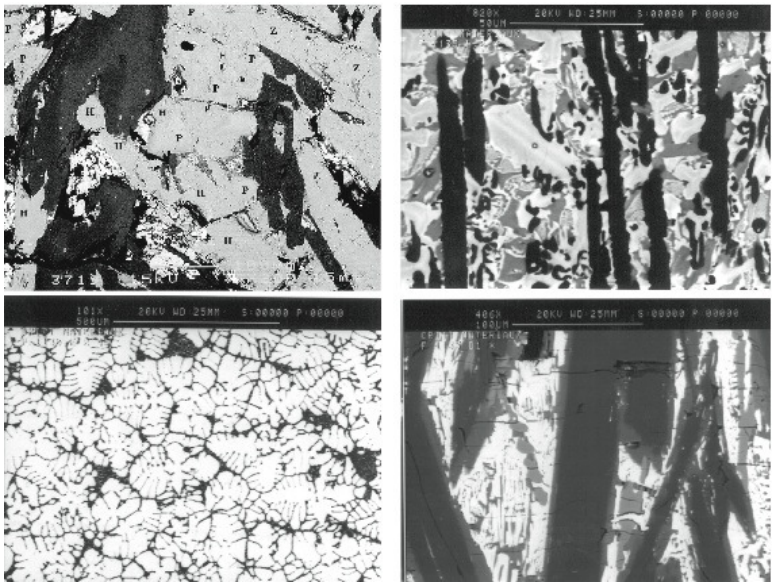
Phosphate Glass

- Not currently being used
- Chemically stable
- Extremely resistant to radiation damage
- Dissolution rates 100-1000X slower than borosilicate
- No single phosphate mineral can incorporate all the waste streams so need more reprocessing



Ceramic Waste Forms

- Possible next-generation
- Incorporate radionuclides into specific atomic positions allowing for high loading
- Monophase or multiphase materials
- Synroc



Nanostructured Materials

- Immobilization by pore size and not by atom sites
- Lower temperature processing
- Altered to make more durable

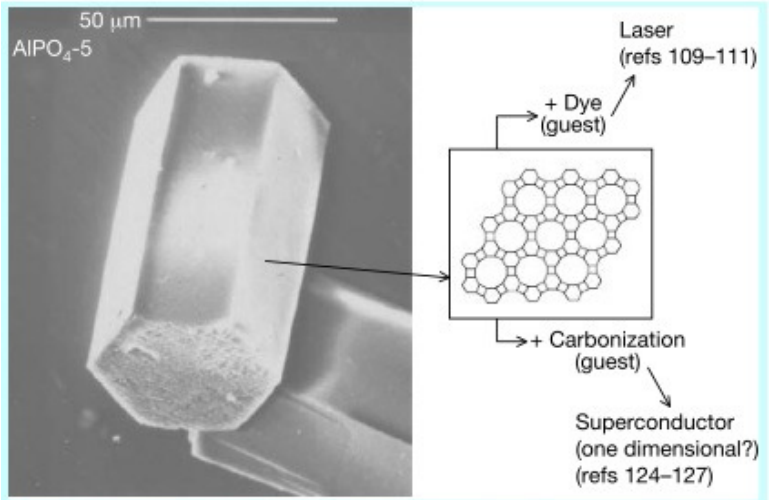
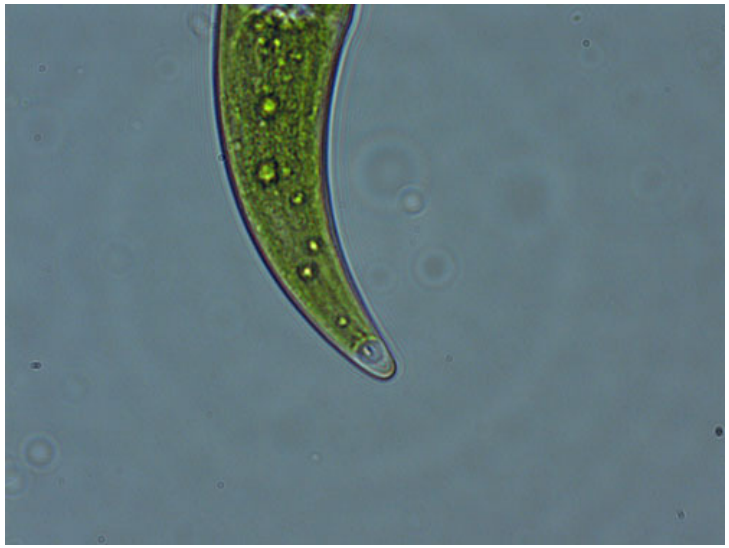


Figure 5 The use of $AlPO_4$-5 as a host for guest molecules. Shown are a micrograph of a $AlPO_4$-5 microcrystal and a schematic representation of its pore structure that can serve as a host for the inclusion of different guest species, to endow the composite structures with new properties

Other Ideas (Specifically my research)

- Main Issue: waste stream volume
- If can remove, the HLW from the non-HLW could reduce the amount of waste needing to be vitrified
- *Closterium Moniliferum*



Summary and Conclusion

- Need long term solution for disposal of high-level radioactive waste produced by nuclear power plants
- One solution is to store in geological repositories in materials that retain integrity for time needed
- Materials for the immobilization are:
  - Borosilicate Glasses
  - Phosphate Glasses
  - Ceramics
  - Nanostructured Materials
- Without a good solution, nuclear energy is a good energy alternative!

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