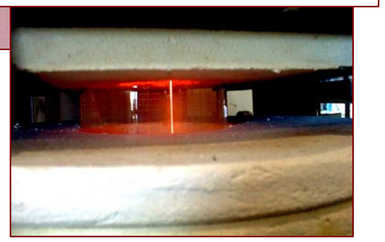
Thermal Processing

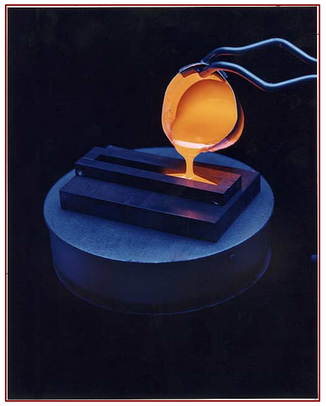
PNNL's Thermal Processing Group has been a leader in glass technology since the late 1960s, when development focused on vitrifying high-level radioactive wastes. The group developed and applied the joule-heated, slurry-fed ceramic melter to the treatment and immobilization of the U.S. Department of Energy's (DOE) high-level radioactive wastes (HLW). Today this technology is being employed at the Savannah River Site's Defense Waste Processing Facility and the West Valley Demonstration Project in West Valley, New York. PNNL is also supporting the application of the technology at the two remaining DOE sites where HLW is stored. Today our focus has broadened to include a variety of research and development activities related to glass and ceramics.

A stream of molten glass pours from the Research-Scale Melter.



Waste vitrification is the group's primary line of business. The staff have the process experience and formulation expertise to adapt vitrification to almost any relevant waste material. Vitrification technology experience and capability at PNNL includes low-level, transuranic, mixed, hazardous, and nonhazardous solid wastes. Our approach is successful because we evaluate glass from nano-scale crystals to crucible melts to pilot-scale processing, ensuring that what's formulated in the lab can be produced at full scale.

- The group's world-class expertise in **glass formulation** is used to design waste forms with targeted properties such as waste loading, durability, melting point, viscosity, and thermal expansion coefficient. We work to improve the solubility of certain materials that are difficult to incorporate into waste glass, such as chrome, phosphorous, and sulfur. We also research ways to avoid the formation of separate phases, such as spinel.



- Another major focus is **batch-to-glass reaction chemistry**. Research is ongoing to understand the complex reactions that occur in converting melter feed to waste glass. These studies allow us to avoid process upsets such as foaming, cold-cap freezing, and reboil and to optimize melter throughput. They also identify off-gas components and release rates.
- **Chemical process development** efforts simulate and evaluate our client's process flowsheets at the bench scale. For testing purposes, we also develop non-radioactive simulants for radioactive waste.
- research-scale melter. Testing at this scale ensures processability and allows specification of equipment for the full scale.
- Evaluations of the **long-term performance** of waste glass and ceramics are conducted through durability testing and study of physical and chemical **microstructure** using state-of-the-art spectroscopy and microscopy, enabling waste form qualification.

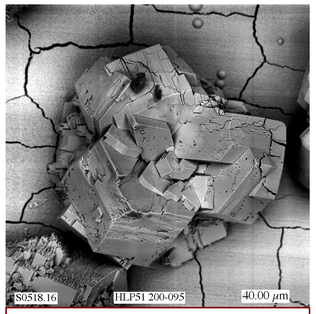
Preparing glass-forming chemicals for crucible melts in the Glass Development Laboratory

Waste vitrification is just one way we apply our expertise in glass and materials processing. We also develop:

- **glass seals** for sensors and other commercial applications;
- other **high-tech applications** for glasses, ceramics, polyceramics, and polymers;
- **alternative waste form** materials; and
- **alternative pathways** for manufacturing glass, such as sol-gel processing.

Our **technology development** experience includes adapting vitrification technology to meet the many needs for other types of wastes including low-level wastes, municipal solid waste, medical waste, hazardous wastes, sludges, and soils. The Laboratory has designed 23 integrated vitrification systems, including:

- A radioactive melter that vitrified 22 MCi of radioactive material for the German government;
- Three high-temperature melter systems capable of vitrifying materials at 1500°C;
- In Situ Vitrification, now available from Geosafe; and
- DC Arc Plasma Melting combined with joule heating, now available from Integrated Environmental Technologies and Svedala Industries, Inc. through its Pyro-Systems Division.



Scanning electron micrograph of a waste glass artificially aged in the lab

The group maintains nonradioactive facilities in the **Applied Process Engineering Lab** (APEL) and radioactive facilities in the **Radiochemical Processing Laboratory** (RPL).

For more information, contact

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