Glassy Materials Investigated for Nuclear Reactor Applications

Studies were made to determine the feasibility of preparing fuel-bearing glasses and glasses bearing neutron-absorbing materials for use as crystalline fuel and control rods for reactors. Primarily, the properties which would determine the usefulness of the glasses as a reactor fuel were investigated—namely, devitrification resistance, urania solubility, and density.

A preliminary study was made of the effects of urania additions on some properties of selected glasses in the systems PbO-Na2O-SiO2, Na2O-CaO-SiO2, Na2O-SiO2, and NaO-K2O-SiO2. Primary areas of possible application investigated were: (1) glass containing fissile material as a single-phase fuel, (2) glass containing one or more high-thermal-cross-section materials as a single-phase control material, (3) glass as a dispersion medium or bonding agent in admixture with crystalline high-cross-section control materials, and (4) fissile-glass as a dispersion medium and sintering agent in admixture with crystalline fissile materials. Some work has been done on glassy coating materials for irradiation chambers and for neutron absorbers.

For application as a reactor fuel, a glassy material should have these general characteristics:

1. The glass should contain as high a content of fissile material as possible.
2. The glass should have a softening point below the operating temperature.
3. The glass should retain integrity as a solution, without a tendency to crystallize, for long periods of time within the operating-temperature range.
4. The glass must be compatible with the jacketing metal, since they will be in intimate contact during operation.

Fabrication methods were devised to form crystalline-glass mixtures of usable densities. Shapes were formed by pressing and sintering, warm pressing at 600°C, vibratory compaction and sintering, and extrusion at 800°C. A control-rod loading was fabricated by vibratory compaction of B4C-glass into the cladding. Induction heating was used to bond the materials in the cladding tube. Glass-bonded uranium dioxide samples were prepared for Doppler-coefficient measurements.

The study revealed the most promising glasses to be based on compositions in the system Na2O-K2O-SiO2. Compositions containing equivalent to about 60 w/o UO2 were melted to single-phase glasses at 1500°C. Glasses containing up to 30 w/o UO2 were extremely resistant to devitrification. Several compositions within this maximum range were maintained for 14 days in a gradient of 300°C-950°C without crystalline development. One sample containing approximately 20 w/o UO2 has been held in the same temperature gradient for 100 days without devitrification.

The work done on glassy coating materials for irradiation chambers involved the development of a technique for obtaining a uniform glaze on the inside of a porcelain tube, in which Sr90 would be used as the source of beta emission. The hazards involved in handling Sr90 prevented the use of the usual spraying or dipping technique for glaze application.

A uniform glaze was achieved by simultaneously rotating the porcelain tube and adding the glaze through a pipette. After the tube was rotated for a predetermined time, the excess glaze was drained out and an Sr90 solution was introduced through a calibrated pipette. Following the Sr90 addition, a blast of hot air was directed against the outside of the tube.
while rotating, to speed drying and to reduce exposure
time. The glaze was then fired in a sealed furnace chamber.

Complete details of this investigation are contained in *Glassy Materials for Nuclear Reactor Applications*, by E. D. Lynch, ANL-7062, November 1965, Argonne National Laboratory, Argonne Illinois. Copies of this report are available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151; price $3.00, microfiche $0.65.

**Note:**
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**Patent status:**
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