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SHATTERPROOF COATINGS FOR GLASS

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OAK RIDGE NATIONAL LABORATORY

operated by

UNION CARBIDE CORPORATION

for the

U.S. ATOMIC ENERGY COMMISSION

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METALS AND CERAMICS DIVISION

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MARCH 1970

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Oak Ridge, Tennessee
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R. J. Gray

ABSTRACT

The shatterproofing of glass with Silastic coatings, which can be applied in the laboratory, has been investigated. The items tested were light bulbs, Pyrex tubing, Dewar flasks, and capillary tubes. Two commercial products definitely improved the impact resistance of the glass and greatly reduced shattering of the sharp particles. The primary purpose of this investigation was to minimize the hazard of glass containers used in glove boxes.

INTRODUCTION

There are numerous occasions in the laboratory when glass is the most suitable material for container or plumbing systems. Because of its lack of reaction with many liquids and gases, the ease in making connections, and its transparency, it is in much demand. A serious drawback of glass is its well-known inability to withstand thermal shock and impact. The subsequent scatter of many sharp fragments can be a serious safety hazard.

One area of particular interest is the need in research and development for glass to contain highly toxic materials that must be handled in glove boxes. Plutonium, for example, is an alpha radiation emitter that has a high toxicity level. However, since it emits only alpha particles, shielding is not a serious matter. Alpha radiation is stopped by plastic, glass, or even paper, so a tightly constructed glove box of thin-gage steel with transparent plastic or glass fronts and rubber gloves provides satisfactory containment. A serious potential danger an operator must face, while performing his experiments with his hands highly limited in movement, is the possible fracture of a glass container and the subsequent puncture or cut of the protective gloves.

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Laminated safety plate glass has been available for many years with the center laminate preventing shattering of the glass. Photographic flash bulbs have had shatterproof outer coatings, and recently bottles containing toxic or flammable liquids (e.g., acetone) are received with an outer coating of plastic as an added protection. Knowledge of the existence of these safety features has interested me in the availability of a commercial product that could be applied as a coating to glass bottles, flasks, tubes, etc. This coating could reduce the possibility of fracture of the glass and, in the event of fracture, reduce the shattering of the sharp fragments.

An advertising brochure¹ recently described a light bulb shatterproofing material that seemed to meet these requirements. I discussed the apparent merits of this material with my colleagues and found sufficient interest to carry out an investigation. Although the intent was to evaluate the protective features of these coatings to reduce the hazards of glass in glove boxes, these protective features could serve a parallel function in any laboratory that uses glass.

DESCRIPTION OF MATERIALS AND PRELIMINARY OBSERVATIONS

The commercial vendor recommended that we try three different products. Literature information and initial visual observations of the cured coatings follow.

Silastic X30-925

This is a silicone rubber dispersion designed specifically for coating electric light bulbs to make them shatterproof. This coating makes the bulb resistant to thermal shock and keeps it from breaking when subjected to extreme changes in temperature. The Silastic is supplied as a 25% dispersion in xylene. Because of the clarity of the coating, a 5- to 7-mil coating will result in only a 0.5% loss of light.

¹Dow Corning Corp., Engineering Materials Sales, Midland, Mich. 48640, phone 517 636-8940.

The coating can be applied by spraying after thinning with additional xylene or directly by painting or dipping. It should be dried in air for 30 to 60 min and then cured for 1 hr at 150 to 200°C.

The coating was optically clear. The increased friction of the coated surface reduced the probability of breakage by slipping from the hand or sliding off a bench. The coating was tough, but I was able to scratch it with a sharp object.

Silicone 92-009

This is a silicone rubber dispersion that was designed to protect various parts and substrates on missiles, rockets, aircraft, and launch equipment from corrosion and erosion. A stronger and more uniform adhesion is obtained after a primer designated as A-4094 is used. This coating cures in 24 hr at room temperature and is thus attractive for glassware that cannot be easily cured in a furnace. The coating is translucent and extremely tough. It can be applied by dipping, painting, or, thinned with added xylene, by spraying.

This air-cured coating was milky optically. It, too, provided a higher friction surface. The coating was tough, but I could scratch it with a sharp object.

Silicone 630

This is a 50% solution of silicone polymer that was designed as a protective coating for electronic assemblies that must operate under adverse environmental conditions. It has excellent water repellency and surface resistivity and dries to a flexible wax-like film. It can be applied by dipping, painting, or, thinned with added xylene to a 5% dispersion, by spraying.

This air-cured coating was very clear. It did not increase the surface friction of the glass like the other two coatings and was more easily scratched.

TESTING PROCEDURE AND RESULTS

Two clear light bulbs were dip coated with Silastic X30-925 to test the designated use of the coating. One coated light bulb was struck with a 0.9-lb mallet. The shatterproofing characteristic and the transparency of the coating can be seen in Fig. 1.

In another test Pyrex glass tubing was coated. Both the X30-925 and the 92-009 Silastic coatings were tested. Some tubes were end closed and dipped so only the outer surface was coated. Other glass tubes were dipped with the end open so both surfaces were coated.

Tubes coated on both surfaces were definitely more difficult to break with the mallet. However, no attempt was made to measure the comparative energy for breaking coated and uncoated tubes. Only relatively crude tests were made in this respect. A tube was placed in a plastic bag, then placed on a flat surface and struck with the 0.9-lb mallet. After the uncoated glass tube was broken, a similar blow was applied to the tubes coated with X30-925 Silastic or the 92-009 Silastic. A pronounced increase in the applied force was necessary for breakage. Usually four or five blows, each with increased force, were required to break the tubes. Apparently, minute surface flaws were sealed by the very adherent coating and a high localized stress was necessary for fracture to occur. The results are shown in Fig. 2.

There is always concern about the protection of personnel around glass systems under vacuum. Implosions can be serious, and the glass shrapnel can be just as hazardous as from an explosion. To test the protection of coatings on glass under negative pressure, two small Dewar flasks were individually coated on all exposed surfaces. One was dipped in dispersion 92-009 and the other in X30-925. The flasks were drained and cured in the required manner. The two coated flasks and one uncoated flask are shown in Fig. 3. A customary protective measure is to wrap Dewar flasks with electrical tape. This procedure is helpful but the tape may become relatively slick after extended use from the transfer of oils from the skin. Accidental dropping of the flask is more likely to occur. Also, Dewar flasks are often used to contain liquid nitrogen,

Fig. 1. Effect of Coating a Light Bulb with Dow Corning Silastic X30-925. (a) Uncoated bulb. (b) Coated bulb. (c) Coated bulb after being struck with a mallet.

Y-92909

Uncoated glass tube

Double coated¹ glass tube -- coated inside and outside

Outer coated¹ glass tube after striking with mallet

Outer coated¹ test tube after striking with mallet

Double coated² glass tube after severe blow with mallet

Outer coated² glass tube after striking with mallet

Fig. 2. Shatterproof Coatings on Pyrex Glass Tubing. Arrows indicate depth of dipping. Coatings are ¹Dow Corning Silastic X30-925 dipped, air cured 1 hr, and heat treated 1 hr at 150°C and ²Dow Corning Silicone Rubber 92-009 dipped and air cured 24 hr.

Fig. 3. Dewar Flasks Before Impact Test. (A) Uncoated. (B) Coated with 92-009. (C) Coated with X30-925.

air, etc., and the adhesive and tape are deteriorated if they are exposed to these low-temperature liquids.

To test the cryogenic properties of the two coatings (X30-925 and 92-003), liquid nitrogen (boiling point -195.8°C) was placed in the two coated bottles and allowed to stand for 2 hr. No adverse effects were detected on the inner surface coatings, which were in direct contact with the liquid nitrogen.

To test the shatter protection of the coatings on the Dewar flasks, each flask was placed in a plastic bag and dropped on the floor from a height of about 2 ft. Each flask was placed in the bag so one side of the top lip was the point of impact. As expected, all flasks were broken, but the shatter prevention properties, shown in Fig. 4, are quite evident.

Another possible use of these coatings is to protect 0.003- to 0.010-in.-diam glass capillary tubes used as holders in the x-ray diffraction studies of highly toxic powders. With plutonium compounds, for example, there is a need to maintain containment if the very fragile capillary tubes should break. These tubes are shown in Fig. 5 in the uncoated condition and coated with X30-925 and 92-005. Although the tubes were intentionally broken the coating maintained containment of the particles. X-ray diffraction tests have been made, and there is no interference with the interpretation of the data due to the presence of the coatings.

Since xylene is the solvent for these dispersions, a flammability hazard is present until drying is completed. After the coatings are cured, a flame applied will char the coating, but the coating will not burn if the flame is removed.

The initial interest in these coatings included the shatterproofing of glove box windows. Although this protective measure cannot be discarded completely, it has some drawbacks:

1. The clear coating (X30-925) requires curing in air for 1 hr and heat curing 1 hr at 150°C . This heat treatment of a glass plate might be difficult to perform.
2. The slightly tacky surface of the coating attracts lint and dust, which diminish the transparency.

Fig. 4. Dewar Flasks After Impact Test. Arrows indicate points of contact. (A) Uncoated. (B) Coated with 92-009. (C) Coated with X30-925.

Fig. 5. Glass X-Ray Diffraction Capillary Tubes. (A) Uncoated. (B) Coated with DC X30-925. (C) Coated with 92-009.

3. The coating is not resistant to scratching with a hard sharp object

We have been quite satisfied with the protection and service performance of the coatings on sample bottles used in the glove boxes. This feature alone can be a preventive step that might pay big dividends in any glove box operation.

CONCLUSIONS

Glass can be successfully shatterproofed by coating the surface with a silicone rubber dispersion. Three Silastic coating materials were tested on glass. One coating material, Silastic X30-925, is 95.5% transparent and provides a shatterproof coating. An air cure of 1 hr plus a 1-hr heat treatment at 150°C are necessary. Glass sizes and shapes that can be subjected to the heat cure and are used in potentially dangerous operations that require high transparency should be coated with this Silastic.

The 92-009 dispersion is milky after the 24 hr air cure, so its use as a coating on glass requiring the retention of transparency may not be desirable. It does have good adherent properties. If the transparency is not a prime consideration, it is a suitable protector, and the air curing feature is highly desirable. It might also be useful as a coating on metals that are exposed to corrosive media or need an insulated coating.

The 630 coating did not prove to be as satisfactory in the tests that were conducted.

This cursory investigation merely touches on some of the many possible applications of these protective coatings. Any laboratory using glass in potentially hazardous operations should make individual evaluation of the protective features of these coatings.

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