NASA TECH BRIEF

Ames Research Center

Transparent Polymeric Laminates

The problem:

To develop transparent polymeric materials which have high mechanical strength at elevated temperatures and are resistant to impact, fire, and high-energy thermal radiation.

The solution:

A laminate prepared from an epoxy-boroxine and a phenolphthalein polycarbonate.

How it's done:

The polycarbonate is prepared by the reaction of phenolphthalein with phosgene in the presence of an amine catalyst and an immiscible organic solvent phase. The solvent, such as methylene chloride, dissolves the polymer as it forms; the polymer is isolated from the organic solvent phase by precipitation with methanol or acetone. Polymers with average molecular weights of 40,000 to 100,000 are obtained.

The polymer, swollen by the addition of up to 40% of acetone which reduces the glass transition temperature, is molded at 230°C and 7 MN/m². The transparent panels are then vacuum-dried at 150°C until the volatile content is as low as 2% by weight, as indicated by thermogravimetric analysis. Samples prepared in this manner show no tendency to undergo solvent crazing, and the thermal properties are little affected by the small amounts of retained solvent. Windows about 3.2 to 6.6 mm thick from this polymer have also been formed directly from the dry polymer powder by a high-speed impact press.

The epoxy-boroxine polymer is prepared from the diglycidyl ether of bisphenol-A (DGEBA) and about 5 to 6.5 parts per hundred of trimethoxyboroxine (TMB) as catalyst. The DGEBA is brought to 40°—45°C, the TMB is added, and the mixture is gradually degassed in a vacuum chamber. The material is then poured into prewarmed metal molds and heat cured for a specified time—temperature cycle; it is cooled slowly before being removed from the molds. Curved sheets can be obtained by bending flat polymer sheets at temperatures above 150°C.

Structural laminates are formed by bonding the two polymers described above with an interlayer film of ethylene-propylene-vinyl acetate terpolymer adhesive; other interlayers may be useful.

The epoxy-boroxine polymer is thermochemically stable to 400°C, gives a char yield of about 35%, and has a tensile strength of 92 MN/m² at 24°C. The phenolphthalein polycarbonate has a glass transition temperature of 280°C, a char yield of about 54%, and about four times the fuel-fire burn-through resistance of the conventional acrylate window. Moldings of the neat polycarbonate have initial tensile strengths at room temperature of about 110 to 138 MN/m² and as much as 41.4 MN/m² at 200°C; the impact strength is six times that of the boroxine. By utilizing these two polymers in the form of a laminate, the composite system may provide operational capability at 260°C, fuel-fire resistance, and high-speed bird-impact resistance; it may also be an effective barrier against high-energy thermal radiation.

(continued overleaf)

Note:

Requests for further information may be directed to:

Technology Utilization Officer
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Reference:TSP 73-10341

Patent status:

Inquiries concerning rights for the commercial use of this invention should be addressed to:

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