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A COMPARISON OF THE TRIBOELECTRIC CHARGING OF POLY(TETRAFLUOROETHYLENE) AND AN AMINE-CURED FLUOROEPOXY RESIN

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SUMMARY

Poly(tetrafluoroethylene) and an amine-cured fluoroepoxy resin are compared with respect to the triboelectric charge generated when the surfaces are rubbed against four types of contacting surfaces. In all cases, the fluoroepoxy resin acquires a larger negative voltage than does the poly(tetrafluoroethylene).

INTRODUCTION

Attempts have been made to rank materials, including polymers, according to triboelectric series[1-2] and to develop consistent theories of frictional charge generation [3]. Although this area of research is somewhat complex and open to argument, there has been agreement that poly(tetrafluoroethylene), PTFE, is near the extreme negative end of triboelectric series. Molecular constitution [4], particularly the presence of much fluorocarbon, seems to be a determinant factor in the effect, but the actual mechanisms, and the role of 'electron traps'[5], involve much complexity and speculation.

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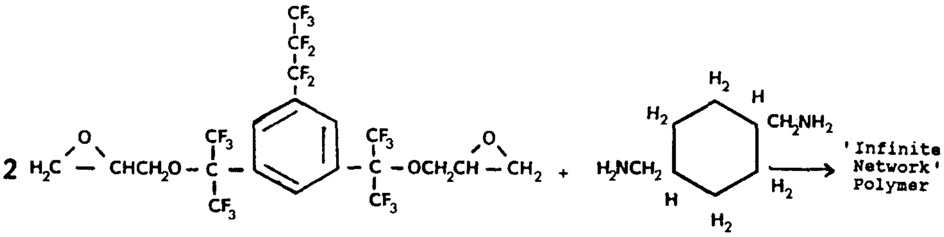
We have synthesized a new plastic which we believe exhibits unusual triboelectric properties. A stroke of the finger on a disc of the material is usually sufficient to cause a cascade of electrical discharges which can be easily heard as a crackling noise and which can be seen as triboluminescence in a dark place. Our measurements indicate that the material should be placed beyond PTFE in triboelectric series.

EXPERIMENTAL

Monomers. Syntheses of heavily-fluorinated, liquid epoxy resins of the diglycidyl ether type (I) have been accomplished at the Naval Research Laboratory [6].



(I) (II)

A coreactant diamine, 1,4-bis(methylamine)cyclohexane, was acquired as a clear, colorless liquid from Eastman and used as received.

Polymer. A stoichiometric ratio of I and II were mixed on the assumption that 2 moles of the former could react with one mole of the diamine. A total of 2 g of liquid resin was obtained. This initially immiscible resin mixture was allowed to react at 25° in a closed vial, to prevent carbon dioxide absorption from the atmosphere, until a miscible, colorless syrup was obtained (approximately 5 hrs). The syrup was poured into a small aluminum dish and allowed to polymerize overnight. A postcure at 60^{o} for 2 hrs gave a disc of plastic 25 mm in diameter which was removed from the mold and polished on both faces to a thickness of 2 mm.

Triboelectric Measurements. A disc of PTFE of identical dimensions to that of the fluorinated epoxy-amine plastic was prepared, and these two materials were rubbed against several substances in a consistent manner so that the same extent of mechanical action was imparted each time. Immediately after each rub, the voltage acquired by a disc was measured in a Faraday cage apparatus. Average values for the voltages acquired by these substances are shown in Table I. Rubbing of PTFE against the fluorinated epoxy-amine produced a small positive voltage on the latter which was not considered significant because of size and shape differences in the surfaces.

TABLE I

Voltages Generated on Fluoroplastics by Rubbing Against Various Substances

Rubbing Substance	Fluoroplastics:	
	Fluoroepoxy-amine	Poly(tetrafluorethylene)
Nylon	-2.32	-2.08
Chamois	-19.8	-15.0
Cellulosic Tissue	-20.3	-18.6
Flesh (finger)	-8.2	-3.6

DISCUSSION

In each instance, a higher negative voltage was acquired by the fluoroepoxy-amine than by the PTFE, which suggests an extension of the triboelectric series on the negative end of the scale. It is of interest to speculate on the cause of this higher voltage acquisition by the fluoroepoxy-amine, and the most obvious compositional difference between the two fluoropolymers is the even distribution of aliphatic amino groups throughout the fluoroepoxy-amine. However, there is also the difference that the fluoroepoxy-amine is a network in which the fluorocarbon is constrained to a fixed molecular position more firmly than that in PTFE which may result in a more efficient 'atomic rubbing' at fluorine atoms in the fluoroepoxy case. The molecules of PTFE are relatively free to move in the direction of the rub at the contact surface.

The amino groups, with their relatively mobile electron pairs, may offer a conductive pathway for electrons to penetrate deeper into the bulk of the fluoroepoxy and become trapped at lower levels than in PTFE. Some degree of internal polarization must exist in a plastic such as this fluoroepoxy, and inductive disturbances must project from surface charges into the interior whether there is an actual penetration of electrons or not.

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