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STATE OF THE ART

METHODS OF BONDING FLUOROCARBON PLASTICS TO STRUCTURAL MATERIALS



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**STATE OF THE ART
METHODS OF BONDING FLUOROCARBON PLASTICS
TO STRUCTURAL MATERIALS**

By

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ABSTRACT

Plastics of the fluorocarbon group are explored for their possible use in constructions which utilize adhesive bonding. The properties and methods of bonding of various materials derived from five basic fluorocarbons are summarized.

The literature has provided information within four general areas. These are presented under the following main headings:

Section 3. Fluorocarbon Plastics: Availability and Properties

Section 4. Methods for Bonding Sintered Fluorocarbons

Section 5. Methods for Bonding Melt-Processible Fluorocarbons

Section 6. Miscellaneous Specialty Products

The technology basic to the identification and description of the various plastics is briefly given. Commercial suppliers are identified. Included are instances illustrating the practical applications of the techniques. The report closes with a bibliography of publications on this subject.

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1. INTRODUCTION

Mention of a particular commercial product neither constitutes an endorsement by the Plastics Technical Evaluation Center nor a voucher for the accuracy of a manufacturer's claim unless specifically noted.

The missile and space age has created a demand for lightweight, aerodynamically smooth structures with high strength-to-weight ratios. To meet this demand, new techniques are being used to assemble composite structures which display high strength and resistance to heat and corrosion. Generally, adhesive bonding is the most effective means of assembling the structural components of these composite members.

The fluorocarbon plastics, with their unique resistance to heat, chemical attack, and low frictional surfaces, would seem to be useful in many missiles and space applications. Unfortunately, difficulties in adhering the fluorocarbons has made attachment by mechanical means necessary.

Several methods for overcoming these deficiencies have been developed. It is the intent of this work to review the available methods for bonding fluorocarbon plastics to themselves and to other materials.

2. SUMMARY

Although several methods have been described for bonding fluorocarbon plastics to themselves and to other substrates, probably the most common method involves the application of an etching solution which modifies the surface of the plastic, making it receptive to conventional adhesives. The bonds thus formed are strong and reproducible. This method has proven to be quite satisfactory for the structural bonding of all types of fluorocarbon plastics.

The advent of the new melt-processible Teflon FEP fluorocarbon makes possible structural bonding without the use of conventional adhesives. The simultaneous application of heat and pressure is sufficient to produce an adhesive bond between the FEP plastic and other materials by using a film of FEP plastic as the bonding agent.

The surface of a fluorocarbon plastic may also be made receptive to adhesive bonding by applying a specialty coating of a monomer and subsequently subjecting the coated fluorocarbon to ionizing radiation. This process is called radiation-induced graft copolymerization. It is a comparatively expensive process, and currently is limited to treatment of tapes and wire sheathing.

Actually there are only two general methods of bonding fluorocarbon plastics to themselves or to other materials. These methods are: bonding treated fluorocarbons by the use of adhesives, and melt bonding. The melt-bonding processes vary, depending upon configuration and application of the end item.

3. FLUOROCARBON PLASTICS: AVAILABILITY AND PROPERTIES

IDENTIFICATION AND AVAILABILITY

Practically the entire commercial fluorocarbon plastic field is derived from five basic monomers. They are: tetrafluoroethylene (TFE, Teflon), chlorotrifluoroethylene (CTFE, Kel F), vinyl fluoride (VF), vinylidene fluoride (VF₂), and hexafluoropropylene (HFP).

Table 1 lists the commercial fluorocarbon polymers to be discussed in this report. These are derivations of the five basic monomers and are grouped in accordance with their physical forms: plastics; elastomers; oils, greases, and waxes. The trade names and manufacturers are identified.

As can be seen, the homopolymers of the first four basic monomers are available: Poly-TFE, Poly-CTFE, Poly-VF, and Poly-VF₂. (1) Poly-HFP has not yet achieved commercial significance. To date, it appears as a copolymer: Poly-(TFE-HFP) and Poly-(VF₂-HFP). Note also that VF₂ appears as a copolymer with CTFE; and that TFE and CTFE essentially form the backbone of the fluorocarbon plastics industry.

Table 1. Commercial Fluorocarbon Polymers

Polymer	Trade name	Manufacturer
PLASTICS		
Poly-TFE -----	TEFLON	E. I. duPont de Nemours & Co., Inc.
Poly-CTFE -----	KEL-F	Minnesota Mining & Manufacturing Co.
Poly-(TFE-HFP) -----	TEFLON 100 x and FEP	E. I. duPont de Nemours & Co., Inc.
Poly-(CTFE-VF ₂) -----	KEL-F	Minnesota Mining & Manufacturing Co.
Poly-VF ₂ -----	RC-2525	Pennsalt Chemicals Corp.
Poly-VF -----	Teslar PVF (film)	E. I. duPont de Nemours & Co., Inc.
ELASTOMERS		
Poly (CTFE-VF ₂) -----	KEL-F elastomer	Minnesota Mining & Manufacturing Co.
Poly (VF ₂ -HFP) -----	Fluorel elastomer	Minnesota Mining & Manufacturing Co.
. . .	Viton	E. I. duPont de Nemours & Co., Inc.
OILS, GREASES, AND WAXES		
Poly-CTFE -----	KEL-F oils, greases, and waxes	Minnesota Mining & Manufacturing Co.
	Fluorolube	Hooker Chemical Corp.
	Halocarbon	Fluoro-Chemical Corp.

PROPERTIES

As an introduction to the discussion of methods of bonding fluorocarbon plastics to structural materials, it is desirable to consider briefly the properties of the various types of fluorocarbons. These are summarized in Table 2.

Poly-TFE was introduced commercially in 1943. It was registered by du Pont under the trade-name of "TEFLON." Because of its completely fluorinated structure, Teflon is one of the most chemically inert polymers known. It has excellent resistance to heat and chemicals, is recommended for continuous use up to approximately 500° F, and it exhibits outstanding electrical insulation properties. It is seriously affected only by chlorine trifluoride and fluorine at high temperatures, and by molten alkali metals. It has one major deficiency which makes it difficult to mold. The polymer does not reach a fluid condition at high temperature; but at 620° F it undergoes a transition from its normal crystalline state to that of a gel. Since the transition of a material from the crystalline state to the fluid state is the factor upon which molding processes depend, Teflon cannot be fabricated like true thermoplastics. Sintering techniques must be used. The Teflon also has a tendency to cold-flow, but this can be controlled.

Poly-CTFE has been given the name of "KEL-F" by the M. W. Kellogg Company. It is a true thermoplastic; it can be fabricated by conventional extrusion and molding techniques at temperatures in the range of 500° F to 625° F. Kel-F is tougher and stronger than Teflon; and has less tendency to cold-flow. However, its maximum continuous service temperature is only 390° F.

The two copolymers, Poly (TFE-HFP) and Poly (CTFE-VF₂), given in Table 2, are copolymers of Teflon and Kel-F, respectively. Poly-(TFE-HFP) or "TEFLON 100-FEP" retains essentially all of the properties of the TFE plastics, while providing a melt viscosity low enough to permit conventional thermoplastic processing. (2) Poly-(CTFE-VF₂) has certain advantages over Kel-F. It is easier to fabricate and has higher impact strength and longer flex life. However, it has lower chemical stability and mechanical strength.

Two other polymers are of more limited background. Poly-VF₂ has just recently been introduced. It has good mechanical strength and radiation resistance, and can be fabricated by conventional means. (3) Poly-VF has appeared as a film product which has good strength, high temperature resistance, excellent flex life, and low shrinkage. However, it has only fair chemical resistance when compared with the other fluorocarbon plastics. (4)

In the above, particular note has been made as to whether the fluorocarbon plastics may be processed in the conventional manner (that is, by heat-forming), or whether they must be processed by the sintering technique. This latter technique is essentially similar to the method used in powder metallurgy in which finely-divided materials are pressure-formed into bulk solids and finally are high-temperature treated (sintered), yielding physical properties which compare favorably with, or even excel, the properties of the parent material.

This difference in production methods has bearing on the methods by which the fluorocarbon plastics may be used in bonding techniques. In the discussion that follows, such techniques will be divided into those which apply to plastics fabricated by the sintering process, and those which are applicable to the melt-processible plastics. It must be understood, however, that in many instances overlapping does occur.