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PROPERTIES OF FLUOROTHENE

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by

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PROPERTIES OF FLUOROTHENE

By W. H. Reysen and P. R. Vanstrum

An extensive investigation of the properties of "fluorothene" plastic (polymerized monochlorotrifluoroethylene) is under way in the Research and Development Laboratories as a part of the broad fluorocarbon research program. It is anticipated that eventually a complete investigation will be made of samples of fluorothene made under varying process conditions and at different temperatures, humidities, and other test variables. However, with a view toward first obtaining the most useful information, emphasis has been placed on the determination of the properties of "normal" fluorothene at standard atmospheric conditions. Normal fluorothene is defined here as material having a molecular weight, molding conditions, and quenching conditions similar to the material in most general use at the present time. All tests performed to date have been made using normal fluorothene samples.

Considerable information has been accumulated by the Fluorocarbon, Metallurgical, and Physical Measurements Sections of the Research and Development Laboratories on the chemical, physical, electrical, and mechanical properties of this material. It is the purpose of this memorandum to make these data available to interested persons. Additional information including data concerning the thermal properties of this material is being accumulated and will be reported in subsequent memoranda. The information is summarized as follows:

Properties (Chemical and physical)	Test	Specified* conditions	Results
Water vapor permeability	ASTM D-697-42T	---	0.4 g/sq m./24 hr
Water absorption	ASTM D-570-42	---	0.00
Flammability	ASTM D-635-44	---	Nil
Specific gravity	ASTM D-792-44T	25°/25°C	2.1115
Chemical resistance	ASTM D-543-43	---	Generally inert (See Tables)
Properties (Electrical)			
Dielectric strength	ASTM D-149-44	40 mil sample	700 v/mil
Arc resistance	ASTM D-495-42	0.050-in. diam tungsten electrodes	250–300 sec (fails by melting)
Power factor	ASTM D-150-44T	2000 cycles	0.015–0.025
Dielectric constant	ASTM D-150-44T	2000 cycles	2.3–2.7
Volume resistivity	ASTM D-257-38	70°F and 50% relative humidity	10^{18} ohm-cm
Surface resistivity	ASTM D-257-38	70°F and 50% relative humidity	10^{18} ohms

Properties (Mechanical)	Test	Specified* conditions	Range	Average
Elastic modulus	ASTM D-638-46T		$1.64-178 \times 10^5$ psi	1.69×10^5 psi
Upper yield			4196–4315 psi	4256 psi
Lower yield	Type I for sheets 1/4 in.		3490–3630 psi	3561 psi
Tensile strength	or under in thickness		5157–5328 psi	5258 psi
Per cent elongation at rupture		2-in. gage length	156–166%	160%

*Conditioning procedure before testing: None. Temperature of test: 75.5–77.5°F.
Rate of testing: 0.05 in./min through lower yield
0.25 in./min to rupture. Yield points determined by drop of beam method.

ACKNOWLEDGMENT

Samples used in these tests were supplied by the Plastics Section of the Engineering Development Division.

The Electrical Engineering Department of the Plant Engineering Division supplied the equipment and helpful suggestions for the determination of dielectric strength and arc resistance.

The data were obtained from the Fluorocarbon Section under Dr. J. L. Gabbard, the Metallurgical Section under G. L. Flint, and the Physical Measurements Section under J. F. Burns, of the Research and Development Laboratories.

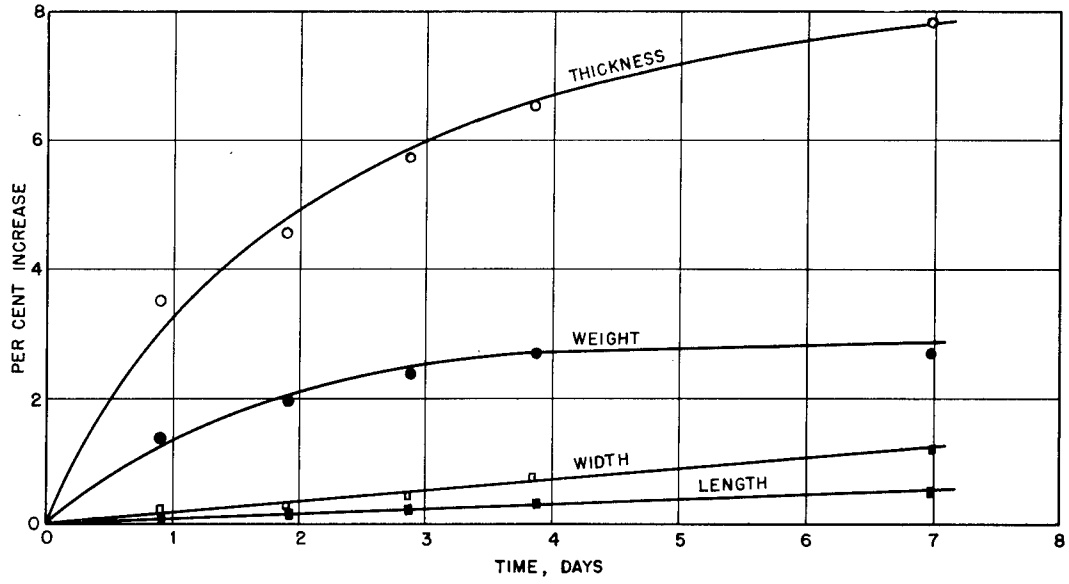

Figure 1. Effect of ethyl ether at 25°C on fluorothene.

Table 1. Weight increase effect of some reagents on fluorothene.*

Reagents	Temp. °C	% weight increase in 7 days
Ether (diethyl)†	25	3.68
Ethyl acetate	25	1.28
Freon 113	25	1.20
Furfuran	25	2.40
Trichloroethylene	25	2.30
Bromobenzene	70	1.90
Carbon tetrachloride	70	9.73
Dichoroethylene	70	1.21
Ethyl acetate	70	6.49
Toluene	70	6.76
Trichloroethylene	70	13.54

* These reagents are those which were absorbed more than 1% by weight of the plastic. The plastic becomes pliable approximately in proportion to the amount of reagent absorbed. † Figure 1.

Table 2. Effect of reagents specified by ASTM on fluorothene at 25°C.

Reagent	Initial thickness in inches	% weight increase after Immersion*	% weight increase after Heating†	% change after immersion* Thickness	Width	Length
Acetic acid (5%)	0.1247	.00	−.01	−.16	−.03	−.03
Acetone	.1234	.11	.04	.08	.00	−.07
	.1242	.11	.04	.24	.04	.00
Ammonium hydroxide (10%)	.1206	.01	.00	−.50	−.09	.00
Carbon tetrachloride	.1208	.40	.22	.49	.02	.07
	.1207	.48	.26	.50	−.02	.00
Dichloroethylene	.1255	.02	.00	−.24	−.04	−.03
	.1240	.02	.00	.56	−.03	−.07
Ethyl acetate	.1245	1.23	.71	2.49	.07	.07
	.1248	1.32	.78	2.32	.10	.03
Ethanol (50%)	.1219	.00	−.01	−.16	−.04	−.01
Ethanol (95%)	.1225	.00	.00	−.08	−.03	−.03
Heptane	.1244	.01	.00	−.08	−.07	−.07
Hydrochloric acid (10%)	.1246	.00	−.01	−.16	−.05	−.07
Hydrogen peroxide (3%)	.1208	.00	.00	.00	−.01	−.03
Nitric acid (10%)	.1226	.01	−.01	−.24	−.08	−.03
Oleic acid	.1245	.00	.00	−.08	−.07	−.07
Sodium carbonate (2%)	.1223	.00	−.01	−.16	−.11	−.03
Sodium chloride (10%)	.1250	.00	.00	−.08	−.08	−.03
Sodium hydroxide (1%)	.1257	.00	−.01	−.16	.10	−.03
Sodium hydroxide (10%)	.1248	.00	−.01	−.16	−.14	−.03
Sulfuric acid (3%)	.1238	.01	.00	−.40	−.05	−.07
Sulfuric acid (30%)	.1253	.00	−.01	−.08	−.04	−.07
Toluene	.1224	.43	.25	.82	.06	.07
	.1232	.49	.26	.89	.00	.03
Water (distilled)	.1205	.00	.00	−.17	−.05	−.03

* 7-day immersion in reagent. † 7-day heating of treated sample in 50°C oven.

Table 3. Effect of reagents other than those specified by ASTM on fluorothene at 25°C.

Reagent	Initial thickness in inches	% weight increase after Immersion*	% weight increase after Heating†	% change after immersion * Thickness	Width	Length
Blank (no reagent)	0.1219	.00	.00	−.08	−.05	−.10
Acetic acid (glacial)	.1236	.01	.00	.16	−.05	.00
Acetic anhydride	.1250	−.04	.00	.16	.02	−.03
Acetophenone	.1218	.00	.00	.00	−.04	.00
Amyl acetate	.1245	.06	.02	.08	−.04	−.07
Aniline	.1250	−.01	−.01	.00	.00	−.03
Antimony pentachloride	.1210	.00	.00	.00	.02	.00
Arochlor 1242	.1242	.00	.00	.00	.01	.03
Arochlor 1248	.1246	.00	.00	.00	.03	.00
Arochlor 1254	.1237	.00	.00	.00	.03	−.03
Benzaldehyde	.1225	.00	.00	.16	.00	−.07
Benzene	.1251	.29	.00	.56	.03	.00
Benzyl alcohol	.1263	.00	.00	.16	.00	.00
Bromine‡	.1238	.04	.02	.00	−.04	−.03
Bromobenzene	.1266	.02	.00	.08	.01	.00
Butyl alcohol	.1263	−.04	−.01	.00	.01	.00
n-Butyl ether	.1200	.04	.02	.17	.04	.00
n-Butyl sebacate	.1235	.00	.00	−.08	.00	.00
Carbon disulfide	.1233	.10	.01	.16	−.02	−.03
1,1-Chloronitropropane	.1227	.00	−.01	−.16	−.02	−.03
Cresol	.1242	.00	.00	−.08	−.01	.00
Dibutylphthalate	.1234	.00	.01	.00	.00	.03
Dichloroethyl ether	.1212	.00	.00	.17	.08	.00
Dichloropropylene	.1224	.02	.00	.16	.01	.00
Dicyclopentadiene	.1235	.00	.00	.00	−.01	.03
Diethylcarbitol	.1230	.14	.07	.16	.04	.00
Diethyl cellosolve	.1204	.83	.47	1.66	.10	.00
1,4- Dioxane	.1257	.01	−.01	.08	.03	.00
Ether (diethyl)	.1248	3.68**	2.13	7.86	1.14	.46
Freon 113	.1239	1.20	.56	1.21	.07	.03
Furfuran	.1235	2.40§	1.44	4.13	.39	.13
Halowax 1000	.1225	.00	.00	.00	−.02	.00
Hydrofluoric acid (~50%)	.1238	.00	−.01	.08	−.09	−.07
Methallyl chloride	.1222	.16	.08	.25	.06	−.10
Methanol	.1242	.00	.00	.08	.02	−.03
Mineral oil	.1225	.00	.00	.08	.02	.00
Naptha solvent	.1214	.01	.00	.08	.01	−.03
Nitric acid (conc.)	.1246	.00	.00	.16	.00	.00
Nitrobenzene	.1254	.00	.00	.00	.01	−.03
Nitromethane	.1200	.00	.00	.00	−.02	−.07
Pyridine	.1248	.02	.00	.08	.05	−.03
Stannic chloride	.1217	.00	.00	.08	−.02	.00
Sulfuric acid (conc.)	.1245	.00	.00	.16	.00	−.03
Tetrachloroethane	.1229	.00	.00	−.24	−.05	.00
Trichloroethane	.1227	.00	.00	.08	.01	−.03
Trichloroethylene	.1244	2.30	1.39	2.89	.19	.07
Trichloropropane	.1234	.00	−.01	−.24	.00	.00
n-Xylene	.1255	.43	.24	.96	.06	.00

*7-day immersion in reagent. †7-day heating of treated sample in 50°C oven. ‡Slight discoloration after test, mostly lost on drying. §Lost some of glassiness by drying. **Became quite flexible.

Table 4. Effects of various reagents on fluorothene at 70°C.

Reagent	Initial thickness in inches	% weight increase after		% change after immersion*		
		Immersion*	Heating †	Thickness	Width	Length
Acetic acid (glacial)	0.1211	.23	.20	1.82	−.70	−.76
Acetic anhydride	.1223	.10	.09	1.71	−.74	−.73
Amyl acetate	.1223	.87 ‡	.71	3.03	−.47	−.63
Aniline	.1219	.01	.01	1.72	−.73	−.80
Bromobenzene	.1208	1.90 ‡	1.57	4.14	−.36	−.43
Butyl alcohol	.1216	.01	.00	1.48	−.76	−.77
Carbon tetrachloride	.1217	9.73 **	7.17	9.86	1.43	1.07
Dichloroethylene	.1216	1.21 ‡	1.00	2.96	−.40	−.53
Ethyl acetate	.1225 §	3.29 **	2.18	6.20	.21	.37
	.1224	6.49 **	3.94	6.54	3.20	3.34
Nitric acid (conc.)	.1228	.01	.00	1.55	−.72	−.77
Phenol	.1226	.00	.00	1.55	−.74	−.73
Sulfuric acid (conc.)	.1217	.00	.00	1.64	−.70	−.77
Toluene	.1224	.76**	4.27	7.27	3.58	3.71
Trichloroacetic acid	.1232	.03	.03	1.46	−.70	−.73
Trichloroethylene	.1220	13.54**	6.40	8.61	4.07	4.14

* 7-day immersion in reagent. † 7-day heating of treated sample in 50°C oven.
‡ Became slightly flexible. § Under test for 40 hours. ** Became very flexible.

Table 5. Dimensional change of solvent-treated samples with no increase in weight.

Reagent	% Change*		
	Thickness	Width	Length
Acetic acid (5%)	0.32	−.19	−.27
Acetone	.40	−.20	−.23
	.24	−.25	−.27
Ammonium hydroxide (10%)	.00	.03	−.17
Dichloroethylene	.16	−.28	−.27
	.32	−.29	−.23
Ethanol (50%)	.16	−.30	−.30
Ethanol (95%)	.33	−.29	−.27
Heptane	.40	−.33	−.33
Hydrochloric acid (10%)	.16	−.30	−.33
Nitric acid (10%)	.40	−.34	−.30
Oleic acid	.24	−.42	−.27
Sodium carbonate (2%)	.25	−.24	−.27
Sodium chloride (10%)	.32	−.32	−.33
Sodium hydroxide (1%)	.16	−.27	−.30
Sodium hydroxide (10%)	.32	−.29	−.27
Sulfuric acid (3%)	.08	−.32	−.33
Sulfuric acid (30%)	.40	−.28	−.27
Water (distilled)	.17	−.31	−.33

*Sample treatment consisted of 7-day exposure to reagent at 25°C followed by 7-day heating in a 50°C oven.

Table 6. Comparison of the effect of reagents on fluorothene weight at 25 and 70°C.

Reagent	% weight increase in 7 days	
	25°C	70°C
Amyl acetate	.06	.87
Acetic acid (glacial)	.01	.23
Acetic anhydride	−.04	.10
Aniline	−.01	.01
Bromobenzene	.02	1.90
Butyl alcohol	−.04	.01
Carbon tetrachloride	.44	9.73
Dichloroethylene	.02	1.20
Ethyl acetate	1.28	6.49
Nitric acid (conc.)	.00	.01
Sulfuric acid (conc.)	.00	.00
Toluene	.46	6.76
Trichloroethylene	2.30	13.54