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SURVEY OF ORGANIC SEMICONDUCTORS INCLUDING ELECTRICAL AND MECHANICAL PROPERTIES OF PLASTICS

DR. JOHN H. MEISER

University of Dayton
Research Institute

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AIR FORCE SYSTEMS COMMAND
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DR. JOHN H. MEISER

FOREWORD

This report was prepared by the University of Dayton Research Institute, Dayton, Ohio, under Contract AF 33(615)-2674 with the Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio. This research was performed under Program Element 6. 16. 46. 01. D. in support of Project 1473 Task 147301. Dr. W. A. Kapp (FDTR) was the Air Force Project Monitor. The research reported herein was performed during the period 16 May 1967 through 30 November 1967 and the report was submitted 13 December 1967. Principal investigator was Dr. John H. Meiser, Assistant Professor of Chemistry, University of Dayton.

This technical report has been reviewed and is approved.

FRANCIS L. JANIK, JR.
Chief, Theoretical Mechanics Branch
Structures Division

ABSTRACT

A comprehensive list of organic semiconductors has been prepared to include compounds having resistivities in the range 10^{-3} to 10^{20} ohm cm. Where electrical and mechanical properties were found, they were included. Five classes of compounds were reviewed and ten compounds were suggested as displaying electrical hysteresis effects due to mechanical loading. Included in the tables is a listing of physical properties of commercially available plastics.

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INTRODUCTION

The following report was designed as a literature survey of organic semiconductors and as a compilation of their electrical, mechanical, and chemical properties. Included in the report are commercially available plastics whose resistivities place them near the low end of compounds considered as semiconductors.

This report is divided into two sections: Part I is a listing of the above properties, and Part II is a discussion of these properties with regard to electrical hysteresis due to mechanical loading.

PART I Review of Published Data

In terms of conductance, an organic semiconductor is found normally with a conductivity $(\text{ohm cm})^{-1}$ between 10^2 and 10^{-14}. Its carrier concentration, either p-type or n-type, will typically be in the range of 10^6 to 10^{19} carriers per cm^3. The mobility, μ (a measure of the ease with which the carriers pass from one molecule to the next), will be found between 10^2 and 10^{-6} $cm^2\ volt^{-1}\ sec^{-1}$. The above quantities, when compared to values for a typical metal, are found to be 10^2 to 10^8 $(\text{ohm cm})^{-1}$, 10^{22} carriers per cm^3, and 10^3 $cm^2\ volt^{-1}\ sec^{-1}$, respectively. Thus, we have the distinction between organic semiconductors and metals and a general idea of their relationships with regard to these quantities.

However, Pohl[140] states that a substance should show six properties in order to be listed as an organic semiconductor:

(1) Conductivity in the range 10^{+4} to 10^{-12} $(\text{ohm cm})^{-1}$;
(2) Negative temperature coefficient of resistance;
(3) Conductivity sensitive to impurity concentrations;
(4) Usually a high thermo-electric power;
(5) Rectification or at least non-ohmic behavior at junctions;
(6) Photo-sensitivity.

Unfortunately, many of the compounds of interest to us have not been studied enough to yield sufficient data to allow their classification according to Pohl's definition - particularly with regard to the last five properties. Therefore, we will list all compounds as semiconductors when their conductivities fall into the above range. For the sake of completeness, many compounds with conductivities down to 10^{-18} $(\text{ohm cm})^{-1}$ will also be listed.

Concepts and Symbols

The conductivity of substances as appears in the tables obeys an equation of the form

$$\sigma = \sigma_0 \, e^{(-E/2kT)} \tag{1}$$

over some range of temperature,

where: σ = conductivity, $(\text{ohm cm})^{-1}$
σ_0 = constant
E = energy gap
T = temperature
k = Boltzmann's constant.

In general, the exponential factor determines the temperature dependence and arises from the exponential increase in probability that charged carriers are thermally liberated across a potential barrier. But depending on the envisaged mechanism for the liberation, a thermal term can be contributed to σ_0.

It may be shown[141] that an equation for conductivity in the form

$$\sigma = \sigma_0 \, (T) \exp \, (-E/kT) \tag{2}$$

can give rise to Equ. 1 where σ_0 (T) represents any function of T, subject to certain conditions. Thus, the experimental value of E may be temperature independent only approximately. Thus, before experimental results can be theoretically evaluated, an assumption as to the manner of charge transport must be made. Such descriptions are outside the purpose of this survey and the interested reader is directed to the many books which discuss this problem.[77, 142, 143, 145]

The reader is cautioned in comparing the data which appears here and those in the original literature. The energy term for Eqn. 1 often appears in several different forms: E/2kT, E/kT, or E/RT. In E/RT, E is expressed in kilocalories per mole and has the numerical value of $\frac{2E}{23}$ electron volts. In our listings, all entries are made to conform to the first expression, E/2kT, and are in electron volts.

For convenience, instead of listing conductivity, we will list the specific resistance. This is easily accomplished since

$$\sigma = 1/\rho \qquad (3)$$

where ρ is the specific resistance. Then Eqn. 1 can be rewritten as

$$\rho = \rho_0 e^{E/2kT} \qquad (4)$$

Thus, the values of ρ and E in the following tables will conform to the above Eqn. 4. Rather than continue a discussion of the various entries here, the meaning of the entries should be clear from the tables.

Compilation Coverage

These tables were obtained by a thorough search of the physics and chemistry literature, including publications in chemical engineering. The search was performed with one computerized search and by manual searching. Manual searching was found to be far more suitable for finding data. This is due in part to the fact that chemical literature has not been thoroughly computerized. The major source searched was Chemical Abstracts. Indeed, cross-checking of references at the end of individual papers insured also the inclusion of those references if not entered into the Chemical Abstracts. The search includes data published up to June, 1967.

In view of the second part of this paper, a few substances which were found with very high specific resistance (low conductivities) 10^{16} or larger, were eliminated from the tables since they fall far outside the limits set for organic semiconductors. No deletions in the opposite direction (low resistivity) were made.

<u>Manner of Presentation</u>

In order to facilitate the listings, the compounds have been divided into a number of sections following that of Gutmann and Lyons[142] This division depends partially on the substances' nature and partially on the manner of their occurrence. Although there is a section on biological materials, some of these materials may be listed under molecular crystals because they occur in nature as crystals or because of the major work performed on them as molecular crystals.

Each compound as appears in the table is listed in alphabetical order and accompanied by the value of its (room temperature) resistivity, temperature range to which the resistivity is applicable, and the energy gap.

PART II Criticism of Data and Recommendations

Review of the Data

The first thing which we note about the tables in this report is the lack of data. The lack of data present is due to several things. Primary among these is that for most of the compounds listed, engineering data simply do not exist. It was decided to compile, at first, as complete a list of organic semiconductors as possible without regard to their mechanical properties and then to add the mechanical properties as far as available.

Although a value appears for the resistivity of a particular compound, the data cannot be accepted without a critical review of the techniques used to obtain the data. Thus, some authors do not list the methods used in the resistivity determination. Other authors do not take into account space-charge considerations, or the effect of the contacts used in their particular method. Rust and others[63] describe some of the dangers involved in using the most simple techniques for contacts and encapsulation of the sample material. It is often found that the temperature or pressure (in compacting samples) is inadequately controlled or not reported. In view of these short comings, the tables of data were reported without critical evaluation of the methods used to obtain the data.

Another problem presents itself in the task of collecting data for many of these compounds.

If the above tables are carefully examined and checked with the original literature, it is seen that many of the compounds were first prepared by the researchers reporting the compounds' resistivity. Quite often, the total yield of such reactions is a few tenth of a gram of product. When the investigator did not find the particular effect desired for this investigation, the compound often no longer was investigated. Thus, automatically, one would not expect much data to be available on these compounds. When data are available, they are included. Thus, commercial plastics have a special table devoted to their physical properties. These data normally are given with a range of values of their physical properties since samples from different commercial suppliers will generally vary.

One will also note that most of the compounds in this table lay outside the resistivity range given by Pohl as appropriate to organic semiconductors. Their inclusion, especially with regard to polymers, was done to present a more complete list of compounds upon which work has been done.

Normally, the procedures for preparing the compounds presented in this survey will be found in the journal article referenced. This is not true for the commercially available plastics whose actual preparation is normally proprietary information.

Compounds Exhibiting Hysteresis

One of the most interesting compounds to come to the attention of this investigation is not even listed as having a determined resistivity in the tables. However, its properties are such that it should be investigated both for possible semiconducting properties and also for resistive or dielectric hysteresis. This organic molecular crystal is thiourea (CH_4N_2S). At normal temperature and pressure the crystal belongs to the orthorhombic centrosymmetric group D_{2h}^{16} (P_{nma}) with four molecules in the single crystal. Bridgman[239] investigated the phase diagram for thiourea. Extrapolation of his data gives a transformation at 25°C of 3460 kg/cm^2. Leonidova[238] found that a first-order transformation occurs in thioruea under a pressure of 4000 kg/cm^2 between 18 and 74°C. Thiourea has ferroelectric properties along the 010 axis at temp ratures below 169°K and between +76 and 180°K. At all other temperatures between 90 and 300°K the crystal is antiferroelectric and the phase transition involves a change from one state to the other at high pressures. The imp tant thing to our discussion is that ferroelectric properties of the samples may be measured by a hysteresis loop which forms with a change in pressure. Leonidova[238] also found after 2 - 3 cycles of increase and decrease of pressure, his single crystal of thiourea broke. Single crystals can be grown by evaporating the solvent from a saturated solution of thiourea in methyl alcohol. The thiourea is commercially available. Samples used in the above work were 7 x 5 x 1 mm.

Other compounds have not yet been investigated for possible first-order transitions to be used in the same manner as thiourea. However, two other compounds show hysteresis loops of sufficient size that a change may easily be recorded. Pyranthrone shows a resistivity versus temperature hysteresis. Ferrocene, on the other hand, has a resistivity versus pressure relaxation. In this case the changing parameters appear to be due to a mechanical lengthening and shortening of the intermolecular bands. Ferrocene has a resistivity in the order of 10^7 ohm cm and thermoelectric power + 1.2 - 1.6 mV/deg. It is found that the resistance normally decreases with increasing pressure reaching a minimum at 5000 atm. followed by an increase with increasing pressure. This is a reversible process except for the hysteresis and is not due to polymorphic change. References 231, 229, 230, and 63 are specific papers on ferrocene or related compounds. References 77 and 142 are more general references treating ferrocene.

Polymers

Several classes of polymer compounds should be mentioned at this point. Charge transfer complexes, in general, can be stable and may display hysteresis. However, the whole set of hydrocarbon/halogen complexes seems to be stable only under their vapor pressure. They are sensitive to air and to water and thus appear unsuitable to applications where they are in contact with these substances. The reason this set is mentioned is because of their rather low resistivities.

The second set which should be mentioned is the phthalocyanines in combination with various metals[240]. There does not appear to be any hysteresis but these compounds do show stability. Their crystalline and electrical properties are similar to anthracene exhibiting low carrier mobilities and high electrical resistivity.

Anion-radicals of tetracyanoquinodimethane normally have crystals which are weak and brittle[33]. However, low - and intermediate - conductivity compounds often are relatively easily obtained in the form of single - crystals, while high-conductivity materials come out of solution in the form of small needles. Compounds of the type $M+(TCNQ)^{-}_{1.5}$ and $M+(TCNQ)^{-}_{2}$ on heating dissociate into $M+(TNCQ)^{-}$ and free TCNQ while compounds of the type $M+(TCNQ)^{-}$ decompose before melting. This class of compounds does not show hysteresis.

Finally, there exist a large number of condensation products which would normally be considered as polymers in the normal sense of the word. Here again there appears to be few reasons to pick one over any other.

For the sake of argument, I would pick the following one or more from the above sets to begin work upon.

Charge-Transfer Compounds

(1) Azulene : Tetracyanoethylene $\rho = 4.7 \times 10^{10}$ ohm·cm

1 : 1 complex made by dissolving equal molar quantities of azulene and TCNE in ether and slowly evaporate solvent. TCNE is available from Eastman and azulene from Rutgerswerke-AG. Reference 6.

(2) Cobaltocene : Chloranil $\rho = 2.05 \times 10^{4}$ ohm·cm

Press versus ρ data given

Reference 73.

(3) Dibenzo [c, d] phenothiazine:

2, 3 - dichloro - 5, 6 - dicyano - p - benzoquinone

2:1 $\rho = 17$ ohm·cm

1:1 $\rho = 5 \times 10^{3}$ ohm·cm

For starting material see: Reference 241.

Reference 2.

(4) p - Phenylenediamine : Chloranil $\rho \approx 10^{6}$ ohm·cm

Seebeck coefficient : 1.1×10^{-3} V/deg.

Thermal conductivity : 2.0×10^{-3} w cm^{-1} deg^{-1}

Chloranil is available from Eastman.

K&K handles p-phenylenediamine.

Reference 167, 6, 62, 233, 1, 27.

Phthalocyanine

(1) Cu phthalocyanine $\rho \approx 10^{12} - 10^{13}$

References 41, 81, 142, 144, 77. The last three give many more references.

Anion-Radicals of Tetracyanoquinodimethane

(1) Diaminodurene (7, 7, 8, 8 - tetracyanoquinodimethane)$_2$

$\rho = 2$ ohm·cm

Reference 33.

(2) N-methylquinolinium (7,7,8,8-tetracyanoquinodi ethane)$_2$

single crystal $\rho = 0.01$ ohm·cm

compacted $\rho = 2.0-10.0$ ohm·cm

Reference 33.

<u>Condensation Products</u>

(A) Polyacenequinone Radical Polymers

(1) Anthraquinone, pyromellitic anhydride, Zm Cl_2

3:1:2 $\rho = 2.0 x 10^4$ ohm· cm

Reference 75.

(2) Pyrene, pyromellitic dianhydride $\rho = 2.58 x 10^4$

Material is insoluble and infusible - slight thermoplasticity allows compacting. It is swellable by acetone.

Reference 25.

(3) Pyrene, p-fluorobenzoic acid, Zn Cl_2 (catalyst)

1:1:1 $\rho = 7.8 x 10^4$ ohm·cm

Reference 55.

PART III - TABLES

TABLE 1

METAL-FREE MOLECULAR CRYSTALS

Substance	ρ ohm·cm	Temp °C	E in 2/kT	Sign of Major-ity Carrier		Ref.
Acenaphthene	10^{14}	60	2.0		Ref. 282: $\rho = 10^{15}$, E = 3.54	63
3-Acentylamino-N-methyl-phthalimide	10^{14}	97	3.46			204
3-Acetylamino-N-penyl-phthalimide	10^{14}	67 to 100 54 to 124	3.46 3.50			204
Anils, substituted	10^{11} to 10^{15}		1.9 to 6.5			176
Acridine, i.e., (2, 3-benzo-quinoline)	5.6×10^{17}		5.02 0.66		Ref. 63: ρ vs 1/T, m.p. 111°C sub. Ref. 270: ionization pot. = 4.04 e.v.	62, 142, 63, 37
Anthracene					Ref. 253: electron affinity (PhCl = 1) = 12 Ref. 270: ionization pot. = 7.40 e.v. m.p. 2.6.2-.4°C Heat of combustion at 20°C Ref. 247: C_V = 9451.0 cal/g. C_P = 9453.2 cal/g Ref. 244: C_P = 1,688.5 kcal/mole Ref. 248: C_P = 1,689.7 kcal/mole Ref. 244: ΔH_{298} = +27,600 cal. ΔS_{298} = -124.7 e.w. ΔG_{298} = +64,800 cal. Ref. 248: Heat of sublimation, 22.3 kcal/mole Ref. 249: Lattice energy 24.4 kcal/mole	
	7×10^{15}		1.66			81
	10^{19}	30 to 70	1.94			76
∥ab (single crystal)	1.35×10^{14}	80 to 200	1.66			142
⊥ab (single crystal)	10^{22}	80 to 200	2.7			80
(single crystal)	1 to 3×10^{17}					
(single crystal	10^{14}	20 to 60	1.5			

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Anthracene, (cont.) (single crystal)	> 10^{15}		0.5	+		145
(compacted)	10^{14} at 200°C	160 to 210	2.92			142
(single crystal)	10^{18}	80 to 150	1.74±0.6			177
(single crystal)	1.5×10^{11} (Cu) contacts			+	Mobility ≥2.3 $cm^2/V\cdot sec$	178
(single crystal)	> 1.5×10^{11} (Al) contacts				Mobility 0.8 $cm^2/V\cdot sec$)(ref. 291)	178
(compacted)	10^{15}	160 to 217	2.92			
For additional data, see						9, 12, 45, 182, 183, 184, 142
			1.94			265
Anthanthrene	10^{18}		1.6		Ref. 270: ionization pot. = 7.01e.v.	76
	1.5×10^{9}	40 to 105	1.67			191
(evaporated)		25 to 90	1.60		$\rho_o=1\times10^4$	12
(single crystal)	1×10^{13}	25 to 90	1.58		$\rho_o=2$	12
Anthanthrone	7.7×10^{18}	40 to 150	1.70		$\rho_o=10^4$ ohm·cm	191
1,9,4,10-Anthradipyrimidine	8.8×10^{24}	15	3.22		$\rho_o=1.3\times10^{-3}$	91
Anthranilic acid	2×10^{15}	72	3.38		m.p. 146°C	204
Anthrone	8×10^{14}	91	1.2		$\rho_o=2.1\times10^5$ ohm·cm, discontinuity in ρ at 91°C	63
1,2-Benzacridine	10^{17}	30	2.10			77
2,3-Benzacridine	10^{17}	30	1.66			77
3,4-Benzacridine	10^{15}	30	2.4			77

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Benzanil	10^{13}	20 to 50	5.6			176
1,2-Benzanthracene	10^{16}	30	2.8		m.p. 162°C	77
Benzanthrone	$1.6x10^{16}$ to $4.3x10^{15}$		2.7 to 3.42			70
Benzene	10^{15}	5 to -14	0.84±0.08		m.p. 5.5°C	142
Benzimidazole	$5x10^{3}$	84 to 144	3.0 to 4.0		Ref. 259: dipole moment=4.03 D	191
		84 to 27	1.9 to 2.3			
	10^{15}	25	3.0-4.0			
Benzophenone	10^{11}	12.7	3.34		m.p. 48.1°C (α)	194, 204
	$3x10^{13}$	-7	3.34		m.p. 26°C (β)	204
Biphenyl	$1.7x10^{15}$	50	2.92		Photoconductivity activation energy 0.087; m.p. 70°C	77
Carbazole	$2.5x10^{15}$	50	1.172		m.p. 247°C	79
o-Chloranil	10^{15}		3.0		m.p. 290°C	142
Chloropromazine (single crystal)	10^{12} at 32°	32 to 80	2.1		m.p. 59-60°C	186
	10^{15}	> 47	2.0			142
	$2.6x10^{11}$			-		84, 147
Chlorpromazine-free radical				-	m.p. 59-60°C	84, 187
Circumanthracene						
(single crystal)	$6x10^{2}$		1.8			188
(film)	10^{16}-10^{17}		1.7			188
Coronene	$1.7x10^{7}$	15	1.7		m.p. 438-40°C	198
Cyamelurine	10^{6}-10^{9}					278
Cyananthrone	$1.2x10^{7}$	30 to 125	0.20		ρ_o= 10^{5} ohm·cm	191
1,6-Diaminopyrene	10^{8}		0.6			278

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Dibenzofuran	7.75×10^{14}	50	0.890		m.p. 86-7°C	79
Dibenzothiophene	1.0×10^{15}	50	1.712		m.p. 332-3°C	79
Dibenzo-(a, h)phrene-7, 14-dione	1×10^{4}				ρ vs pressure	24
Dibenzo-(cd, jk)pyrene-6, 12-dione	2×10^{4}				ρ vs pressure	24
2, 3-dichloro-5, 6-dicyanobenzo-quinone	5×10^{8}	25	0.6		decomposes: 214-15°C	277
Flavanthrone	1.4×10^{11}	30 to 125	0.70		ref. 191: $\rho_o = 10^5$ ohm·cm	191
	1.25×10^{11}	30 to 125	0.70			57
9-Fluorene(fluorenone)	3×10^{15}	50	5.40		m.p. 83°C	63
Fluorescein	10^{14}	84	2.44		decomposes: 314-6°C	204
Fluoridine	6×10^{3}	20 to 140	1.6	+		189
	4×10^{15}	20 to 140	1.	+		189
	2.5×10^{13}	20 to 140	p. 95	+		189
Hexacene	3.8×10^{10}	50	1.14 to 1.3			12, 79
Hexamethylbanzene	10^{18}	20 to 140	1.78	+		190
Hydroviolanthrene	1.1×10^{25}	145 to 227	3.4			191
3-Hydroxy-n-methyl-phthalimide		60 to 91	3.80			142
Imidazole	7×10^{11}	30	2.6		m.p. 90°C; ref. 259: dipole moment 3.99 D	194, 286
Indanthrazine	1.4×10^{15}	30 to 125	0.66		$\rho_o = 2.2\times10^{9}$ ohm·cm	191, 57

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Indanthrone	7.5×10^{14}	30 to 125	0.64			191
(black)	2.5×10^{8}	30 to 125	0.56			191
	2.5×10^{8}		0.76		$\rho_o = 1.8 \times 10^{-1}$ ohm·cm	63
Meso-naphthodianthrene		40 to 450	1.48			160
		5 to 110	0.86			
		110 to 250	1.46			160
			.74			267
2-Methoxynaphthalene		42 to 58	6.5			192
Naphthacene					Ref. 248: heat of combustion (C_p at 20°C) 2140.86 kcal/mole Ref. 283: 6.95 e.v. ion. pot. Heat of sublimation 29.7 kcal/mole Ref. 41: work function 5.25 m.p. 335°C	
	1.2×10^{14}	30	1.70 to 1.64			76
						12, 181
Naphthalene					Ref. 249: lattice energy 17.3 kcal/mole m.p. 80.22°C Ref. 253: electron affinity (PhCl = 1) = 0.01 Ref. 270 & 294: Ionization pot. = 8.08 e.v.; ref. 283: 7.53 e.v. Ref. 244: $S_{298} = 39.9$ e.w. $\Delta H_{298} = 15,960$ cal. $\Delta S_{298} = -98.0$ e.w. $\Delta G_{298} = +45,20$ cal.	
	10^{15}	60 to 75	3.7			193
	10^{19}	20 to 75	1.4			83
	10^{15}	40 to 72	3.0			194
	10^{15}	40 to 80	1.46			83, 195
	10^{14}	25 to 70	1.5			176
	10^{14}	27 to 47	3.5			142
			2.25			265

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Major-ity Carrier		Ref.
Naphthalene-picrate		48 to 96	2.2 to 2.6		m.p. 151.5°C	192
m-Naphthodianthrene	4×10^{8}	40 to 150	1.20			191
m-Naphthodianthrone	1.5×10^{18}	40 to 150	1.30		$\rho_o = 6 \times 10^{6}$ ohm·cm	191
meso-naphthodianthrone			0.74 & 0.43			267
β-Naphthol	2×10^{5}	60 to 110	2.36±.01		m.p. 122°C	90,58
1-Naphthylamine		25 to 42	2.2 to 2.9		m.p. 50°C	
	10^{10}–10^{13}	20	1.8 to 2.8		$\rho_o = 5.6 \times 10^{-14}$ ohm·cm	192
					7.6×10^{-8} ohm·cm	273
1-Naphthylamine picrate		28 to 98	2.7 to 2.9			192
2-Naphthylphenylsulfone		67 to 102	3.5 to 3.8			192
1-Nitronaphthalene		25 to 44	2.5±0.1		m.p. 58.5°C	192
Octahydroviolanthrene	1.1×10^{25}		3.4			191
Octoido-p-benzquinhydrone	10^{11}					62
Ovalene	2.3×10^{15}	40 to 125	1.14			191,93
	2.3×10^{15}		1.13			144,180,
						12,196
Pentacene	1×10^{14}		1.5		Ref. 41: workfunction 5.1	77,
					m.p. high; b.p. 290-300°C sub.	144
		0 to 150	1.62		Ref. 76: $\sigma = 10^{-2}$ ohm^{-1}cm^{-1}	24,76
			1.5			265
	6×10^{13}	20 to 140	1.5		Unit cell a(7.90, 101.3);	
					b(6.06, 111.8); c(15.95, 94.4)	79,41
Perylene	4×10^{8}	15	2.0		m.p. 273-4°C	198
	10^{17}		1.96		$\rho_o = 1$	76
	1×10^{18}	60 to 80	2.0		Ref. 270: Ionization pot. = 7.06 e.v.	142

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Perylene (continued)	10^{18}	80 to 180	2.0			198, 93
	$\sim 10^{13}$	50 to 130	2.2			198, 93
(single crystal)	6.5×10^{15}	40 to 100	$\perp$(001)2.1			197, 77
(single crystal)	4.1×10^{13}	40 to 100	$\perp$(001)2.2			197, 77
			1.80			265
Phenanthrene	10^{13}	27 to 90	2.82		Ref. 3: electron affinity $\sim$ -1.3	142
					Ref. 270: ionization pot. =8.22 e.v.	
(single crystal)	4.8×10^{15}	12 to 72	$\perp$(ab)1.14		Ref. 253: =0.05 (PhCl= 1)	200
(single crystal)	1.3×10^{14}	12 to 72	$\parallel$(ab)1.15		m.p. 101°C	200
(single crystal)	5.4×10^{13}				Ref. 244: ΔH_{298}= +23,100 cal ΔS_{298}= -123.7 e.v. ΔG_{298}= +60.0 kcal	199
See also:						3, 63, 201, 202
(compacted)			2.24		Shows phase transition at 64-71°C	265
					Ref. 248: heat of combustion (Cv at 20°C) 1,684.88 kcal/g	298
Phenazine	7×10^{14}	100	2.1		m.p. 171°C	37, 203
					Ref. 37: thermal activation energy	7
					at illuminated electrode 0.17(-), 0.11(+)	142
1-Phenyl-naphthalene	1.7×10^{11}				m.p. ca. 45°C	235
Phenosafranine	10^{12}	84	2.08		T vs σ, λ corresponding to E is 595 mμ	204
Phenothiazine	10^{11}	50 to 150	1.6		Ref. 270: ionization pot. =7.28 e.v.; m.p. 185.5°C	68, 203

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Phenylanthranilic acid	$2x10^{15}$	87 to 119	3.30		T vs σ, λ corresponding to E is 375mμ	204, 260
Phosphonitrilic chloride trimer	$> 10^{15}$					142
	10^{15}		1.68			142
	$8x10^{10}$		0.7			205
Phthalocyanine, metal free	10^{13}	26 to 350	1.66	-	Mobility 0.1 to 0.4 $cm^2/V \cdot sec$	207
					Ref. 254: pK in H_2SO_4 =1.65±0.02	
		-35 to 60	1 to 2	+	Mobility $4x10^{-3}$ $cm^2/V \cdot sec$	206
		15 to 140	1.68		Does not melt	142
		0 to 100	1.9			142
	10^{12} to 10^{13}	60 to 110	1.7±.1		See ref. 142 for more references	208
			1.74			261
Phthalocyanine	$2x10^4$	25	1.385		Seebeck coef.:-1.68mV/°C	285
(metal-free α)	$4x10^5$	-60 to 135	0.48			209
(metal-free β)	$2x10^{15}$	200 to 315	1.82			209
(metal-free α)	$2x10^{11}$	20 to 100	1.32	+		142
(metal-free β)	$5x10^{12}$	25 to 165	0.81	+	Mobility 0.1 to 0.4 $cm^2/V \cdot sec$	207, 42
			1.66			
(single crystal) (metal-free β)	$3.6x10^{17}$	60 to 200	‖ (b) 1.82			210
Pinocyanol	10^{12}		1.8		at 10^{-4} to 10^{-5}mm press.	219
Pyranthrene	$1x10^{15}$		1.11			12
	$4.5x10^{16}$	15	1.71		$\rho_o = 2x10^7$	57, 12, 145, 77
Pyranthrone	$3x9x10^{15}$	40 to 150	1.06;1.8		m.p.:d.sub. vac.	56
					ρ_o=$3.7x10^6$ ref. 56; $1.3x10^{-1}$ ref. 63	63

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Pyranthrone (continued)			1.5±0.05		See 24 for pressure effects no hysteresis with pressure E activation of photocurrent = 0.18 e.v.	144, 77, 24 266
	10^{20}	60 to 90	2.4		Electron affinity +0.8	80
	$5x10^{17}$		2.02		Ionization potential 7.4_eV ref. 74, 283	76
					Ref. 181: $3.6x10^{-2}$ photocurrent	3, 12, 15, 22
	10^{18}		2.02		ρ_o = 1 ohm·cm, 1_{E_1} = 3.70 Ref. 247: heat of combustion C_V at 25°, 9260.1 cal/g Ref. 249: lattice energy 22.5kcal/mole Ref. 255: relative electron absorption coef. (PhCl=1)= 6.0 m.p. 159-50°C	76
5,6-N-pyridine-1,9-benzanthrone	$8.5x10^{22}$	15	3.20		ρ_o = $1.4x10^{-5}$ ohm·cm	191, 77 144
p-Quaterphenyl	$1.0x10^{15}$		1.78		photoconduction thermal activation energy 0.12±0.015 eV m.p. 118°C	37, 77
Quaterrylene (single crystal)	10^5 ab 10^{13} ab		0.6	-	Mobility 10^{-3} cm^2/V·sec Does not melt or decompose at 500°C	91, 272
Quinhydrone	10^{11}				m.p. 171°C	62
α-Resoicin	$2x10^{16}$	30 to 94	2.10			

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
β-Resoicin	$2x10^{18}$	30 to 94	3.27			142
	$5x10^{18}$	56 to 98	4.24			142
Salanil	10^4	20 to 40	4.1			92
Salen	10^{11}		5.7			92
Salphen	10^9		5.4			92
Stilbene	$5x10^1$		1.70	+	Mobility 2.4;10^{-3} $cm^2/V \cdot sec$	45, 176
<u>cis</u> - Stilbene					Electron affinity ~0.0	3
					Ref. 253:(PhCl= 1)=1.0	
trans - Stilbene		70 to 120	2.4		m.p. 124°C	
					Electron affinity ~+0.5	
					Ref. 253: 4.0	3, 77
m-Terphenyl				+	Mobility: $3x10^{-5}$ $cm^2/V \cdot sec$	142
p-Terphenyl (single crystal)	10^{14}	25	1.2	+	Mobility: 0.025 $cm^2/V \cdot sec$	37, 77
	$5x10^{14}$	50	2.12	+	Mobility: ~10^{-5} $cm^2/V \cdot sec$	45, 142
Tetracene	$8x10^9$		1.70		m.p. ca. 335°C	24
					Compressed at 100 kbar	
	10^{15}	15	1.32		Ref. 23: a 7.98; b 6.14; c 13.57	24
	$3.2x10^{12}$	50	1.38			
	$3.2x10^{12}$	50	1.38		α 98.0;β 112.4;γ 92.5	79
					See also: 76, 77	
Tetracyanoethylene	10^{12}	150				159
1,1,10,10 Tetracyandecapenta-ene	10^{13}	> 68	2.24			180
1,1,6,6-Tetracyanhexatriene	10^{14}		1.54			180

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Major-ity Carrier		Ref.
1,1,8,8-Tetracyanotetraene	10^{12}		1.42	-		180
1,2,4,5-Tetraiodoimidazole	10^{6}					105
Tetrathiotetracene	10^{4}		0.46		Mobility: 1. $cm^2/V\cdot sec$	67
Thionine	10^{13}-10^{11}	49 to 97	1.83			204
Thiphenodioxazine	$5x10^{14}$	20 to 140	1.65			142
	$2x10^{16}$	20 to 140	1.7			142
	10^{15}-10^{16}	20 to 140	1.7	-		142
2,4,7-Trinitrofluonenone	$10^{9}$to 10^{12}				ρ vs varying frequencies	58
Violanthrene	$2.1x10^{14}$	40 to 105	0.86			12
	10^{14}		0.9			57,93
	$2.1x10^{14}$	60 to 80	0.85			198
	10^{14}	80 to 180	0.9			198
	10^{9}	50 to 130	0.9			198
Violanthrone	$2,3x10^{10}$	40 to 150	0.79		No hysteresis of ρ with T m.p. 490-5°C d.	56,24
	$5x10^{9}$				Ref. 24 gives ρ vs pressure	57
					ρ_o= $2.9x10^{3}$	144
Isoviolanthrene	$3.6x10^{14}$		1.92		ρ_o= 20 ohm·cm	29
	$8.4x10^{13}$		0.86 to 1.62			
Isoviolanthrone	$5.7x10^{9}$		0.75		Ref. 266: thermal emf=$\sim 10^{-4}$v/°C	56
	$5.7x10^{9}$	40 to 150	0.76			93,142
	$8.5x10^{9}$		0.96			82
	$3.2x10^{19}$	50 to 130	1.76			70

TABLE 2

COMPLEX METAL COMPOUNDS

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Co-dipyrromethene-1	1.4×10^{11}	> 159	1.88			173
Cu-dipyrromethene-1	1.0×10^{11}	> 112	1.85			173
Co-dipyrromethene-2	2.51×10^{11}	> 100	2.30			173
Cu-dipyrromethene-2	2.81×10^{11}	> 100	2.33			173
Ni-dipyrromethene-2	4.47×10^{11}	> 100	2.29			173
Zm-dipyrromethene-1	1.05×10^{14}	> 152	2.24			173
Dipyrromethene-1-hydrobromide	4.36×10^{13}	> 142	2.27			173
Ferrocene (single crystal	1.2×10^{13}	20 to 80	0.6	+	Mobility: 1 $cm^2/V \cdot sec$ Ref. 63: ρ_o= .65, E= 1.56 eV	142
	10^{13}	150				159
	8.6×10^6				1 atm	231, 230
	1.78×10^7				33,000 atm	239
	6.4×10^{12} to 2.56×10^{13}			+	Mobility: 1.2 $cm^2/V \cdot sec$ Thermoelec. power 1.2 [illegible]	296
Co-phthalocyanine (single crystal)	4×10^9				Mobility: 2.2×10^{-2} $cm^2/V \cdot sec$ Ref. 77: E= 1.6 eV	142
Cu-phthalocyanine	10^{12} to 10^{13}	-100 to 200	1.7	+	Ref. 41: work function 5.0	142
			2.4			261
	10^{12} to 10^{13}	60 to 160	1.7±0.1		Ref. 254: pK in H_2SO_4=1.64±0.03	142
	2×10^{11}					174
	10^{12}	5 to 85	1.3			142, 271
(single crystal)	10^{12}-10^{13}	25 to 150	>370°K 1.66 <370°K 2.0	- 300°K + >370°K	Mobility =75 $cm^2/V \cdot sec$ See also 41, 77, 81, 144	175 175

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Fe-phthalocyanine	$4x10^9$				Work function 4.85	41
Fe-tetracyanoethylene	$3.3x10^8$				Dielec. const. E= 7 at 3000 cycles/sec	268
Mg-phthalocyanine	10^9 to 10^{10}	60 to 180	0.5 to 0.8 1.56		Work function 4.75	41,77 261
Mn-phthalocyanine (single crystal)	$4x10^6$					174
Mo-phthalocvanine	$\sim 2x10^9$		1.1		ρ_o= 20, ρ vs T given	63
Ni-phthalocyanine(single crystal)	$6x10^{10}$				Ref. 77: E= 1.6 eV	174
Pt-phthalocyanine			3.52		ρ_o= $4.4x10^3$ ohm. cm	77
Zm-phthalocyanine	10^{12} to 10^{13} 10^{12} to 10^{13}	-100 to 200 60 to 150	1.8±0.1 1.8±0.1	+	Ref. 254: pK in H_2SO_4=2.31±0.04	142 142
(single crystal)	$3x10^9$					174
Ni (2) - Salen	10^{14}		2.1			92
Cu (2) - Salen	> 10^{15}					92
Ni (2) - Salphen	10^{15}		3.4			92
Cu (2) - Salphen	> 10^{15}					92
Sulfur compounds of aromatic hydrocarbons (structure unknown)	10^2 to 10^4	below 450	0.2			93
Cu-tetra-2, 3-pyridinoporphyrazine	$2.9x10^{10}$ $3x10^7$	5 to 100	1.7 0.81 0.81		Ref. 271: E= 1.17 eV	142
Tri-p-methoxylphenylmethyl-perchlorate (single crystal)	$3.5x10^9$	18.5		-		142

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Majority Carrier	Ref.
Cs-1,3,6,8-tetrabromopyrene	1.6				109
Cs-1,3,6,8-tetrachloropyrene	8				109
Cs-1,3,6,8-tetracyanopyrene	$6x10^5$				109
Cs-1,3,6,8-tetranitropyrene	$2x10^6$				109
Cs-pyrene	2.1x10[illegible]				109

TABLE 3

CHARGE TRANSFER COMPLEXES

Donor/Acceptor	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Acenaphthene/tetracyano-ethylene	5.3×10^{13}	20 to 85	2.04			66
Acridine/I_2	10^{13}					62
Al-diethylchloride/pyridine	5×10^{2}					299
p-Aminodiphenylamine/chloranil	10^{10}					62
Aniline/1,3,5-trinitrobenzene	1×10^{17}		2.54			113
p-Anisidine/chloranil	10^{11}					62
Anthracene/tetracyanoethylene	1.1×10^{10}	20 to 85	1.34			66
Anthracene/I_2 vapor	10^{15-16}					142
Azulene/tetracyanoethylene	4.7×10^{10}	20 to 80	0.76			6, 66
Benzidine/I_2 (1:1)	2×10^{6}	-150 to -10	0.48			142
Benzidine/I_2 (1:0.96)	2.5×10^{9}					264
Benzidine/I_2 (0.75:1)	1.6×10^{5}	-70 to 20	0.68		Ref. 264: $\rho = 3.3 \times 10^{5}$ (1:1.35)	101
(1.00:1)	6.2×10^{2}		0.38		Ref. 264: $\rho = 3.3 \times 10^{5}$ (1:1.17)	101
(1.25:1)	2.2		0.38		Ref. 264: $\rho = 2.5 \times 10^{5}$ to 2×10^{2} (1:1.50)	101
(1.50:1)	12		0.38			101
Benzidine/1,3,5-trinitrobenzene	3.3×10^{8}					264
Benzophenothiazine/I_2	20		0.28 to 0.40			68
2:3-Benzoquiloline/ICl	10^{13}					62
3:4-Benzoquinoline/Br_2	10^{6}		0.37		Series of isomers given, compression at 8-12 kg/cm^2 leaves ρ uneffected	162

Donor/Acceptor	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
5,6-Benzoquinoline/Br_2	$3.1x10^7$		1.70			162
7,8-Benzoquinoline/Br_2	$7.5x10^6$					162
1,2-Benzpyrene/tetracyano-quinodimethane	$5x10^{11}$		3.1			142
3,4-Benzpyrene/tetracyano-quinodimethane	$4x10^{10}$		2.44			34
Cs/Pyrene	$2.1x10^4$		0.42			109
Cs/1,3,6,8-tetracholorpyrene	8		0.34			109
Cs/1,3,6,8-tetrabromopyrene	16		0.35			109
Cs/1,3,6,8-tetranitropyrene	$2x10^6$		0.94			109
Cs/1,3,6,8-tetracyanopyrene	$6x10^5$		0.70			109
Carbazole/chloranil	$< 10^9$					142
Carbazole/tetracyanoquinodi-methane	$7x10^{10}$	10 to 127	1.1			142
Carbon/F_2	0.059			-		69
β-Carotene/Tri-iodide	$2x10^8$	-48 to 27	1.1±0.1			163
p-Chloroaniline/1,3,5-trinitro-benzene	$5x10^{13}$		2.72			166
Chloropromazine/melanine	1000					84
Cobaltocene/chloranil	$2.05x10^4$				Pressure vs ρ data given	73
Cobaltocene/2,3-dichloro-5,6-dicyanoquinone (1:1)	$3x10^3$		1.8			164

Donor/Acceptor	ρ ohm. cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Cobaltocene/3, 3', 5, 5'-tetra-chloro-p-diphenoquinone	40.1				Pressure vs ρ data given	73
Cobaltocene/tetracyanoethylene	10^{12}		5.2			164
Cobaltocene/3, 3', 5, 5'-tetra-bromo-p-diphenoquinone	40.1				Pressure vs ρ data given	73
Coronene/I_2	$2x10^8$	25 to 70	0.5	+	Seebeck coef. +1.7 V/°C	6, 86
	10^9					62
Coronene/picric acid	10^{12}					62
Coronene/1, 3, 5-trinitrobenzene	10^{13}					
Coronene/2, 4, 7-trinitro-fluorenone	10^{12}					
Diaminodurene/chloranil (crystal)	X7.0x10^4	-50 to 30	0.26	+	Seebeck coef. +0.3±15% V/°C	61
	Y6.9x10^4	-50 to 30		+		61
	Z8.4x10^4	-50 to 30		+		61
(powder)	$3x10^4$	-50 to 30	0.29	+		61
1, 5-Diaminophthalene/chloranil (single crystal)	X1.3x10^9	20 to 90	0.6	+		61
	Y6.3x10^{11}	20 to 90	0.74	+		61
	Z2.0x10^{11}	20 to 90	0.74	+		61
(powder)	7.2x10^{11}	20 to 90	0.65	+		61, 62
	6.1x10^{10}				Resistance =4.3x10^8Ω, thickness 0.34 cm at 12.5 Kbar	27, 26 102
1, 6-Diaminobenzene/2, 3-dichloro-5, 6-dicyanobenzoquinone	10^6	25	0.37			277
1, 5-Diaminonaphthalene/1:1 chloranil	6.1x10^{10}					27, 26, 102
1, 6-Diaminopyrene/Br_2	10^4	-72 to 23			Ref. 74: ~100% ionic	85

Donor/Acceptor	ρ ohm·cm	Temp °C	E in E/2kT	Mobility $\frac{cm^2}{V \cdot sec}$	Sign of Majority Carrier		Ref.
1,6-Diaminopyrene/chloranil (single crystal)	X10^9		0.19				61
	Y10^6		0.19				
	Z10^9		0.19				
(powder)	$4x10^3$		0.15				73, 13, 62
	10^4		0.30				
1,6-Diaminopyrene/(1:1) chloranil	$1.2x10^4$						27, 26, 102
1,6-Diaminopyrene/ 2,3-dichloro-5,6-dicyanobenzoquinone	10^2					~95% ionic character	74
3,8-Diaminopyrene/chloranil	$4x10^3$	25 to 70	0.15	$< 10^{-2}$	+	Shows irreversible pressure effect Seebeck coef. +0.005 V/°C	86, 6
3,8-Diaminopyrene/bromanil	1000	25 to 70	0.15	$< 10^{-2}$	+	Seebeck coef. +0.1 V/°C	86
	1000	-70 to 80	0.12			ref. 74: 35% ionic component	6, 62
3,8-Diaminopyrene/dodanil	$2x10^6$	25 to 70	0.43 to 0.38		+	Seebeck coef. +0.7 V/°C	86
3,10-Diaminopyrene/chloranil	$3x10^6$ to $1x10^7$	25 to 70	0.39 to 0.41		+	Seebeck coef. +0.4 V/°C	86, 62
Dibenzo [c, d] -phenothiazine/ dichloro-5,6-dicyano-p-benzoquinone (2:1)	20.7	27 to 127	0.42			no hysteresis with pressure	26 142
(3:2)	230	27 to 120	0.44				26

Donor/Acceptor	ρ ohm·cm	Temp °C	E in E/2kT	Mobility $\frac{cm^2}{V \cdot sec}$	Sign of Majority Carrier		Ref.
Dibenzo [c,d]-phenothiazine/ 2,3-dichloro-5,6-dicyano-p-benzoquinone (2:1)	17	0 to 120	0.18		+	Thermoelectric power + (about 100μ V/C°)	2
(2:1)	1.6		0.18			$\rho_o = 5.6x10^{-2}$ at 36 K bar	73
(1:1)	5000	0 to 120					2
Dibenzo [c,d]-phenothiazine/ 2,3-dibromo-5,6-dicyano-p-benzoquinone (1:1)	10^8	0 to 120				No. of free spins/g $1.6x10^{20}$	2
	230	27 to 127	0.44			ρ affected by absorbed moisture	26
(3:2)	240	0 to 120	0.27			No. of free spins/g $4.8x10^{20}$	2
(3:2)	4.8		0.22			at 36 K bar; press. vs ρ for 2 to 36 K bar	73
Dimethoxybene/tetracyano-ethylene	10^{11}						62
Dimethylanaline/chloranil	$1.0x10^7$		0.47				93
	$5x10^7$ ac $8.1x10^8$ dc	20 to -45	0.47				152
	$1.0x10^9$	15	0.47				62
Dimethylanaline/bromanil	$1.7x10^9$		0.45				93
	$9x10^7$ ac $1.5x10^9$ dc	20 to -45	0.45				152
Dimethylanaline/iodanil	$1.9x10^8$		0.43				93
	$3x10^7$ ac $1.7x10^8$ dc	20 to -45	0.43				152
N,N-Dimethylanaline/ 1,3,5-trinitrobenzene	$1x10^6$		2.08			ref. 62: $\rho = 10^8$ single crystal	63, 166 142

Donor/Acceptor	ρ ohm·cm	Temp °C	E in E/2kT	Mobility $\frac{cm^2}{V \cdot sec}$	Sign of Majority Carrier		Ref.
Durenediamine/chloranil	1.80×10^{15}		0.475			ref. 73: $\rho = 8.4\times10^4$, $\rho_o = 9.39\times10^1$	59, 73
N-Ethylcarbazole/Tetracyanoquinodimethane (1:1)	$-.8\times10^{13}$	10 to 127	1.1				142
Ferrocene/2,3-dichloro-5,6-dicyanoquinone (1:1)	3×10^{10}		1.4				164
Ferrocene/tetracyanoethylene	3×10^{12} 10^9						164 142
Graphite/Br_2	10^{-4} 2.6 to 4.5×10^{-3}	25 to -196			+		87 69
(fully brominated)	6.3×10^{-6}						142
Hexamethylbenzene/chloranil	10^{11}						62
Hexamethylbenzene/tetracyanoethylene	4.1×10^{13} 10^{11}	20 to 85	-.16				66 62
1-Hydroxy-anthraquinone/1.8-napthalic anhydride	3.05×10^5					ρ vs load given	25
Li / anthracene (1.16:1)	10^{11} 2.2×10^{11}	25 to 50	1.34 2.72			$\rho_o = 3\times10^2$ $\rho_o = 1.1\times10^2$	165 165
Lumiflavin/hydroquinone	2×10^{10}						212
Methylamine/chloranil	10^{14}	10 to 70	58 to 1.02				142
N-Methylphenothiazine/I_2	1.4	20	0.28				68
Naphtholene/tetracyanoethylene	3.2×10^{15}	20 to 85	2.48				6, 66, 113
β-Naphthol/2,4,7-trinitrofluorenone	10^{13} to 10^{18}		1.8			ρ vs varying frequencies	58

Donor/Acceptor	ρ ohm·cm	Temp °C	E in E/2kT	Mobility $\frac{cm^2}{V \cdot sec}$	Sign of Majority Carrier		Ref.
α-Naphthylamine/1,3,5-trinitrobenzene	$3x10^7$	20 to 85	2.48				6,66, 113
1,5-Naphthylenediamine/I_2							
(0.75:1)	$6.1x10^7$		1.32				
(1.00:1)	$1.6x10^6$		0.84				101
(1.25:1)	$1.0x10^6$		0.80				
(1.50:1)	$3.1x10^5$		0.64				
Pentanethylbenzene/tetracyanoethylene	$4.4x10^{13}$	20 to 85	1.12				66
Perylene/Benzoquinone	$3x10^6$		0.9				
Perylene/Br_2	7.8	-20 to -170	0.13				167,168
Perylene/chloranil	$2.8x10^{11}$					ref. 78: ρ_o = 1 ohm cm	108,106, 78,93
(single crystal)	$3x10^{14}$		0.73				27,26, 102
Perylene/fluoranil mean	$6x10^{13}$		0.73				142
Single crystal ∥c	$8.5x10^{13}$						142
⊥c	$2x10^{14}$						142
∥c	$6.6x10^{13}$		1.46				142
⊥c	2x	1.46					142
compacted 1:1	$3.4x10^{12}$						142
Perylene/I_2 (1:1)	10		0.06				27,26, 102
(1:1)	8	-70 to 20 -180 to 25	-.038	< 0.01		ref. 232: spin concentration (ESR) @ 300°K = $4.6x10^{19}$	113 31
(1:3)	6.3		Ref. 100: $X_M = -342x10^{-6}$			for 2 Perylene·3 I_2	26,27,102
(2:3)	3.0-8.0		Ref. 100: $X_M = -217x10^{-6}$			complex stable in closed container	26,27,102
(1:1)	2 to 3	25 to 70	0.011 to 0.019	$< 8x10^{-3}$		see also: 6,66,62, 59,232	86

Donor/Acceptor	ρ ohm·cm	Temp °C	E in E/2kT	Mobility $\frac{cm^2}{V \cdot sec}$	Sign of Majority Carrier		Ref.
Perylene/metal halides	10^5		0.5		+ or -		88
Perlene/Sb Cl_5	32	-73 to +20 -73 to -155	0.196 0.134				60
Perlyene/tetracyanoethylene (single crystal)	2.4×10^{12}	20 to 85	1.44			ref. 6: molecular structure apparently changed with pressure	6, 66, 113
Perlene/I Cl	10^5	7 to 40	0.34		+	Seebeck coeff. +0.015 V/°C	114, 142
Perylene/Pt Cl_4	10^7 to 10^9	7 to 40	1.0		+	Seebeck coeff. +0.04 V/°C	114, 142
Perylene/Sb Cl_5	625	7 to 40	0.34				114
Perylene/Sb Cl_3	3.6×10^9	7 to 40	1.06				114
Perylene/tetracyanoethylene	10^{14}	7 to 40					114
Perylene/I_2	125	7 to 40	0.2		+	Seebeck coeff. +0.035 V/°C	114, 142
Perylene/ 2,3-dichloro-5,6-dicyanobenzoquinone	3×10^6	25	0.45			-0.01 V/°C Decomposes 204°	277
Perylene/Fe Cl_2	7.7×10^5	7 to 40	0.5				114
Perylene/Fe Cl_3	8.3×10^6	7 to 40	0.66		+ or -		114
Perylene/Os Cl_3	5.9×10^{10}	7 to 40	1.2				114
Phenanthrene/tetracyano-ethylene	2.2×10^{12}	20 to 85	1.52				66, 113
Penanthrene/1,3,5-trinitro-benzene	7×10^{18}		2.48				113, 142

Donor/Acceptor	ρ ohm·cm	Temp °C	E in E/2kT	Mobility $\frac{cm^2}{V \cdot sec}$	Sign of Majority Carrier		Ref.
Phenazine/o-hydroquinone	$7x10^{12}$		0.5				142
Phenazine/dehydrophenazine	$3.7x10^{10}$		1.3 to 1.5				142
Phenazinium chloride/ pyrene	$6x10^{10}$		1.2				142
Phenazinium chloride/ p-hydroquinone	$3x10^{11}$		1.1 to 1.5				142
Phenazinium methosulfate/ pyrene	$1.5x10^{13}$		2.8				142
Phenazinium methosulfate/ p-hydroquinone	$2.9x10^{12}$		3.7				142
Phenothiazine/I_2	20		0.34				68
Phenothiazine/I_2 (recrystallized)	20		0.28 to 0.40				68
m-Phenylenediamine/ chloranil (5:3)	$5x10^8$	-90 to 50	1.17				142
p-Phenylenediamine/ chloranil (1:1)	$2x10^7$	15 to 100	0.86		+	see also ref. 1, 27, 167, 170	142
	$5x10^6$		0.570			ref. 170: Seebeck coeff. $1.1x10^{-3}$ V deg^{-1} °C	6
						Thermal conductivity $2.0x10^{[illegible]}$ w cm^{-1} deg^{-1} °C	62
p-Phenylenediamine/benzoquinone	10^6		0.74		+		167
Phenylenediamine/chloranil	$6x10^6$ to $1x10^8$	25 to 70	0.57 to 0.65		+		86

Donor/Acceptor	ρ ohm·cm	Temp °C	E in E/2kT	Mobility $\frac{cm^2}{V \cdot sec}$	Sign of Majority Carrier		Ref.
p-Phenylenediamine/chloranil	$5x10^5$	-10 to 20	0.5				1, 169
	$6x10^6$	25	1.67				86
	$5x10^7$	-23 to 57	1.14	Thermal cond.: $2.0x10^{-3}$ w./cm·°C	+	Seebeck coef. +0.83 to 1.22 m V deg^{-1} °C	170
	$4.3x10^6$						26, 27, 102
p-Phenylenediamine/fluoranil	$\sim 10^9$						6
p-Phenylenediamine/iodanil	10^{11}						62
p-Phenylenediamine/I_2	10^5			ortho - $\rho = 10^9$, meta - $\rho = 10^7$			295
(0.45:1)	$5.3x10^3$	25 to 85	1.60				115
(0.67:1)	$3.5x10^7$	25 to 85	1.22				115
(0.82:1)	$1.7x10^5$	25 to 85	0.82				115
(1.03:1)	$2.7x10^5$	25 to 85	0.88				115
(1.36:1)	$1.04x10^6$	25 to 85	0.96				115
(1.62:1)	$5.4x10^6$	25 to 85	1.18				115
(3:1)	$2x10^{10}$	27					6, 62
p-Phenylenediamine derivatives/I_2 (1:1.2)	3	-20 to 90	0.086				107
p-Phenyldiamine/1,3,5-trinitrobenzene	$0.8x10^{16}$		2.04				113, 142
Poly(4-vinyl) pyridine/I_2							
(2:1)	10^4		1.3				116
(3.3:1)	10^7						116
Phthalocyanine/chloranil	100	25 to -100	0.4	10^{-4}	+	Seebeck coef. +0.130 m V deg^{-1} °C	117
K / anthracene	10^{11}	25 to 50	2.20			$\rho_o = 2.2x10^4$	165

Donor/Acceptor		ρ ohm·cm	Temp °C	E in E/2k	Sign of Majority Carrier		Ref.
K/ graphite		1.72 to 0.68×10^{-3}		-183 to 15	+	Ref. 252: $\Delta H_5 = 6.6$ kcal/C_8K, 11.92 kcal/$C_{24}K$ $\rho_o = 1.0 \times 10^{-3}$	69
K 1.42: Isoviolanthrene	1	2600		0.28			29,70
4:05 :	1	100		0.166	-		29,70
4:35 :	1	27		0.060	-		29,70
Pyranthrene/Br_2		220	-20 to -170	0.20		Ref. 78: $\rho_o = 3 \times 10^{-2}$ ohm·cm	62,93, 108, 106, 78
Pyranthrene/I_2		17		0.09			93
Pyrene/Benzoquinone		10^{13}		1.8	-		167
Pyrene/chloranil		10^{16}		0.73			142
Pyrene/Tetracyanoquino-dinemethane		10^{16}		0.73			142
Pyrene/I_2		75 77	-18 to -70 15	0.136 0.14-0.28		Mobility: 0.01 $cm^2/V \cdot sec$	31,62 35,66
Pyrene/Tetracyanoethylene		4.5×10^{15}	20 to 85	1.65	+	Mobility: $\mu_- = 10^{-2}$ $cm^2/V \cdot sec$ $\mu_+ = 30$	113,66 171
Pyrene/2,3-dichloro-5,6-dicyanobenzoquinone		10^{13}	25	0.9		Decomposes 233-4°C	277
Pyrene/1,3,5-trinitrobenzene		1×10^{20}		2.20			113, 142
Riboflavin/hydroquinone		1×10^{6}				1×10^{8} ohm·cm after 30 hrs. electrolysis	212

Donor/Acceptor	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Riboflavin/resorcinol	$1.5x10^8$				ρ unchanged after 30 hrs. electrolysis	212
Na 1.07/Acridine	$1.2x10^{16}$	293	3.98			162
Na/Anthracene	10^8-10^{10}	25 to 50	0.63		Ratio 1.08 to 2.12:1 given with ρ values	165
Na 1.60/Ahthracene (Et_2O) 0.30	$6.2x10^{10}$		0.26			
Na/3,4-benzoquinoline (1.5:1)	10^{10}		0.35			166, 162
Na/5,6-benzoquinoline (1.6:1)	$1.4x10^{11}$		2.36			162
Na/7,8-benzoquinoline (1.10:1)	$4x10^{17}$		4.30			162
Na/Bromanil	$< 10^{10}$					74
Na/Isoviolanthrene (0.31:1)	$3.1x10^5$		0.42	-		29, 70
(2.37:1)	61		0.092	-		29, 70
Tetramethylbenzidine/chloranil	$2.3x10^7$					26, 27, 102
Tetramethylbenzene/Br_2(1:.48)	$1x10^6$				(1:51) $\rho = 3.3x10^5$	264
Tetramethylbenzidine/fluoranil	$2.8x10^{12}$					26, 27, 102
Tetramethylbenzidine/I_2(1:135)	$1.6x10^9$					264
Tetramethyl-p-phenylene-diamine/chloranil	$2.4x10^4$		0.53			93, 6, 62
	$1.3x10^4$ ac $2.0x10^4$ dc	0 to 25	0.53			89
Tetramethyl-p-phenylene-diamine/bromanil	$1.6x10^5$		0.56			6, 93
	$4.2x10^4$ ac $1.3x10^5$ dc	10 to 25	0.56			89

Donor/Acceptor	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Tetramethyl-p-phenylene-diamine/iodanil	1.8×10^6	15	0.59			93
	1.1×10^5 ac 1.5×10^6 dc	-10 to -30	0.59			89
Tetrathiotetracene/chloranil	2 to 4	0 to 120	0.20	+	Thermoelectric power= 20 to 30μ V/°C	67
Tetrathiotetracene/o-chloranil						
(3:1)	5.6	20 to 120	0.24			26
(3:1)	0.30	0.040			$\rho_o = 4.0 \times 10^{-1}$, ρ vs P given for 2 to 36 Kbar	73
Tetrathiotetracene/o-bromanil	6 to 8	0 to 120	0.20	+		67
	1.8	27 to 120	0.24			26
(3:1)	0.42	27	0.02		$\rho_o = 2.4 \times 10^{-1}$; ρ vs P from 2 to 36 Kbar	73, 26
Tetrathiotetracene/tetracyanoethylene	15	0 to 120	0.20	+	Thermoelectric power = +20 to +30 μV/°C	67
o-Toluidine/I_2 (0.75:1)	3500	0.54				101
(1.00:1)	290	0.48				101
(1.25:1)	29	0.36				101
(1.50:1)	91	0.36				101
Triethylamine/chloranil	10^{14}	10 to 70	0.88 to 1.7			142
Violanthrene/Br_2	66	-20 to -170	0.20			93,78 108,1
Violanthrene/I_2 (1:1)	45	-20 to -170	0.15			93
(1:1)	45	10 to 60	0.14			93
(1:3.17)	127	-180 to 15	0.25	+	Mobility: 1.7×10^{-3} cm^2/V·sec	100
(1:1.90)	18.0	-180 to 15	0.14	+	" 2.7×10^{-3} "	100
(1:1.31)	24.0	-180 to 15	0.18	+	" 5.4×10^{-3} "	100

Donor/Acceptor		ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Violanthrene/I_2 (continued)							
	(1:0.118)	2.2×10^{2}	-180 to 15	0.18	+	Mobility 4.7×10^{-3} $cm^2/V \cdot sec$	100
	(1:1x10-2)	3.1×10^{5}	15 to 90	0.45	+	" 8.4x10-3 "	100
	($1:3.6 \times 10^{-3}$)	2.8×10^{7}	15 to 90	0.45	+	" 2.6×10^{-4} "	100
	(1.3×10^{-4})	6×10^{8}			+	" 5.4×10^{-4}	100
	($1:5 \times 10^{-4}$)	1.4×10^{9}	15 to 65	0.44	+	" 3x10-5 "	100
	(nil)	2.0×10^{14}	60 to 200	0.94	+		100
Violanthrene/tetracyanoethylene		5.2×10^{8}	20 to 85	0.35			66
Violanthrene/1,3,5-trinitro-benzene		5×10^{13}		1.14			113 142
Isoviolanthrene/$AlCl_3$	(1:3.7)	2.6×10^{12}		1.30			29,70
	(1:3.2)	36		0.22	-		29.70
Isoviolanthrene/$TiCl_4$	(1:1.87)	3.0×10^{10}		1.28		$\rho_o = 0.69$, density 1.56	29
	(1:1.29)	354		0.26	-		29,70
Isoviolanthrene/ICl	(1:1.45)	4.5×10^{11}		1.24		Attacked by water and oxygen	29,70
	(1:1.90)	2.2×10^{8}		0.94			29,70
	(1:3.73)	1.1×10^{9}		0.98			29,70
Isoviolanthrene/I_2	(1:1.52)	580		0.22		Seebeck coef. -0.3 V/°C	29,70
Isoviolanthrene/Na	(1:2.37)	61		0.96		$\rho_o = 10$ Thermoelectric power -10μ V/°C	29
	(1:0.31)	3.1×10^{5}		0.42		$\rho_o = 2.6$ attacked by water and oxygen	29
Isoviolanthrene/K	(1:4.35)	27		0.060		$\rho_o = 8.9$ Thermoelectric power -20μ V/°C	29
	(1:4.05)	100.0		0.166		$\rho_o = 3.7$ Thermoelectric power -10μ V/°C	29
	(1:1.42)	2600		0.028		$\rho_o = 5.2$ Attacked by water and oxygen	29

TABLE 4

FREE RADICALS AND RADICAL SALTS

Substance*	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Banfield and Kenyon's Radical	10^{15}	40 to 25	2.31		$\rho_o = 10^5$	146, 77
Ba: $(TCNQ)_2$	5×10^7	0 to 25	0.90	+	Seebeck coef. +1 to 1.5mV/°C	30, 33
2-Bromopyridine $(TCNQ)_2$	21.5 to 1115					257
(3-bromoquinolinium)$_2$$(TCNQ)_2$	0.5					257
$(C_2H_5)_3NH\ (TCNQ)_2$	1000		0.1-0.3	-		119
Cs (TCNQ)	2×10^3	0 to 25	0.36	+		30, 33
Cs $(TCNQ)_{1.5}$	10^5			-		30, 33
Cs $(TCNQ)_3$ (single crystal)	1000	0 to 25	0.60		Seebeck coef. -1.1mV/°C Mobility < 0.1 cm^2/V·sec	30, 33
	2.5×10^4 2.5×10^4					
$Cs_2(TCNQ)_3$	1000		0.1-0.3		Seebeck coef. -0.5mV/°C	119
Cu (TCNQ)	100	0 to 25	0.32	-	Ref. 257: m.p. < 300°C	30, 33
4-Cyano-N-methylquinolinium $(TCNQ)_2$ (single crystal)	1, 50 33	0 to 25	0.16			30, 33 30, 33
4-Cyano-N-methylquinolinium (TCNQ)	1.4×10^5	0 to 25			Ref. 257: m.p. 196-8°C	30, 33
4-Cyano-N-methylquinolinium $(TCNQ)_2$	50	0 to 25				30, 33
3, 7-diamino-2, 8-dimethyl-5-phenylphenazinium $(TCNQ)_2$					m.p. > 230° decomposes	257

* (TCNQ) = 7, 7, 8, 8-Tetracyanoquinodimethane
(TCNQD) = 7, 7, 8, 8-Tetracyanoquinodimethanide - Li salt

Substance*	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
3,7-diamino-2,8-dimethyl-5-phenylphenazinium (TCNQD)	6.4×10^6				m.p. = 185-210°C decomposes	257
Di minodurene $(TCNQ)_2$	2	0 to 25	0.16			30,33
1,6-Diaminopyrene (TCNQ)	0.5	-72 to 23	0.28	+	Seebeck coef. +0.052mV/°C	13
1,6-Diaminopyrene Br_2	10^4				Seebeck coef. +0.052mV/°C	13
5,8-Dihydroxyquinolinium (TCNQ)	10 14		0.14	+		30,33 72
α,α'-diphenyl-β-picryhydrazyl (DPPH)	1.3×10^{10}dc 1.5×10^8ac	20 to 100	0.15 0.26		$\rho_o = 10^{-7}$ $\rho_o = 10^{-8}$	82,147
DPPH	0.17×10^8ac		0.263			82,143
DPPH c-axis single x-axis crystal Thin film	4.6×10^{10} 2.6×10^{10} 10^{10}		1.22 1.7 ev	-	Mobility < 1 cm^2/V·sec Surface-type cell	149,150 151 304
Galvinoxyl (Coppinger's radical)	10^{13}		1.45			152
Fe $(TCNQ)_2 \cdot 3H_2O$	5×10^4	0 to 25	0.48	+		30,33
Li (TCNQ)	2×10^4	0 to 25	0.64	-	Seebeck coef. -0.6 to -1.4 mV/°C	30,33, 72
Mn$(TCNQ)_2 \cdot 3H_2O$	10^5	0 to 25	0.32			30,33
N-Methyl-2,3-benzoquinolinium $(TCNQ)_2$ (single crystal)	36		0.22		Ref. 257: m.p. = 170°C	120,33
N-Methyl-3,4-benzoquinolinium $(TCNQ)_2$ (single crystal)	230		0.28			120,33

* (TCNQ) = 7,7,8,8-Tetracyanoquinodimethane
(TCNQD) = 7,7,8,8-Tetracyanoquinodimethanide - Li salt

Substance*	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
N-Methyl-7, 8-benzoquinolinium $(TCNQ)_2$ (single crystal)	125		0.30			120, 33
N-Methylquinolinium $(TCNQ)_2$	2 to 10 331.3	0 to 25	0.14			30, 33 257
N-Methylquinolinium$(TCNQ)_2$ (single crystal)	0.01	0 to 25	0.14	-	Seebeck coef. - 50μ V/°C	30, 33
N-Methylquinolinium (TCNQ)	10^7					30, 33
N-Methylquinoxalinium(TCNQ)	62					257
N-Methyl-2-strylpyridinium $(TCNQ)_2$	6.6					257
N-methyl-2-styrylpyridinium (TCNQD)	3.7×10^7					257
Methyl derivative of (TCNQ)/ methyl phenazinium	3×10^6					257
Methyl derivative of (TCNQ)/ methyltriphenylarsonium	57				m.p. = 180°C	257
Mono(2, 2'-bipyridine) copper (TCNQ) bis (TCNQD)	19					257
Mono(1, 10-phenanthroline)copper (II) $(TCNQ)_4$	15					257
Mono(1, 10-phenanthroline) copper(II) bis (TCNQD)	34					257
Morpholinium (TCNQ) (single crystal)	10^9	0 to 25	0.64			30, 33

* (TCNQ) = 7, 7, 8, 8-Tetracyanoquinodimethane
(TCNQD) = 7, 7, 8, 8-Tetracyanoquinodimethanide - Li Salt

Substance*	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Phenazinium chloride-pyrene	6×10^{10}	20 to 50	1.2			153
Phenazinium complex salts	10^{11} to 10^{16}		0.5 to 3.7			153
Poly(N-vinylcarbazole)-(TCNQ)	10^{14} to 10^{16}		1.1 to 1.5			302
Poly(4-vinylpyridine)-TCNQ)	1.58×10^7 18°					303
$K(TCNQ)_2$	> 100		> 0.2	-		119
K(TCNQ)	5×10^3 10^4	0 to 25 0 to 25	0.72 0.70	+ +	Seebeck coef. +0.9mV/°C	30,33 30,33
Pyridium pyridine $(TCNQ)_2$	123.1					257
Pyridine $(TCNQ)_2$	85					257
Quinoline · hydroquinoline	2.7×10^{14}				m.p. = 104-5°C	257
Quinolinium $(TCNQ)_2$	< 100		< 0.1			119
Quinolinium $(TCNQ)_2$ (single crystal)	0.01		< 0.02		m.p. 220° decomposing Seebeck coef. -50μV/°C	30,33, 54,36, 72
	0.01					301
Quinolinium $(TCNQ)_2$	0.25 31.5	0	0.06	-	Mobility < 0.02 cm^2/V·sec	30,33 257
Quinolinium $(TCNQ)_2$ (single crystal)	0.01	0 to 25	0.06			30,33
Quinolinium/acetyldiethylamine $(TCNQ)_2$	3.4					257

* (TCNQ) = 7,7,8,8-Tetracyanoquinodimethane

Substance*	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Quinolinium/2-bromopyridine $(TCNQ)_2$	49.8					257
Quinolinium/2-chloropyridine $(TCNQ)_2$	9.0					257
Quinolinium/pyridine$(TCNQ)_2$	12.7					257
Ag (TCNQ)	$2x10^4$	0 to 25	0.74	-		30, 33
Na (TCNQ)	10^5	0 to 25	0.66		Ref. 257: m.p. > 300°C	30, 33
Tributylamine $(TCNQ)_2$	8.2 to 10					257
Triethylammonium$(TCNQ)_2$ (2:1)	10^9				Ref. 257: m.p. > 195°C	30, 33 257
Triethylammonium$(TCNQ)_2$	20					30, 33, 72
Triethylammonium $(TCNQ)_2$ (single crystal)	0.25 25 1000	0 to 25	0.28	-	Seebeck coef. -0.10 mv/°C Mobility 0.04 cm^2/V·sec ref. 54: ~ 1% free radicals	30, 33 54
Trimethylammonium$(TCNQ)_2$ (2:1)	$5x10^6$	0 to 25	0.86		Ref. 257: m.p. =245°C	30, 33
Triphenylmethylarsonium $(TCNQ)_2$ (single crystal)	50 500 10^5	0 to 25	0.60		Seebeck coef. +1mV/°C ref. 54: ~ 0.1% free radicals no photoconductivity	30, 33 54
Triphenylmethylphosphonium (TCNQ) (single crystal)	$5x10^{10}$					30, 33
Triphenylmethylphosphonium $(TCNQ)_2$ (single crystal)	50 500 10^5	0 to 25	0.60	+		30, 33

* (TCNQ) = 7, 7, 8, 8-Tetracyanoquinodimethane

Substance*	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier	Ref.
2,4,6-Triphenylperylium $(TCNQ)_2$	10		0.08		30,33
Tris (2,2'-bipyridine) nickel (II)-bis-(TCNQD)	10^5				257
Tris (2,2'-bipyridine) nickel (II)-bis-$(TCNQD)_2$-bis-(TCNQ)	$2x10^3$				257
Tris (1,10-phenthroline) cobalt (II) bis-(TCNQD)	10^7				257
Tris (1,10-phenanthroline) cobalt (II) bis-(TCNQD) bis-(TCNQ)	10^4				257
Tris (1,10-phenanthroline) copper (II) bis-(TCNQD)	10^5				257
Tris (1,10-phenanthroline) copper (II) bis-(TCNQD)-bis-(TCNQ)	10^4				257
Tris (1,10-phenanthroline) manganese(II) bis-(TCNQD)	10^3				257
Tris (1,10-phenanthroline) manganese (II) bis-(TCNQD)-bis-(TCNQ)	140				257
Tris (1,10-phenanthroline) nickel (II) bis-(TCNQD)	10^4				257
Tris (1,10-phenanthroline) nickel (II) bis-(TCNQD) - bis-(TCNQ)	200				257
Violanthene - B compound	$7x10^6$ $1.1x10^{11}$		0.67 0.79		93

* (TCNQ) = 7,7,8,8-Tetracyanoquinodimethane
(TCNQD) = 7,7,8,8-Tetracyanoquinodimethanide - Li salt

TABLE 5

POLYACENEQUINONE RADICAL POLYMERS

Hydrocarbon/Acidic Derivatives	ρ ohm·cm	Temp °C	E in E/2kT	Mobility $\frac{cm^2}{V \cdot sec}$	Sign of Majority Carrier		Ref.
7-Acenaphthol/1, 8-naphthalic anhydride	1.37×10^8		0.60				172
7-Acenaphthol/pyromellitic dianhydride	4.9×10^7		0.71				172
7-Acenaphthol/phthalic anhydride	4.2×10^7		0.58				172
Anthracene/phthalic anhydride (2:1)	9.5×10^7	25	0.698			$\rho_o = 70.8$	75
Anthracene/pyromellitic dianhydride	4.53×10^6					ρ vs load at 25°C and 105°C	25
Anthracene/terephthaloyl chloride (1:1)	1.3×10^8	25					75
Anthraquinone/pyromellitic anhydride (3:1)	2.0×10^4	25	0.382			$\rho_o = 8.90$	75
1, 4-Bisanthraquinonylamino-anthraquinone/1, 8-naphthalic anhydride	2.7×10^6		0.472				172
1, 4-Bisanthraquinonylamino-anthraquinone/pyromellitic dianhydride	1.5×10^7		0.515				172
1-Bromo-2-naphthol/1, 8-naphthalic anhydride	6.8×10^6		0.53				172
1-Bromo-2-naphthol/pyromellitic dianhydride	1.13×10^7		0.68				172
1-Bromo-2-naphthol/phthalic anhydride	4.6×10^6		0.62		+		172
6-Bromo-2-naphthol/1, 8-naphthalic anhydride	9.6×10^5		0.58				172
	2.9×10^6		0.571				172

Hydrocarbon/Acidic Derivatives	ρ ohm·cm	Temp °C	E in E/2kT	Mobility $\frac{cm^2}{V \cdot sec}$	Sign of Majority Carrier	Ref.
6-Bromo-2-naphthol/pyromellitic dianhydride	5.9×10^6		0.66			172
6-Bromo-2-naphthol/phthalic anhydride	7.2×10^6		0.58			172
9-Bromophenanthrene/1,8-naphthalic anhydride	5.6×10^6		0.34			172
2-Bromo-4-phenylphenol/1,8-naphthalic anhydride	1.0×10^{11}		1.20			172
2-Bromo-4-phenylphenol/phthalic anhydride	2.3×10^8		0.62			172
Carbazole/1,8-naphthalic anhydride	2.1×10^8		0.59			172
Carbazole/phthalic anhydride β	1.9×10^8		0.54			172
Dibenzanthrone (violanthrone)/pyromellitic dianhydride	1.9×10^8		0.43			172
1,2-Dihydroxyanthraquinone/1,8-naphthalic anhydride	7.9×10^7		0.690			172
1,2-Dihydroxyanthraquinone/1,8-naphthalic anhydride	2.1×10^7		0.68			172
1,4-Dihydroxyanthraquinone/1,8-naphthalic anhydride	1.8×10^7		0.50			172
1,4-Dihydroxyanthroquinone/pyromellitic dianhydride	7.0×10^9 5.5×10^8		0.570			172
1,5-Dihydroxyanthrquinone/1,8-naphthalic anhydride	3.6×10^5 5.2×10^6		0.63 0.703		+	172 172
1,5-Dihydroxyanthroquinone/pyromellitic dianhydride	5.8×10^8		0.845			172

Hydrocarbon/Acidic Derivatives	ρ ohm·cm	Temp °C	E in E/2kT	Mobility $\frac{cm^2}{V \cdot sec}$	Sign of Majority Carrier	Ref.
1,8-Dihydroxyanthraquinone/ 1,8-naphthalic anhydride	2.8×10^5 2.2×10^7		0.52 0.766		+ +	172 172
1,8-Dihydroxyanthraquinone/ pyromellitic dianhydride	9.2×10^7 2.3×10^8		0.67 0.563			172 172
1,8-Dihydroxyanthraquinone/ tetraphenyl-1,2-dihydrophthalic anhydride	2.9×10^5		0.52			172
1,4-Dihydroxynaphthalene/1,8-naphthalic anhydride	10^{12}		1.11			172
1,4-Dihydroxynaphthalene/ pyromellitic dianhydride	5.6×10^{11} 1.4×10^9		1.00			172
1,4-Dihydroxynaphthalene/ phthalic anhydride	1.01×10^8		0.56			172
2,3-Dihydroxynaphthalene/1,8-naphthalic anhydride	9.4×10^7		0.58			172
2,7-Dihydroxynaphthalene/ pyromellitic dianhydride	3.3×10^{10}		1.83			172
p,p'-Diphenol/phthalic anhydride	1.0×10^{12}					172
1,4-Diphenylpiperazine/ phthalic anhydride	2.0×10^{12}					172
1-Hydroxyanthraquinone/1,8-naphthalic anhydride	1.34×10^6 5.0×10^5		0.62 0.503		 +	172 172
1-Hydroxyanthraquinone/ phthalic anhydride	6.0×10^6		0.58			172
1-Hydroxyanthraquinone/ pyromellitic dianhydride	7.0×10^5					172
Hydroquinone/phthalic anhydride	1.4×10^6		0.58			263

Hydrocarbon/Acidic Derivatives	ρ ohm·cm	Temp °C	E in E/2kT	Mobility $\frac{cm^2}{V \cdot sec}$	Sign of Majority Carrier		Ref.
p-Naphthalobenzein/1,8-naphthalic anhydride	1.0×10^{11}		0.68				172
p-Naphthalbenzein/phthalic anhydride	1.3×10^{8}		0.13				172
α-Naphthalphthalein/phthalic anhydride (2:1)	6.5×10^{6}	25	0.544			$\rho_o = 05.0$	75
Phenanthrene/acetic anhydride (2:1)	4.1×10^{8}	25					75
Phenanthrene/benzoic acid (1:1)	2.4×10^{5}	25	0.444			$\rho_o = 30.1$	75
Phenol/phthalic anhydride (4:3)	1.1×10^{8}	25	0.638			$\rho_o = 276$	75
Phenolphthalein/1,8-naphthalic anhydride	6.4×10^{6}		0.77		+		172
Phenolphthalein/phthalic anhydride	6.0×10^{8}		0.60				172
(2:1)	8.8×10^{7}	25					75
Phenolphthalein/pyromellitic dianhydride	5.3×10^{9}		0.65				172
Terephthaloyl chloride/naphthalene	6.0×10^{11}		0.956			$\rho_o = 251$	75
1,4,9,10-Tetrahydroxyanthracene/1,8-naphthalic anhydride	8.7×10^{5}		0.516				172
	2.4×10^{6}		0.63				172
1,4,9,10-Tetrahydroxyanthracene/phthalic anhydride	1.39×10^{7}						172

Hydrocarbon/Acidic Derivatives	ρ ohm·cm	Temp °C	E in E/2kT	Mobility $\frac{cm^2}{V \cdot sec}$	Sign of Majority Carrier		Ref.
Polyacenequinone Radical copolymer pyrolyzed/ pyromellitic dianhydride	0.03	25 to 100	-0.001		+		111
Polyacenequinone radical polymers prepared at 256°C	4.4×10^4 to 1.0×10^6		0.516 to 0.680				118
Pyrene/pyromellitic dianhydride	2.58×10^4	25					25
Terphenyl/pyromellitic dianhydride	7.7×10^6	25				ρ vs load plot at different T	25
Triphenylchloromethane/ pyromellitic dianhydride	5.5×10^{13}	25				ρ vs load plot at different T	25

Polymer Reactants	ρ ohm·cm	Temp °C	E in E/2kT	Mobility $\frac{cm^2}{V \cdot sec}$	Mole Ratio	Catalyst		Ref.
Alizarin/pyromellitic anhydride	$1.5x10^6$	25	0.46	$1.29x10^{-3}$	1:1:1	$ZnCl_2$	$\rho_o = 1.9x10^2$	55
Alizarin/pyrene/ pyromellitic anhydride	$1.3x10^4$	25			2:2:2:3	$ZnCl_2$		55
Amaranth/pyromellitic anhydride	$5.8x10^8$	25			1:1:1	$ZnCl_2$		55
Amaranth/pyrene/ pyromellitic anhydride	$1.0x10^8$	25			2:2:2:3	$ZnCl_2$		55
Aniline black/pryomellitic anhydride	$5.2x10^7$	25	1.01	$4.37x10^{-6}$	1:1:1	$ZnCl_2$	$\rho_o = 1.4x10^{-1}$	55
Aniline black/pyromellitic anhydride	$1.4x10^6$	25	0.11	$1.52x10^{-6}$	2:2:2:3	$ZnCl_2$	$\rho_o = 1.5x10^{-1}$	55
Anthracene/pyromellitic anhydride	$2.4x10^6$	25			1:1:1	$ZnCl_2$		55
	$3.32 x10^6$		0.534					65
Benzoazurine G/ pyromellitic anhydride	$3.1x10^7$	25			1:1:1	$ZnCl_2$		55
Benzoazurine G/pyrene/ pyromellitic anhydride	$2.4x10^{10}$	25			2:2:2:3	$ZnCl_2$		55
Chrysene/pyromellitic anhydride	$1.0x10^6$	29	0.387			$ZnCl_2$		65
Congo Red/pyromellitic anhydride	$3.1x10^7$	25			1:1:1	$ZnCl_2$		55
Congo Red/pyromellitic anhydride	$7.4x10^9$	25			2:2:2:3	$ZnCl_2$		55
Dibenzpyrene/pyromellitic anhydride	$7.4x10^9$	25			2:2:2:3	$ZnCl_2$		65

Polymer Reactants	ρ ohm·cm	Temp °C	E in E/2kT	Mobility $\frac{cm^2}{V \cdot sec}$	Mole Ratio	Catalyst		Ref
2,5-Dichloro-3,6-dihydroxy-p-benzoquinone/pyromellitic anhydride	7.2×10^8	25	1.20	4.92	1:1:1	$ZnCl_2$	$\rho_o = 5.1 \times 10^{-2}$	55
2,5-dihydroxy-p-benzoquinone/pyromellitic anhydride	5.4×10^8	25	0.95	2.54×10^{-5}	1:1:1	$ZnCl_2$	$\rho_o = 4.8$	55
Eosine Y/pyromellitic anhydride	1.3×10^9	25			1:1:1	$ZnCl_2$		55
Eosine Y/pyrene/promellitic anhydride	1.0×10^6	25	0.11	2.13×10^{-6}	2:2:2:3	$ZnCl_2$	$\rho_o = 8.9 \times 10^1$	55
Ferrocene/salicylic acid	2.5×10^8	50	0.33		1:1:8	t-butyl peroxide		237
Fluorescein/pyromellitic anhydride	7.7×10^{10}	25			1:1:1	$ZnCl_2$		55
Fluorescein/pyrene/pyromellitic anhydride	7.1×10^7	25	0.38	5.85×10^{-6}	2:2:2:3	$ZnCl_2$	$\rho_o = 2.7 \times 10^1$	55
Indigo/pyromellitic anhydride	3.9×10^6	25			1:1:1	$ZnCl_2$		55
Indigo/pyromellitic anhydride	1.5×10^5	25			2:2:2:3	$ZnCl_2$		55
Meldola blue/promellitic anhydride	1.7×10^8	25	0.82	1.31×10^{-2}	1:1:1	$ZnCl_2$	$\rho_o = 1.9 \times 10^1$	55
Meldola blue/pyrene/pyromellitic anhydride	6.8×10^6	25			2;2:2:3	$ZnCl_2$		55
Naphthalene/pyromellitic anhydride	1.48×10^7	23	1.05			$ZnCl_2$		65
Naphthalene/terephthaloyl chloride	6.0×10^{11}	25	0.956		1:1:1	$ZnCl_2$	$\rho_o = 2.51 \times 10^2$	75

Polymer Reactants	ρ ohm·cm	Temp °C	E in E/2kT	Mobility $\frac{cm^2}{V \cdot sec}$	Mole Ratio	Catalyst		Ref.
p-Naphtholbenzein/pyromellitic anhydride	3.3×10^8	25	1.02	3.22×10^{-1}	1:1:1	$ZnCl_2$	$\rho_o = 7.8 \times 10^{-1}$	55
p-Naphtholbenzein/pyrene/ pyromellitic anhydride	7.5×10^5	25			2:2:2:3	$ZnCl_2$		55
α-Naphthol-phthalein/ phthalic anhydride	6.5×10^6	25	0.544		2:1:1	$ZnCl_2$	$\rho_o = 1.05 \times 10^2$	75
Perylene/pyromellitic anhydride	1.25×10^5	25	0.318			$ZnCl_2$		65
Phenanthrene/benzoic acid	2.4×10^5	25	0.444		1:1:1	$ZnCl_2$		75
Phenanthrene/pyromellitic anhydride	2.9×10^5 3.59×10^6	25 30	0.47 0.545	8.23×10^{-3}	1:1:1	$ZnCl_2$		55 65
Phenol/phthalic anhydride	1.1×10^4	25	0.638		4:3:2	$ZnCl_2$	$\rho_o = 2.67 \times 10^2$	75
Picene/pyromellitic anhydride	2.35×10^5	29	0.219			$ZnCl_2$		65
Pyrene/m-amenobenzoic acid	4.7×10^2	25			1:1:1	$ZnCl_2$	Ka (acid discoloration constant) = 1.51×10^{-5}	55
Pyrene/1, 12-benzoperylene	2.8×10^4	25			1:1:1	$ZnCl_2$		55
Pyrene/chloroacetic acid	5.9×10^2	25			1:1:1	$ZnCl_2$	$K_a = 1.4 \times 10^{-3}$	55
Pyrene/o-chlorobenzoic acid	7.3×10^2	25			1:1:1	$ZnCl_2$	$K_a = 1.29 \times 10^{-3}$	55
Pyrene/m-chlorobenzoic acid	1.3×10^3	25			1:1:1	$ZnCl_2$	$K_a = 1.51 \times 10^{-4}$	55
Pyrene/p-fluorobenzoic acid	7.8×10^4	25			1:1:1	$ZnCl_2$	$K_a = 7.22 \times 10^{-5}$	55
Pyrene/9-fluorene carboxylic acid	9.8×10^{11}	25			1:1:1	$ZnCl_2$		55
Pyrene/gallic acid	1.3×10^7	25			1:1:1	$ZnCl_2$		55
Pyrene/o-iodobenzoic acid	2.7×10^2	25			1:1:1	$ZnCl_2$	$K_a = 1.25 \times 10^{-3}$	55
Pyrene/p-nitrobenzoic acid	2.7×10^3	25			1:1:1	$ZnCl_2$	$K_a = 3.98 \times 10^{-4}$	55

Polymer Reac tants	ρ ohm·cm	Temp °C	E in E/2kT	Mobility $\frac{cm^2}{V \cdot sec}$	Mole Ratio	Catalyst		Ref.
Pyrene/pyromellitic anhydride	3.9×10^5	25	0.10	4.50×10^{-6}	1:1:1	$ZnCl_2$		55
	3.82×10^5		0.42					65
Pyrene/pyrene/pyromellitic anhydride	5.6×10^3	25			2:2:2:3	$ZnCl_2$		55
Pyrene/syringic acid	2.2×10^7	25			1:1:1	$ZnCl_2$		55
Pyrene/X anthene-10-carboxylic acid	1.5×10^7	25	0.61	2.46×10^{-3}	1:1:1	$ZnCl_2$	$\rho_o = 7.6 \times 10^{-1}$	55
Pyromellitic anhydride/chloroacetic acid	4.00×10^2					$ZnCl_2$		65
Pyromellitic anhydride/quinizarin	8.2×10^5	25	0.41	4.53×10^{-8}		$ZnCl_2$	$\rho_o = 5.2 \times 10^2$	55
Pyromellitic anhydride/quinoxaline	5.6×10^6	25	0.80	5.58×10^{-7}		$ZnCl_2$	$\rho_o = 9.2 \times 10^{-1}$	55
Pyromellitic anhydride/terephenyl	1.05×10^8	25	0.820			$ZnCl_2$		65
Tetracene/phthalic anhydride	9.27×10^6		0.657		1:1:1	$AlCl_3$	$\rho_o = 80.4$	32
	7.50×10^9	25						
Tetracene/pyromellitic anhydride	3.95×10^5	25	0.557		1:1:1	$Al\ Cl_3$		32
Violanthrone/pyromellitic anhydride	5.9×10^3	25	0.09	2.44×10^{-4}	1:1:1	$ZnCl_2$	$\rho_o = 1.0 \times 10^3$	55
Violanthrone/pyrene/pyromellitic anhydride	2.8×10^3	25	0.10	6.28×10^{-4}	1:1:1:1.5	$ZnCl_2$	$\rho_o = 3.7 \times 10^2$	55

TABLE 6

LONG CHAIN COMPOUNDS AND POLYMERS

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Acethylferrocence polymer	10^7	50	0.31-0.47		$ZnCl_2$ catalyst (1:1)	236
Anthracene polymer reactant	$1.66x10^8$	25	0.771		$\rho_o = 9.84x10^2$, $ZnCl_2$ catalyst	32
Benzothiadiazole	$3.3x10^{11}$	25	2.6			71
Benzoselenodiazole	$1.6x10^{14}$	25	2.8			71
2,2'-Bisbenzimidazole	$1.6x10^{17}$	25	1.92			71
5,5-Bibenzoselenodiazole	$5x10^{16}$	25	1.54			71
1,3-Bis-(2-benzimidazolyl) benzene	$1x10^{17}$	25	1.76			71
1,4-Bis(2-benzimidazolyl)benzene	$5x10^{16}$	25	1.56			71
β,β'-Bis-(2-benzimidazolyl)-1,4-divinylbanzene	$2.5x10^{13}$	25	1.18			71
Bromodihydropolycyclopentadiene	10^6					154
Carbazole-tetralone polymer reactant	$7.5x10^3$					32
Cu-Phthalocyanine polymers	20 to 100	27				284
Cu-imidazole polymer	$> 10^{15}$					142
Co-imidazole polymer	10^{17}	114			$\rho = 10^{15}$ at 150°C	286
1,5-Diformyl-2,6-dihydroxy-naphthalene oxime, metal polymers						
(Pd)	10^6	-78 to 78	0.48		Mobility: high	95,96
(Cu)	10^4-10^5		0.46			
(Ni)	10^4-10^5		0.46			

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
2,5-dihydroxy-p-benzoquinato Cu(II)	10^{10}dc 10^{7} ac	100				28
1,6-Dihydroxyphenazinato-Cu(II)	10^{13}dc 10^{7} ac	60 to 160 60	2 2		No hysteresis with pressure	28
Diketopiperazine	1.3×10^{10}		2.19			142
Diphenylamine polymers	10^{8}-10^{10}		0.8 to 1.1			142
Ferrocene-acetone polymer	6.7×10^{14}	50	0.83		7-butyl peroxide catalyst	237
Ferrocene-benzal copolymer	10^{7}-10^{8}					121, 118
Ferrocene, α-bromo-naphthaline polymer	4×10^{11} to 3.5×10^{9}	50	0.47 to 0.3		ρ vs various ratios of reactants	237
Ferrocene-carbonyl copolymer	10^{3}-10^{12}					118
Ferrocene, 1,1'-diacetyl polymer	3.6×10^{9}	50	1.45 to 0.42			237
Ferrocene, 1,1'-diacetyl polymer	10^{5} to 10^{10}		0.05 to 0.4			237
Ferrocene, m-dichloro-benzene polymer	4×10^{11} to 3.5×10^{9}	50	0.47 to 0.3		ρ vs various ratios of reactants	237
Ferrocene polymers (polyketones)	10^{3}-10^{11}		>0.9			99, 121, 281
Ferrocenyl acetate polymer	3.6×10^{9}	50				276
$FeCl_2$ polymer of chloranil: o-phenylenediamine	$<3.8 \times 10^{14}$	20 to 250				110
Furan, pyrrole	7.9×10^{10}	25	1.488		$\rho_o = 8.08 \times 10^{-2}$ ohm cm	32

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Fumaronitrile, pyrolyzed	6.3×10^{1}		0.22			284
Graphite	0.0285	15			$\Delta H_f^{o} = 0.00, \Delta G_f = 0.00, S^{o} = 1.3909, C_p = 2.066$ at 25°C	69, 245
Graphites, pyrolytic	500-3500	-13 to 800	0.09	+ or - f(temp)	Mobility 1-10 $cm^2/V \cdot sec$	122
Indole, tetralone polymer	8.80×10^{3}					
3-(4'-isopropylphenyl)-benzo-quinoline	1.4×10^{13}					32
Malonitrile polymer	10^{11}	20				235
2-(2'-methyl-5'-isopropyl-phenyl) quinoline	3.2×10^{9}					236
1-methyl-2-picolinium polyiodide	$10^{7}-10^{10}$	20 to 100	1.5 to 2.2			235
1-methylquinolinium polyiodide	$10^{7}-10^{10}$	20 to 100	2	+		142
2-β-naphthylbenzimidazole	1.4×10^{15}	25	1.32			142
2-α-Naphthylbenzimidazole	2.5×10^{15}	25	1.44			71
2,2'-Di-β-naphthyl-5,5'-bibenzimidazole	2.5×10^{14}	25	0.62			71
2,3-naphthoselenodiazole	2.5×10^{7}	25	2.0			71
1,2-Naphthothiadiazole	3.3×10^{20}	25	8.0			71
2,3-Naphthothiadiazole	3.3×10^{13}	25	5.2			71
Naphthalene, polymer reactant	1.31×10^{11}					71
1,4-naphthazuinone, p-toluene dissocyanate polymer	1.19×10^{11}	23	2.00			32, 65

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Naphthylenediamine polymer	10^{10}-10^{13}	20				273
Neoformazan	10^{13} to 10^{14}		4.87		$\rho_o = 2.7 \times 10^{-25}$	119, 63
Nylon (fully hydrated)	10^{8}					142
Nylon 6-10	10^{8}	400	2 to 4			155
Nylon 66 (theoretical value as single crystal)	8.4		2		Elastic constant 0.012×10^{12} dyne cm^2 Ref. 246: $-\Delta H^{20°}_{comb} = 1715.7$	7
N-methylated nylon 10-10	1.5×10^{10}	-20 to 60	2.5			142
Pyrolyzed phenol formaldehyde cation exchanger with Na	10^{-5} to 10^{-1}			+		123
Mg	10^{8} to 10^{-2}			+		123
Al	10^{7} to 10^{-2}			+		123
Metal-free	10^{8} to 10^{-2}			+		123
Perylene-polymer	1.22×10^{7}				$\rho_o = 2.49 \times 10^{2}$ ohm·cm ; $AlCl_3$ catalyst, mole ratio 1:0:1	32
Phenolphthalein polymer	4.7×10^{8}	25				75
3-Phenyl-benzo-quinoline	8.7×10^{12}					235
1-Phenyl-2-butyl-naphthalene	3.5×10^{12}					235
1-Phenyl-2-dodecyl-naphthalene	2.7×10^{12}					235
2-phenyl-5-methylbenzimidazole	5×10^{15}	25	2.46			71
Phosphonitrile chloride trimer	10^{13}-10^{15}					278
Phthalocyanine polymers	> 1000		0.6			124 284

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Polyacenaphthylene: tetracyanoethylene; atactic	10^9		0.65	+		142
Polyacenequinones	10^4 to 10^{10}	60 to 280	0.26 to 1.8	+	Mobility: 10^{-2} $cm^2/V \cdot sec$	121
Polyacety ferrocene	8.1×10^{11}	50	0.67			237
Polyacetylene	4.2×10^5		0.46			97
Polyacetylene	3×10^{13}					142
Polyacetylenes, crystalline	10^5 to 10^8 1.4×10^4		0.45 0.46			97
Polyacetylene, amorphous	10^9 to 10^{12}		0.46			97
Polyacrylonitrile	5×10^8	400	0.64			263
Polyacrylonitrile, pyropolymer, $CuCl_2$-impregnated	100	300				125
Polyacrylonitrile pyropolymer	10^{13}	28 to 120 120 to 169	1.2 1.8			142
Polyacrylonitrile, pyrolyzed	1.30 mean range to 10^{12}	-65 to 140	0.21 mean range	-	Mobility: < 1×10^{-2} $cm^2/V \cdot sec$	127 126
Polyamides (nylon)	10^8 to 10^{10}	400	2 to 3			142
Polyanthracene	8.3×10^5		0.26			111
Polyazochlorphenylene	10^{14}	50 to 110	5.2			156
Polyazofluorine	1.3×10^{12}	50 to 110	3.6			142
Polyazomethoxyphenylene	7×10^{13}	50 to 110	2.4			156
Polyazonitrophenylene	2×10^{14}	50 to 110	5.0			156

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Polyazophenylenes	1 to 2.5×10^2	120 to 150	1.24 to 1.92			128, 129
Polyazophenylene	5×10^{11}	50 to 110	3.6			156
Poly(azophenylether)	2×10^{14}	50 to 110	4.4			156
Poly (azophenyl sulfide)	10^{15}	50 to 110	5.2			156
Poly (azophenyl sulfone)	1.5×10^{14}	50 to 110	4.4			156
Polyazostilbene	2.5×10^{13}	50 to 110	3.6			156
Polybenzenes from hexachloro-benzene	0.2 to 25					104
Polybenzenes from trichloro-benzene	10^3-10^4					104
Polybenzimidazoles	4×10^{10} to 10^{16} at 1800 atm		1.12 to 2.23 at 1800 atm			75, 138, 157
Polybutadiene (glow-discharge polymerized)	10^{12} to 10^{15}		0.29 to 1.8			142
Poly-Cu-phthalocyanine	40	25 to 300	0.26	+	Ref. 287: $\rho = 3.8 \times 10^{-1}$ Mobility: 10 $cm^2/V \cdot sec$	94
Poly-Cu-phthalocyanine, heat treated	4	50 to 400	0.12	+	Ref. 287: $\rho = 1.35 \times 10^{-2}$ Mobility: 2.5 $cm^2/V \cdot sec$	94
Poly-Cu-tetracyanoethylene	3.0		0.12			287
Polydehydrocondensation products of bis-acetylenes	10^{14}	20 to 800	1.2 to 1.8			158
Polydibenzpyrene	950	25 to 100	0.206	-		111
Polydiketone	10^4					118

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier	Ref.
Polyethylen DFD 4400	5×10^{18}		3.05		234
Polyethylene β-irradiated: pyrolyzed	10^{9}		0.64	+	142
Polyethylene β-irradiated: complex with I_2	2500		0.02		130
Polyimidazoles, pyrolyzed	2				105
Polyisobutyl ferrocenylene	2.7×10^{11}	50	0.45		237
Polymer carbon Ni doped (pyrolyzed ion exchange resins)	0.348 to 0.00418	98 to -55	0.065 to 0		131, 132
Polymer, N-substituted dithiocarbamate	$\geq1.5\times10^{10}$	17 to 152	0.36 to 0.72		142
Polymer, dithiooxamade (Co)	10^{15}	127 to 227	0.7		142
(Cu)	2.5×10^{7}	17 to 77	0.6		142
(Ni)	5×10^{10}	17 to 227	0.6		142
Polymeric phthalocyanines	10^{7} to 10^{11}				142
Polymers, thiocyanate	$\sim10^{12}$		0.58 to 0.76		142
Polymer, thiophene	10^{15}		1.2	-	159
Polymer, thioacetamide	10^{15}	25 to 175	2.0		159
Polymer, pyrrole	10^{15}		1.3		159
Polymer, pyrazole	10^{14}		1.4		159
Polymeric condensation product of phthalic anhydride and hydroquinone	10^{5} to 10^{6}		0.6 to 0.8		133

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Polymeric product of tetracyanoethylene with metals or metal compounds at 160 to 300°C	100		0.21 to 0.26			134
Polymeric Schiff bases	10^7 to 10^{11}	25			Insoluble and infusible Ref. 292: ρ= 2.5×10^7 to 10^{16}	269
Polynaphthalene	9.7×10^6	25 to 100	0.32	+		160
Poly [N-N'-(p-p'-oxidiphenylene) pyromellitimide]	0.05		2.2±0.26			135
Polypentyne -1	3×10^9	10-15				75
Polyphenanthrene	10^5		0.2	+		111
Polyphenyl	10^{10} to 10^{11}					121, 118
Polyphenylacetylene	4.8×10^{10}	25	0.432		ρ_o= 7.94×10^6 ohm·cm; Ref. 79: ρ= 10^{16}	75, 58
Polyphenylene	10^{11}					
	> 10^{15}	25 to 90				116
Poly-p-phenylene	> 10^{15}			+	Mobility: 0.1 $cm^2/V\cdot sec$	142
Poly-p-phenylene-iodide	2.5×10^4		0.87			288
Polypropyne	10^{11}		0.65			157, 75, 138,
Polyphenyltriazine	6.2		0.72			287
Polypyrene	10^4	25 to 100	0.16 to 0.2	+	Mobility: 0.04 $cm^2/V\cdot sec$	111
Polypyridines, substituted	0.03 to 15					105

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Poly-β-pyridylacetylene	10^{12}-10^{13}	25	2.50			79
Poly (quinone imines)	2.5×10^5					290
Poly-Schiff bases (p-pyenylene-diamine-benzyl polycondensate	3×10^{11}	21 to 75 90-115 60-90	2.8 1.08 0.45		 $\rho_o = 1.2 \times 10^3$ $\rho_o = 2.5 \times 10^7$	290 274
Polystyrene (tablet)	5×10^3		1.3			262
Polystyrene-$AgClO_4$ atactic	4×10^8		1.48			120, 34
Polystyrol	10^9	20 to 60	0.8			83
Polysulfur-anthracene	330					104
Polysulfur nitride	0.6167 to 0.0394	0	< 0.04	-		136
Polyterephthalonitrile	2.1×10^{10}		0.622		$\rho_o = 4.20 \times 10^4$ ohm cm	59
Polytetrachlorophenyl-thioether	1 to 10^7					119, 121
Polytetrachlorothiophenol	3.38×10^6					65
Polytetracyanoethylene-Cu film	10(highest)		0.1 to 0.5			297
Poly-s-triazine			1.081		$\rho_o = 1.25 \times 10^4$ heating cycle; $\rho_o = 5.22 \times 10^2$ cooling cycle	59
Polytriphenylmethane	5.8×10^{11}	25 to 100	0.42			142
Polyvinylalcohol, pyrolyzed	10^5 to 10^{13}		0.3 to 0.5			137
Polyvinylalcohol: metal chelates	$> 10^{13}$		1.2 to 3.3			137
Polyvinylanthracene: 9-Vinyl	10^{15}		1.59			142

Substance	ρ ohm· cm	Temp °C	E in E/2kT	Sign of Majority Carrier	Ref.
Polyvinylanthracene: 9-Vinyl/I_2 (1:7)	2.1×10^6		1.02		142
Polyvinylanthracene: 9-Vinyl/I_2 (1:2.8)	3.7×10^6		1.03		142
Polyvinylanthracene-Iodine	10^5 at 57000 atm	38 to 80	0.8		142 138
Polyvinylanthracene-I_2 complex (polymer)	3.1 to 7.9×10^4 at 57000 atm				139
Polyvinylcarbazole	10^{17}	10 to 127			
Poly (N-vinyl) carbazole: Tetracyanoquinodimethane	10^{14}-10^{16}	10 to 127	1.1-1.5		142 142
Polyvinylchloride, pyrolyzed	>> 10^5				
Polyvinylchloride (chlorinated), pyrolyzed	1.4×10^7 >> 10^5		0.4		142 263
Polyvinylene	10^{11}	25 to 90			142
Polyvinylene	10^7	25 to 90	1.06		116
Polyvinylmesitylene	10^{13}				116
Poly-N-vinyl-5-methyl-2-oxazolidinone	> 10^{14}				120, 34
Poly-N-vinyl-5-methyl-2-oxazolidinone complexed with resorcinol	10^{14}				118 118

Substance	ρ ohm· cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Poly-N-vinyl-5-methyl-2-oxazolidinone complexed with p-quinone	10^{14}					118
complexed with Iodine	4.5×10^{6}					118
Polyvinylnaphthalene	10^{13}					120
Polyvinylnaphthalene-2,3-dichloro-5,6-dicyano-p-benzoquinone	10^{13}					120
Polyvinylnaphthalene-tetracyanoethylene	3×10^{4}		1.20	+		120
Poly(-2-vinylpyridine)-I_2 complex (5:3)	10^{4}					116
Poly(4-vinyl)pyridine:I_2	10^{4}					116
Polyvinylpyridinium: tetracyanoquinodimethane derivatives	$>10^{6}$					142
2-(4'-propylphenyl)-3-ethylquinoline	3.1×10^{9}					235
Pyrene-polymer reactant	3.55×10^{7}	25	0.952		$AlCl_3$ catalyst, mole ratio 1:0:1	32
Pyromellitonitrile, H_2S reaction product (polymeric, pyrolyzed)	38.6 to 55	85		-		98
	8.0		0.72			287
Pyromellitonitrile, NH_3	14 to 1.5×10^{-3}		0.32-0.84		Cooling and heating	287
Pyromellitonitrile, methanol reaction product (polymeric, pyrolyzed)	5.4	70 to 227	0.30	+		98
	at 92.6°C	20 to 70	1.2	-		
	33		0.98			287
	2.8×10^{-3}		0.50		After heating to 500°C	287

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Pyrophyllite (lava)	10^9 to 10^{14}	25				73
Pyrrole, p-benzoquinone polymer	3.03×10^5	25	0.641		$ZuCl_2$ catalyst, mole ratio 1:1:1	32
Pyrrole, Tetralone polymer	4.95×10^{10}				$ZuCl_2$ catalyst, mole ratio 1:1:1	32
Rubeanato - Cu(II)	5×10^4 ac 2.5×10^5 dc	-10 to 80 -10 to 80	0.4 0.3		Above 90^0 decomposes with increasing ρ but E unchanged	28
Terephthalate polyesters (unoriented)	10^8 to 10^{13}					142
Tetracene, anthraquinone polymer	5.11×10^7	25	0.798		$AlCl_3$ catalyst, mole ratio 1:1:1	32
Tetracyanoethylene: Metal polymeric chelates Reaction time: A 20 hrs	(A)0.045	-80 to 160	0.06	+		103
B 20 hrs	(B)8600	-80 to 160	0.48	-		103
Tetracyanoethylene polymer	10^8	-100 to 300	1.68	+	Mobility: $\mu_+/\mu_- = 1.5\ cm^2/V \cdot sec$	142
Tetramethylammonium - polyiodide	10^8	20 to 100	1.5	+		142, 161
2-0-tolybenzimidazole	2.5×10^5	25	1.52			71
2-p-tolylbenzimidazole	1×10^6	25	1.42			71
2-m-tolylbenzimidazole	1×10^7	25	1.76			71
2, 4, 5-triiodoimidazole polymers	1.3×10^6					105
1, 3, 5-trinitrobenzene/I_2 polymer	1.2×10^{13}		1.03			142

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier	Ref.
Triphenylammonium - polyiodide	10^7 to 10^{10}	20 to 100	1.4 to 2.0		161, 142
Triphthaloylbenzene	$3.3 x 10^{14}$	25	1.06		71
Triphenodioxazine	$1.3 x 10^{17}$	25	1.68		71
1, 3, 5-Tris-(2-benzimidazolyl) benzene	$1.6 x 10^{17}$	25	1.58		71
Tris(x-ethylphenyl)-cyanelurine	$8 x 10^6$				235
2, 4, 6-Tris(x-ethylphenyl)-s-triazine	$2.4 x 10^{13}$				235
2-Undecyl-quinoline	$2.0 x 10^9$	20 to 100	1.4 to 2.0	+	235
Xanthene polymer	7x72x 10^3	20 to 250	0.46	+	112
Zn-imidazole polymer	1015	140			286

TABLE 7

ORGANIC DYES

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier	Ref.
Acid Blue 83(CI No. 42660)	$3x10^{10}$	20	1.67		213, 279
Capri Blue	10^{15}	49	1.67		214
Crystal Violet	10^{10}	-30 to 70	0.74 1.48	- + & -	145 261, 255
Crystal Violet - Cl	10^{10}	~84	~1.2 to 1.4	-	213, 214, 144
Crystal Violet - Sulfate	10^{8}			-	215, 144
Crystalline Violet	$\sim 10^{10}$	70	1.78		204
Cynanthrone +	$1.2x10^{7}$ 10^{6}	33 to 127	0.2 0.2		191, 220
Flavanthrone +	$1.4x10^{11}$	33 to 127	0.70		142
Fluorescein · Na-	10^{13}	-50 to 150	2.03		213
Gelatin Dye Complexes:					
Basic Fuchsia	10^{20}	90 to 123	2.0±0.2		77, 211, 213
			2.9±0.1		211
Chlorophyll	10^{22}	100 to 123	2.8±0.4 3.4±.2		211
Crystal Violet	$4x10^{20}$	100 to 115 115 to 140	2.4±0.4 3.0±0.2		211

Substance	ρ ohm· cm	Temp °C	E in E/2kT	Sign of Major-ity Carrier		Ref.
Gelatin Dye Complexes, continued:						
Methylene Blue	$4x10^{14}$	40 to 95	1.3			211
			2.10			261
Rhodamine B	$2x10^{18}$	40 to 95	2.3±0.1	+ & - (Ref. 255)		211
Riboflavin	10^{20}	105 to 119	2.1±0.1			211
		119 to 140	2.9±0.1			211
	$> 5x10^{12}$					212
Indanthrazine +	$1.4x10^{15}$	33 to 127	0.66			142
Indanthrone +	$7.5x10^{14}$	33 to 127	0.63			142
Indanthrone Black +	$2.5x10^{8}$	33 to 127	0.56		Ref. 191: $\rho_o = 3.5x10^3$	144 191, 77
Indigo	10^{13}	-50 to 150	1.75			77
		40 to 110	1.75			213
Malachite Green	10^{11}		1.54			215, 77
Malachite Green - Chloride	10^{11}			-		142
Malachite Green solid				+ & -		255
Solutions	$\sim 10^{17}$		0.05	-		216
Nacrosol Black +	10^{7}	30 to 140	0.8			194
	10^{11}	30 to 140	1.6			194
Orthochrome T	10^{13}		2.05		at 10^{-4} - 10^{-5} mm press.	219
Orthochrome T+	$> 10^{15}$	40 to 100	2.05±0.1	+		219
Pinacyanol +	10^{15}	40 to 100	1.8±0.1	-		219, 220
5, 6-(N)-pyridino-1, 9-benzathrone +	$8.5x10^{22}$	33 to 170	3.20			142

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Rhodamine B +		60 to 10 10 to -54	1.6 0.32	-	Mobility: $3x10^{-2}$ $cm^2/V\cdot sec$	142
Rhodamine B	10^{12}	< 60	1.2	-	Mobility: 1 $cm^2/V\cdot sec$	215, 142
				+ & -		255

TABLE 8

BIOLOGICAL MATERIALS

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Adenine	1.7×10^{16}	120	2.4		Ref. 289: specific conductance = 3, E = 2.6 e.v. m.p. 360-5°C	217
Adenine phosphate	$\sim 10^{15}$		2.0			221
Adenosine	$\sim 10^{15}$		4.5			221
Adenosine triphosphate (ATP)	$\sim 10^{15}$		2.0			221
Adenylic acid, yeast	$\sim 10^{15}$		1.8		m.p. 195°C d.	221
Adenylic acid, muscle	$\sim 10^{15}$		2.0			221
Acetioporphyrin -1	3.31×10^{13}	100 to 370	1.99@127°			218
Acetioporphyrin -1, Co	1.66×10^{11}	180 to 40	1.87@127°			218
Acetioporphyrin -1, Cu	3.47×10^{11}	160 to 45	1.82@127°			218
Acetioporphyrin-1, Mg	1.45×10^{13}		1.86@127°			218
Acetioporphyrin-1, Ni	7.76×10^{11} >	170 to 45	1.81@127°			218
α-Alanine > 132°C	5.3×10^{14}	127	3.31		m.p. 297°C d.	222
< 132°C	5.3×10^{14}	127	2.16			
β-Alanine	5.3×10^{12}	127	4.07			222
Albumen, serum	$> 10^{10}$					142
28% water	10^{5}					
Albumen	10^{16} to 10^{17}	40 to 100	2.26			223, 211
Bovine Plasma albumen	7.9×10^{11}	127	2.78			224
Collagen	2.9×10^{13}	117	2.73		Ref. 293: elastic modulus = 2×10^{6} dynes/cm^2	224

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Coproporphyrin - III	$5.0x10^{11}$	127	1.91			218
Cytidilic acid	$\sim 10^{15}$		2.2		m.p. 231-3°C d.	142
Cytidine	10^{11} to 10^{13}		4.9		m.p. 230-1°C d.	221
Cytochrome C	$3.8x10^{11}$	127	2.60			224
Cytosine	$3.5x10^{14}$	120	2.4		Ref. 289: specific conductance = 0.25, E=2.4 e.V., m.p. 154°C	217
DNA		170 to 60	2.42±0.5			288
(dried)	$5x10^{11}$	127	2.42			288
	$2x10^{4}$ ac					218
(calf thymus)	10^{16}	20 to 95	1.7		Ref. 289: specific conductance = 10^{7}, E = 2.1	142
Na salt, native	10^{11}	20 to 50	1.52			225
Na salt, denatured	10^{13}	20 to 50	1.52			225
Na salt, heat treated	10^{12}	20 to 50	1.70			225
Mg salt	10^{15}	20 to 50	1 to 1.4			225
Diketopiperazine	$1.3x10^{10}$	> 157	2.19			222
Dioxyribonucleic acid	10^{13}	90	2.44 and 1.90±0.4 ev		$\rho_o = 1.6x10^{-3}$	275, 280
Elastin	$2.0x10^{14}$	127				224
Fibrinogen	$6.2x10^{11}$	127	2.69		$\rho_o = 10^{8}$ ohm cm	224
Gelatin (fully hydrated)	10^{9}					142
	$2x10^{2}$[illegible]	110 to 140	2.96		Ref. 228: E= 2.2; Ref. 250: heat of solution 23.24±0.25 cal/g Ref. 251: energy of activation for removal of H_2O, 1.6 kcal/mole (100-200°C) H A_c treated, 0.46 kcal/mole untreated	

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Gelatin (fully hydrated), continued:						
(completely dry)	1.25×10^{18}					142
	4.7×10^{13}	117	3.05			224
Globin	4.5×10^{13}	100 to 160	2.97@127°C			222
Glycine (single crystal) ⊥ ac	6.4×10^{13}	127 to 155	3.2		All values at 127°C	222
(single crystal) ⊥ ac	6.4×10^{13}	90 to 127	2.67		m.p. 232-6°C	222
(single crystal) ∥ ac	1.8×10^{13}	127 to 155	2.82			222
(single crystal) ∥ ac	1.8×10^{13}	90 to 127	1.99			222
(compressed powder)	1.7×10^{12}		2.92			222
Glycine - Cu chelate	10^{15}	127				222
Guanine	1.2×10^{16}	120	2.6		Ref. 289: specific conductance = 0.003, m.p. 360°C d., E = 1.96 e.V.	217
Guanylic acid	$\sim 10^{15}$		1.5		m.p. 280°C d.	221
Guanosine	10^{11} to 10^{12}		2.1		m.p. 208°C d.	221
Hematin	1.3×10^{12}	20 to 180	1.74@127°C		m.p. >200°C	222
Hemoglobin (denatured)	10^{8}	2.89				226, 224
	4.6×10^{12}	84 to 140	2.75@127°C	+	Ref. 228 for bovine hemoglobin	222
Heme, ferric	1.32×10^{12}	127	1.80			173
Hemoglobin (natural)	5.4×10^{11}	117	2.66		Ref. 258: dipole moment = 380D Dielectric relaxation time $T_o = 1.45 \times 10^{-8}$ sec	224
(denatured)	1.1×10^{12}	117	2.89			224
Insulin, pig	3.2×10^{12}	117	2.91			224
	7.3×10^{14}	120 to 200	3.13			224

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Keratin	10^8					142
Lysozyme	3.9×10^{11}	127	2.62			224
Melanin from Japanese squid	3×10^{10}			-		84
Oxamide	2.7×10^{15}		1.87			222
Plasma albumen (dry)			2.2			144
(moist)			1.6			81
Plasma, bovine	8×10^{17}		2.80			227
(chloranil complex)	3×10^{12}		1.06			227
Polyglycine	1.6×10^{13}	117	2.99			224
	2.0×10^{13}	127	3.12			222
Poly-I-tyrosine, helical	1.6×10^{12}	117	2.99			224
random coil	4.7×10^{12}	117	2.98			224
Protein, dry	10^{18}			+and-		142
RNA, yeast	3.02×10^{11}	170 to 60	2.42±0.05			218
Riboflavin	10^{14}		2.4		m.p. 280°C d.	221
Thrombin	2.6×10^{11}	127	2.59			224
Thymidine	10^{11} to 10^{13}		4.7		Ref. 289: specific conductance = 0.25, E=2.4 e.V. m.p. 185°C	221
Thymine	9×10^{14}	120	1.96		m.p. 226°C	217
			2.4			289
Thymus nucleoprotein	6.2×10^{11}	127	2.57			224
Tobacco mosaic virus	1.1×10^{13}	127	2.92			224

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Tyrosine (DL)	1.1×10^{15}	127	2.2		m.p. 316-20°C d.	222
Uracil	8.5×10^{15}	120	2.72		Ref. 289: Specific conductance = 30; E = 2.72 e.V.; m ρ. 338°C	217
Uridine	10^{11} to 10^{13}		5.2		m.p. 164-5°C	221

TABLE 9

LIQUIDS AND GLASSES

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Benzene	10^4	17 to 60	1.16 to 0.84±0.08		saturated with air	77
					Ref. 253: electron affinity (PhCl=1) =0.01	77
	1.45×10^{14}				m.p. 5.5°C	142
	1.64×10^{15}				saturated with air in N_2	142
	ΔH_{298}=+11,630 cal., ΔS_{298}=-59.6e.w., ΔG_{298}=29,400					244
Chlorpromazine	10^{-2}	32	2.1		+2, large space charges m.p. 59-60°C	186
1,3-Cyclohexadiene	1.5×10^{14}	20 to 65	1.5×10^{14}			233
1,4-Cyclohexadiene	2×10^{16}	20 to 65	0.84			233
Cyclohexane	$> 10^{16}$	20 to 65	0.32		m.p. 6.5°C	233
	1.2×10^{15}	5 to 72	1.9		saturated with water at the freezing point	233
	$\rightarrow \infty$	0				233
Cyclohexene	6.7×10^{14}	20 to 65	0.84		m.p. -103.50°C	233
Dimethylbenzene	1.5×10^{15}		0.82			233
n-Heptane	$> 10^{10}$	20 to 65	0.30			233, 142
n-Hexane	10^{16} to 10^{17}		0.32		Mobility: $1.4 \pm 0.1 \times 10^{-3}$ $cm^2/V \cdot sec$	233, 142
Methylcyclohexane	$> 10^{16}$	20 to 65	0.32			233
Salanil	2.8×10^8		0.8			92
Toluene	1.25×10^{14}		0.82		m.p. -95°C	233
1,2,4-Trimethylbenzene	1.15×10^{15}		0.84			233
1,3,5-Trimethylbenzene	10^{16}		0.38			233
m-xylene			0.82		ρ_o= 1×10^8 ohm cm	77
	ΔH_{298}=-4,670 cal., ΔS_{298}=0106.3 e.w., ΔG_{298}= +27,000 cal					244

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
o-xylene			0.90		$\rho_o = 3x10^9$ ohm cm	77
	ΔH_{298}= -4,670 cal., ΔS_{298}= -107.3 e.w., ΔG_{298}= +27,300 cal					244
p-Xylene			0.82		$\rho_o = 1x10^8$ ohm cm	77
	ΔH_{298}= -8,470 cal., ΔS_{298}= -106.1 e.w., ΔG_{298}= +23,200 cal					
Zn-9-anthrate	10^{14} to 10^{17}			+		142

In the following, conductivity was found to depend on temperature exponertially. Samples were examined as solids and as liquids.

Substance	ρ ohm·cm	Temp °C	E in E/2kT	Sign of Majority Carrier		Ref.
Acridine	10^{13} to 10^{22}	25				300
Anthracene	10^{13} to 10^{22}	25				300
Benzanthrone	10^{13} to 10^{22}	25				300
β-Methylnaphthalene	10^{13} to 10^{22}	25				300
Naphthalene	10^{13} to 10^{22}	25				300
α-Naphthol	10^{13} to 10^{22}	25				300
β-Naphthol	10^{13} to 10^{22}	25				300
α-Naphthoquinoline	10^{13} to 10^{22}	25				300
β-Naphthoquinoline	10^{13} to 10^{22}	25				300
Phenanthrene	10^{13} to 10^{22}	25				300
o-Phenanthroline	10^{13} to 10^{22}	25				300
Phenazine	10^{13} to 10^{22}	25				300
1-Phenylazo-2-naphthol	10^{13} to 10^{22}	25				300
1-(o-Tolylazo)-2-naphthol	10^{13} to 10^{22}	25				300

TABLE 10

PHYSICAL PROPERTIES OF COMMERCIALLY AVAILABLE PLASTICS

FROM REFERENCE 242:

PHYSICAL PROPERTIES OF COMMERCIALLY AVAILABLE PLASTICS
ABS (ACRYLONITRILE - BUTADIENE - STYRENE)

Properties	Extrusion Grade	High Impact	High Heat Resistance	Medium Impact
Specific gravity	0.99 to 1.15	1.02 to 1.2	1.03 to 1.2	1.02 to 1.2
Specific volume, cu.in/lb.	24 to 28	-	23 to 27	-
Refractive index, n_D	-	-	-	-
Tensile strength, psi	2400 to 6500	4500 to 7000	6000 to 7500	5500 to 7000
Elongation, %	-	-	-	-
Tensile modulus, 10^5 psi	1 to 3.3	2 to 3.5	3 to 4	2.8 to 4
Compressive strength, psi x 10^3	2.5 to 6.5	4.5 to 7.0	6.0 to 7.5	5.5 to 7.0
Flexural strength, psi x 10^3	4.0 to 10.0	7.0 to 10.5	9.0 to 12.0	8.0 to 11.0
Impact strength, ft.-lb/in.	1.8 to 10	3 to 7	1 to 4.5	0.7 to 2.5
Hardness, Rockwell	30 to 105	80 to 110	100 to 120	95 to 115
Thermal conductivity, 10^{-4} cal./sec./sq.cm., /1(°C./cm)	4.6 to 8	4.6 to 8	4.6 to 8	4.6 to 8
Specific heat, cal./°C per gm.	0.3 to 0.4	0.3 to 0.4	0.3 to 0.4	0.3 to 0.4
Thermal expansion, 10^{-3} per °C	9 to 13	9 to 11	5.5 to 8.5	7.5 to 9
Resistance to heat, °F. (continuous)	140 to 200	170 to 210	190 to 230	160 to 200
Deflection temp., °F				
@264 psi fiber stress	140 to 200	175 to 210	195 to 230	175 to 200
@ 66 psi fiber stress	190 to 215	190 to 215	215 to 245	190 to 210

Volume resistivity, ohm-cm.	$0.5x10^{13}$-$4x10^{16}$	1-$4x10^{16}$	$1.5x10^{16}$	1.5-$4x10^{16}$
Dielectric strength (short time) volts/mil	400 to 550	400 to 550	400 to 550	400 to 550
(step-by-step) volts/mil	350 to 500	350 to 500	350 to 500	350 to 500
Dielectric constant, 60 cycles	2.4 to 3.4	2.4 to 3.4	2.4 to 3.4	2.4 to 3.4
10^3 cycles	2.4 to 3.4	2.4 to 3.4	2.4 to 3.4	2.4 to 3.4
10^6 cycles	2.4 to 3.4	2.4 to 3.4	2.4 to 3.4	2.4 to 3.4
Dissipation (power) factor 60 cycles	0.003-0.013	0.003-0.013	0.003-0.013	0.003-0.013
10^3 cycles	0.003-0.013	0.003-0.013	0.003-0.013	0.003-0.013
10^6 cycles	0.005-0.015	0.005-0.015	0.005-0.015	0.005-0.015
Arc resistance, sec.	55 to 90	55 to 90	55 to 90	55 to 90
Water absorption, 24 hr., %	0.25 to 0.45	0.25 to 0.45	0.25 to 0.45	0.25 to 0.45
Burning rate (flammability, in./min.)	slow	slow	slow	slow
Effect of sunlight	none to slightly yellow			
Effect of weak acids	none	none	none	none
Effect of strong acids	attacked by oxidizing acids			
Effect of weak alkalies	none	none	none	none
Effect of strong alkalies	none	none	none	none
Effect or organic solvents	soluble in ketones, esters, and some chlorinated hydrocarbons			
Machining qualities	good to excellent			

PROPERTIES	Acetal Homopolymer	Acetal Copolymer	Acrylic Methyl Methacrylate Cast	Acrylic Methyl Methacrylate Molding
Specific gravity (density)	1.425	1.41	1.17-1.20	1.17-1.20
Specific volume, cu. in/lb.	19.5	19.7	23.1 to 23.7	23.1 to 23.7
Refractive index, n_D	1.48	-	1.48 to 1.50	1.49
Tensile strength, psi	10000	8800 (73°F.)	8000 to 11000	7000 to 11000
Elongation, %	15(Inj); 75(Ext)	60 to 75	2 to 7	2 to 10
Tensile modulus, 10^5 psi	4.10	4	3.5 to 5.0	4.5
Compressive strength, psi x 10^{-3}	18. (10% defl)	16. (10% defl)	11. to 19.	12. to 18.
Flexural strength, psi x 10^{-3}	14	13	12 to 17	13 to 17
Impact strength, ft.-lb/in.	1.4(inj); 2.3(ext)	1.2 to 1.4	0.4 to 0.5	0.3 to 0.5
Hardness, Rockwell	M94, R120	M78 to M80	M80 to M100	M85 to M105
Thermal conductivity 10^{-4} cal./sec./sq.cm., 1(°C./cm)	5.5	5.5	4 to 6	4 to 6
Specific heat, cal./°C per gm.	0.35	0.35	0.35	0.35
Thermal expansion, 10^{-3} per °C	8.1×10^{-5}	8.1×10^{-8}	5 to 9	5 to 9
Resistance to heat, °F (continuous)	185	220	140 to 200	140 to 190
Deflection temp., °F				
@ 264 psi fiber stress	255	230	160 to 215	155 to 210
@ 66 psi fiber stress	338	316	165 to 235	165 to 225

Volume resistivity, ohm-cm.	$6x10^{14}$	$1x10^{14}$	$> 10^{15}$	$> 10^{14}$
Dielectric strength (short time) volts/mil	465-1900	500 (90 mil)	450-550	450-550
(step-by-step) volts/mil	400	-	350-400	350-400
Dielectric constant, 60 cycles	-	3.8	3.5 to 4.5	3.5 to 4.5
10^3 cycles	3.7	3.8	3.0 to 3.5	3.0 to 3.5
10^6 cycles	3.7	3.8	2.2 to 3.2	2.2 to 3.2
Dissipation (power) factor 60 cycles	-	-	0.05-0.06	0.04-0.06
10^3 cycles	0.004	0.004	0.04-0.06	0.03-0.05
10^6 cycles	0.004	0.005-0.007	0.02-0.03	0.02-0.03
Arc resistance, sec.	129 on 15 mil	240 (burns)	no track	no track
Water absorption, 24 hr., %	0.25	0.22	0.3 to 0.4	0.3 to 0.4
Burning rate (flammability, in./min.)	slow (1.1)	slow (1.1)	slow (1.0-1.3)	slow (0.9-1.2)
Effect of sunlight	chalks slightly	chalks slightly	nil	nil
Effect of weak acids	resists some	resists some	nil	nil
Effect of strong acids	attacked	attacked	attacked only by high conc. oxidizing acids	
Effect of weak alkalies	resists some	none	nil	nil
Effect of strong alkalies	resists some	none	attacked	attacked
Effect of organic solvents	excellent resistance		soluble in ketones, esters, aromatic & chlorinated solvents	
Machining qualities	excellent	excellent	fair to excellent	good to excellent

PROPERTIES	Acrylic Methyl Methacrylate/ styrene copolymer	Acrylic Methyl Methacrylate/ α-methylstyrene copolymer	Acrylic Impact Acrylic Molding Compound	Allyl Monomer Cast Allyl
Specific gravity (density)	1.08-1.16	1.16	1.08-1.18	1.30-1.40
Specific volume, cu. in/lb.	23.8-25.6	24	23.3-25.6	19.8-20.9
Refractive index, n_D	1.533-1.565	1.519	not appl.	1.50-1.575
Tensile strength, psi	9000 to 11000	9000	5000 to 9000	5000 to 6000
Elongation, %	2 to 5	3	> 15 to 50	-
Tensile modulus, 10^5 psi	4.4 to 5.0	4.8	2.0 to 4.0	3.0
Compressive strength, psi x 10^{-3}	11 to 15	18	4 to 14	21 to 23
Flexural strength, psi x 10^{-3}	16 to 19	15	8 to 13	6 to 13
Impact strength, ft.-lb/in.	0.35 to 0.50	0.3	0.5 to 4.5	0.2 to 0.4
Hardness, Rockwell	M70 to M85	M104-M107	R99 to R120	M95 to R120
Thermal conductivity 10^{-4} cal./ sec./sq. cm., /1°C./cm.)	3.0 to 4.0	-	4 to 5	4.8 to 5
Specific heat, cal./°C per gm.	0.34	0.35	0.34	0.26-0.55
Thermal expansion, 10^{-3} per °C	6 to 8	5.4x10^{-3}	6 to 8	5 to 10
Resistance to heat, °F (continuous)	180 to 200	260	160 to 185	212
Deflection temp., °F				
@ 264 psi fiber stress	185 to 210	244 tc 252	165 to 215	140 to 190
@ 66 psi fiber stress	-	260 to 267	180 to 225	-

Volume resistivity, ohm-cm.	$> 10^{16}$	-	$2.0x10^{16}$	$> 4x10^{14}$
Dielectric strength (short time) volts/mil	400 to 500	475	400 to 500	380
(step-by-step) volts/mil	-	-	400 to 500	320
Dielectric constant, 60 cycles	-	3.12	3.0 to 4.0	3.45 to 5.0
10^3 cycles	3.13	3.0	2.5 to 3.5	3.35 to 5.0
10^6 cycles	2.81	3.03	2.0 to 3.0	3.6 to 4.5
Dissipation (power) factor 60 cycles	-	0.039	0.03 to 0.04	0.006-0.019
10^3 cycles	0.025	0.028	0.02 to 0.035	0.01
10^6 cycles	0.019	0.011	0.01 to 0.02	0.028-0.06
Arc resistance, sec.	-	-	no track	120 to 250
Water absorption, 24 hr., %	0.2	0.2	0.2 to 0.4	0.03 to 0.44
Burning rate (flammability, in./min.)	slow	slow(1.7)	slow (1.0 to 0.3)	0.3 to self-extinguishing
Effect of sunlight	nil	nil	sl. strength loss	yellows v. slightly
Effect of weak acids	none	nil	pract. nil	none
Effect of strong acids	— attacked by high conc. of oxidizing acids ——			only by oxidizing acids
Effect of weak alkalies	none	nil	pract. nil	none
Effect of strong alkalies	none	nil	pract. nil	none to slight
Effect of organic solvents	soluble in ketones, esters, aromatic and chlorinated hydrocarbons			resistant
Machining qualities	good to excellent			good

	Cellulosic Molding Compound and Sheets			
	Ethyl Cellulose Molding Cpds. and Sheets	Cellolose Acetate		
PROPERTIES		Sheet	Molding	High Acetyl
Specific Gravity (density)	1.09 to 1.17	1.28 to 1.32	1.23 to 1.34	1.26 to 1.34
Specific volume, cu. in./lb.	23.6 to 25.5	20.9 to 21.6	20.6 to 22.5	20.6 to 22.5
Refractive index, n_D	1.47	1.49 to 1.50	1.46 to 1.50	1.46 to 1.50
Tensile strength, psi	2000-8000	4500-8000	1900-8500	3000-11000
Elongation, %	5 to 40	20 to 50	6 to 70	4 to 55
Tensile modulus, 10^5 psi	1.0 to 3.0	3.4	0.65 to 4.0	3.5 to 4.5
Compressive strength, psi $\times 10^{-3}$	10 to 35	18 to 25	2.2 to 36	14 to 36
Flexural strength, psi $\times 10^{-3}$	4 to 12	6 to 10	0.2 to 16	3.5 to 13
Impact strength, ft.-lb/in.	2.0 to 8.5 0.3 to 1.7 -40°F	1.0 to 3.0	0.4 to 5.2	0.4 to 5.2
Hardness, Rockwell	R50 to R115	R95 to R120	R35 to R125	R65 to R125
Thermal conductivity 10^{-4} cal./sec./sq. cm., /1°C./cm.)	3.8 to 7	4 to 8	4 to 8	4 to 8
Specific heat, cal./°C per gm.	0.3 to 0.75	0.3 to 0.5	0.3 to 0.42	0.3 to 0.42
Thermal expansion, 10^{-3} per °C	10 to 20	10 to 15	8 to 16	8 to 16
Resistance to heat, °F (continuous)	115 to 185	140 to 220	140 to 220	150 to 220
Deflection temp, °F				
@ 264 psi fiber stress	115 to 190	130 to 160	111 to 190	118 to 195
@ 66 psi fiber stress	-	-	120 to 205	130 to 212

Volume resistivity, ohm-cm.	10^{12} to 10^{14}	10^{11} to 10^{13}	10^{10} to 10^{14}	10^{10} to 10^{13}
Dielectric strength (short time) volts/mil	350 to 500	250 to 300	250 to 365	250 to 365
(step-by-step) volts/mil	300 to 500	-	200 to 300	200 to 300
Dielectric constant, 60 cycles	3.0 to 4.2	4.7	3.5 to 7.5	4.7
10^3 cycles	3.0 to 4.1	4.5	3.5 to 7.0	4.5
10^6 cycles	2.8 to 3.9	4.4	3.2 to 7.0	4.4
Dissipation (power) factor 60 cycles	0.005-0.020	0.018	0.01-0.06	0.018
10^3 cycles	0.002-0.020	0.022	0.01-0.06	0.022
10^6 cycles	0.010-0.060	0.051	0.01-0.10	0.051
Arc resistance, sec.	60 to 80	180 to 200	50 to 310	50 to 310
Water absorption, 24 hr., %	0.8 to 1.8	2.0 to 4.5	1.9 to 6.5	1.3 to 2.0
Burning rate (flammability, in./min.)	slow	——— slow to self-extinguishing ———		
Effect of sunlight	slight	no visible change	slight	slight
Effect of weak acids	slight	no visible change	slight	none
Effect of strong acids	decomposes	decomposes	decomposes	decomposes
Effect of weak alkalies	none	no visible change	slight	no visible change
Effect of strong alkalies	slight	swells	decomposes	decomposes
Effect of organic solvents	widely soluble	soluble in liquid ketones and esters, softened or dissolved by chlorinated & aromatic hydrocarbons		
Machining qualities	good	good	excellent	good

Cellulosic Molding Compound and Sheets

PROPERTIES	Cellulose Propionate Molding Compound	Cellulose Acetate-Butyrate Sheet	Cellulose Acetate-Butyrate Molding	Cellulose Nitrate (Pyroxylin)
Specific gravity (density)	1.18 to 1.24	1.15 to 1.22	1.15 to 1.22	1.35 to 1.40
Specific volume, cu. in/lb.	22.5 to 23.4	22.7 to 24.0	22.7 to 24.0	19.8 to 20.5
Refractive index, n_D	1.46 to 1.49	1.46 to 1.49	1.46 to 1.49	1.49 to 1.51
Tensile strength, psi	2000 to 7800	2600 to 6900	2600 to 6900	7000 to 8000
Elongation, %	29 to 100	60 to 100	40 to 88	40 to 45
Tensile modulus, 10^5 psi	0.6 to 2.15	2.0 to 2.5	0.5 to 2.0	1.9 to 2.2
Compressive strength, psi $\times 10^{-3}$	3.1 to 22.0	-	2.1 to 22.0	22.0 to 35.0
Flexural strength, psi $\times 10^{-3}$	3.2 to 11.4	4.0 to 9.0	1.8 to 9.3	9.0 to 11.0
Impact strength, ft.-lb/in.	0.5 to 11.5	0.8 to 6.3	0.8 to 6.3	5.0 to 7.0
Hardness, Rockwell	R10 to R122	R30 to R115	R31 to R116	R95 to R115
Thermal conductivity 10^{-4} cal./sec./sq. cm., /1°C./cm.)	4 to 8	4 to 8	4 to 8	5.5
Specific heat, cal./°C per gm.	0.3 to 0.40	0.3 to 0.4	0.3 to 0.4	0.3 to 0.4
Thermal expansion, 10^{-3} per °C	11 to 17	11 to 17	11 to 17	8 to 12
Resistance to heat, °F (continuous)	155 to 220	140 to 220	140 to 220	ca. 140
Deflection temp., °F				
@ 264 psi fiber stress	111 to 228	113 to 202	113 to 202	140 to 160
@ 66 psi fiber stress	158 to 250	130 to 227	130 to 227	-

Volume resistivity, ohm-cm.	10^{12} to 10^{16}	10^{11} to 10^{15}	10^{11} to 10^{15}	$(10-15)\times10^{10}$
Dielectric strength (short time) volts/mil	300 to 450	250 to 400	250 to 400	300 to 600
(step-by-step) volts/mil	300 to 375	-	-	250 to 550
Dielectric constant, 60 cycles	3.7 to 4.0	4.7	3.5 to 6.4	7.0 to 7.5
10^3 cycles	3.6 to 4.0	4.5	-	7.0
10^6 cycles	3.4 to 3.6	4.4	3.2 to 6.2	6.4
Dissipation (power) factor 60 cycles	0.01 to 0.04	0.018	0.01 to 0.04	0.09 to 0.12
10^3 cycles	0.0. to 0.04	0.022	-	0.03
10^6 cycles	0.01 to 0.04	0.051	0.01 to 0.04	0.06 to 0.09
Arc resistance, sec.	175 to 190	-	-	-
Water absorption, 24 hr., %	1.2 to 2.8	0.9 to 2.2	0.9 to 2.2	1.0 to 2.0
Burning rate (flammability, in./min.)	slow (1.0 to 1.3)	slow	slow	very fast
Effect of sunlight	slight	no visible change	slight	discolors and becomes brittle
Effect of weak acids	slight	no visible change	slight	slight
Effect of strong acids	decomposes	decomposes	decomposes	decomposes
Effect of weak alkalies	slight	no visible change	slight	slight
Effect of strong alkalies	decomposes	decomposes	decomposes	decomposes
Effect or organic solvents	soluble in ketones and esters, softened or dissolved by chlorinated and aromatic hydrocarbons			widely soluble
Machining qualities	excellent	good	excellent	excellent

PROPERTIES	Chlorinated Polyether	Epoxy Resins Cast Resins No filler	Epoxy Resins Cast Resins Silica Filler	Epoxy Resins Cast Resins Flexibilized
Specific gravity (density)	1.4	1.11 to 1.40	1.6 to 2.0	1.05 to 1.35
Specific volume, cu. in/lb.	19.8	20 to 24.9	17.3 to 13.9	20.5
Refractive index, n_D	-	1.55 to 1.61	-	-
Tensile strength, psi	6000	4000-13000	7000-13000	2000-10000
Elongation, %	60 to 160	3 to 6	1 to 3	20 to 70
Tensile modulus, 10^5 psi	1.6	3.5	-	0.01 to 3.5
Compressive strength, psi $\times 10^{-3}$	-	15.0 to 25.0	15.0 to 35.0	1.0 to 14.0
Flexural strength, psi $\times 10^{-3}$	5.0	13.3 to 21.0	8.0 to 14.0	1.0 to 13.0
Impact strength, ft.-lb/in.	0.4	0.2 to 1.0	0.3 to 0.45	3.5 to 5
Hardness, Rockwell	R-100	M80 to M110	M85 to M120	-
Thermal conductivity 10^{-4} cal./sec./sq. cm., /1(°C./cm.)	3.1	4 to 5	10 to 20	-
Specific Heat, cal./°C per gm.	-	0.25	0.20 to 0.27	-
Thermal expansion, 10^{-3} per °C	8.0	4.5 to 6.5	2.0 to 4.0	2 to 10
Resistance to heat, °F. (continuous)	290	250 to 550	250 to 550	250 to 300
Deflection temp., °F				
@ 264 psi fiber stress	-	115 to 550	160 to 550	RT to 250
@ 66 psi fiber stress	285	-	-	-

Volume resistivity, ohm-cm.	10^{15}	10^{12} to 10^{17}	10^{13} to 10^{16}	$1.3\text{-}15 \times 10^{14}$
Dielectric strength (short time) volts/mil	400	400 to 500	400 to 550	235 to 400
(step-by-step) volts/mil	-	380	-	235 to 400
Dielectric constant, 60 cycles	3.1	3.5 to 5.0	3.2 to 4.5	3 to 6
10^3 cycles	3.0	3.5 to 4.5	3.2 to 4.0	3 to 5
10^6 cycles	2.9	3.3 to 4.0	3.0 to 3.8	3 to 6
Dissipation (power) factor 60 cycles	0.01	0.002-0.010	0.008-0.03	0.010-0.040
10^3 cycles	0.01	0.002-0.02	0.008-0.03	0.012-0.050
10^6 cycles	0.01	0.030-0.050	0.02-0.04	0.018-0.090
Arc resistance, sec.	-	45 to 120	150 to 300	50 to 180
Water absorption, 24 hr., %	0.01	0.08-0.15	0.04-0.10	0.27-0.5
Burning rate (flammability, in./min.)	self-extinguishing	slow	self-extinguishing	slow
Effect of sunlight	slight	none	none	none
Effect of weak acids	none	none	none	none
Effect of strong acids	attacked by oxidizing acids	attacked by some	attacked by some	attacked by some
Effect of weak alkalies	none	none	none	none
Effect of strong alkalies	none	slight	slight	slight
Effect of organic solvents	resists most	generally resistant	generally resistant	generally resistant
Machining qualities	excellent	good	poor	good

Epoxy Resins

PROPERTIES	Molding Compounds: Glass Filled	Molding Compounds: Mineral Filled	Encapsulating Grades: Mineral Filled	Encapsulating Grades: Glass Filled
Specific gravity (density)	1.6 to 2.0	1.6 to 2.0	1.7 to 2.1	1.7 to 2
Specific volume, cu. in/lb.	14 to 15.4	13.4 to 14.2	14	14
Refractive index, n_D	-	-	-	-
Tensile strength, psi	10000-30000	5000-15000	4000-10000	5000-15000
Elongation, %	4	-	-	-
Tensile modulus, 10^5 psi	30.4	-	-	-
Compressive strength, psi $x10^{-3}$	25.0 to 40.0	18.0 to 40.0	18.0 to 30.0	18.0 to 30.0
Flexural strength, psi $x10^{-3}$	10.0 to 60.0	8.0 to 15.0	6.0 to 15.0	8.0 to 20.0
Impact strength, ft.-lb/in.	10.0	0.3 to 0.4	0.3 to 0.45	0.5 to 2.0
Hardness, Rockwell	M100 to M110	M100 to M110	M100 to M112	M100 to M112
Thermal conductivity 10^{-4} cal./sec./sq. cm., /1(°C./cm.)	4 to 10	4 to 30	4 to 10	4 to 10
Specific heat, cal./°C per gm.	0.19	-	-	-
Thermal expansion, 10^{-3} per °C	1.1 to 3.5	2.0 to 5.0	3 to 6	3.5
Resistance to heat, °F. (continuous)	300 to 500	300 to 500	300 to 450	300 to 450
Deflection temp., °F @ 264 psi fiber stress	250 to 500	250 to 500	225 to 450	225 to 450
@ 66 psi fiber stress	-	-	-	-

Volume resistivity, ohm-cm.	$> 10^{14}$	$> 10^{14}$	$> 10^{14}$	$> 10^{14}$
Dielectric strength (short time) volts/mil	300 to 400	300 to 400	250 to 400	250 to 400
(step-by-step) volts/mil	300 to 400	300 to 400	250 to 400	250 to 400
Dielectric constant, 60 cycles	3.5 to 5.0	3.5 to 5.0	3.5 to 5.0	3.5 to 5.0
10^3 cycles	3.5 to 5.0	3.5 to 5.0	3.5 to 5.0	3.5 to 5.0
10^6 cycles	3.5 to 5.0	3.5 to 5.0	3.5 to 5.0	3.5 to 5.0
Dissipation (power) factor 60 cycles	0.01	0.01	0.01	0.01
10^3 cycles	0.01	0.01	0.01	0.01
10^6 cycles	0.01	0.01	0.01	0.01
Arc resistance, sec.	120 to 180	150 to 190	120 to 180+	120 to 180+
Water absorption, 24 hr., %	0.05 to 0.2	0.04	0.03 to 0.2	0.04 to 0.2
Burning rate (flammability, in./min.)	— self-extinguishing —		— self-extinguishing to non-burning —	
Effect of sunlight	slight	slight	slight	slight
Effect of weak acids	none	none	none	none
Effect of strong acids	negligible	none	slight	slight
Effect of weak alkalies	none	none	slight	slight
Effect of strong alkalies	none	slight	— slight to attack —	
Effect of organic solvents	none	none	slight	slight
Machining qualities	fair to good	fair	fair to good	fair

PROPERTIES	Fluoroplastics			
	Polychloro-Trifluoro-Ethylene	Polytetrafluoro-ethylene Molding Compound	FEP Fluorocarbon	Poly-vinylidene Fluoride
Specific gravity (density)	2.1 to 2.2	2.13 to 2.22	2.12 to 2.17	1.76 to 1.77
Specific volume, cu.in/lb.	12.7 to 13.2	12.6 to 13.2	12.8 to 13.0	15.6 to 15.7
Refractive index, n_D	1.425	1.35	1.338	1.42
Tensile strength, psi	4500 to 6000	2000 to 4500	2700 to 3100	7000
Elongation, %	80 to 250	200 to 400	250 to 330	100 to 300
Tensile modulus, 10^5 psi	1.5 to 3	0.58	0.5	1.2
Compressive strength, psi $x10^{-3}$	4.6 to 7.4	1.7	-	10.0
Flexural strength, psi $x10^{-3}$	7.4 to 9.3	-	-	-
Impact strength, ft.-lb/in.	2.5 to 2.7	3.0	no break	3.5
Hardness, Rockwell	R75 to R95	D50 to D65	R25	D-90(Shore)
Thermal conductivity 10^{-4} cal./sec./sq. cm., /1(°C./cm.)	4.7 to 5.3	6	6	3
Specific heat, cal./°C per gm.	0.22	0.25	0.28	0.33
Thermal expansion, 10^{-3} per °C	4.5 to 7.0	10	8.3 to 10.5	12
Resistance to heat, °F. (continuous)	350 to 390	550	400	300
Deflection temp., °F -				
@ 264 psi fiber stress	-	-	-	195
@ 66 psi fiber stress	258	250	-	300

Volume resistivity, ohm-cm.	1.2×10^{18}	$> 10^{18}$	$> 2 \times 10^{18}$	2×10^{14}
Dielectric strength (short time) volts/mil	500 to 600	480	500 to 600	260
(step-by-step) volts/mil	450 to 550	430	-	-
Dielectric constant, 60 cycles	2.24 to 2.8	2.1	2.1	8.4
10^3 cycles	2.3 to 2.7	2.1	2.1	8.0
10^6 cycles	2.3 to 2.5	2.1	2.1	6.6
Dissipation (power) factor 60 cycles	0.0012	<0.0002	<0.0003	0.049
10^3 cycles	0.023 to 0.027	<0.0002	<0.0003	0.018
10^6 cycles	0.009 to 0.017	<0.0002	<0.0003	0.17
Arc resistance, sec.	>360	>200	>165	50 to 70
Water absorption, 24 hr., %	0.00	0.00	0.01	0.04
Burning rate (flammability, in./min.)	none	none	none	self extinguishing
Effect of sunlight	none	none	none	sl. bleaching on long exposures
Effect of weak acids	none	none	none	none
Effect of strong acids	none	none	none	attacked by fuming sulfuric
Effect of weak alkalies	none	none	none	none
Effect of strong alkalies	none	none	none	none
Effect of organic solvents	halogenated cpds. cause sl. swelling	none	none	resists most
Machining qualities	excellent	excellent	excellent	excellent

PROPERTIES	Ionomers	Melanine-Formaldehyde Molding Compounds: α-Cellulose Filler	Asbestos Filler	Macer. ted Fabric Filler
Specific gravity (density)	0.93 to 0.95	1.47 to 1.52	1.70 to 2.0	1.5
Specific volume, cu. in/lb.	29.2 to 29.8	18.2 to 18.8	13.8 to 16.3	18.5
Refractive index, n_D	-	-	-	-
Tensile strength, psi	3500-5500	7000-13000	5500-7000	8000-10500
Elongation, %	340 to 450	0.6 to 0.9	0.30 to 0.45	0.6 to 0.8
Tensile modulus, 10^5 psi	0.2 to 0.5	12 to 14	19.5	14 to 16
Compressive strength, psi $x10^{-3}$	-	25.0 to 45.0	30.0	30.0 to 35.0
Flexural strength, psi $x10^{-3}$	-	10.0 to 16.0	9.0 to 11.0	12.0 to 15.0
Impact strength, ft.-lb./in.	6 to 15	0.24 to 0.35	0.28 to 0.4	0.6 to 1.0
Hardness, Rockwell	600 (shore)	M110 to M125	M110	M120
Thermal conductivity 10^{-4} cal./sec./sq. cm., /1°C/cm.)	5.8	7 to 10	13 to 17	10.6
Specific heat, cal./°C per gm.	0.55	0.4	-	-
Thermal expansion, 10^{-3} per °C	-	4.0	2.0 to 4.5	2.5 to 2.8
Resistance to heat, °F (continuous)	160 to 212	210	250 to 400	250
Deflection temp., °F				
@ 264 psi fiber stress	-	360 to 370	265	310
@ 66 psi fiber stress	-	-	-	-

Volume resistivity, ohm-cm.	$> 10^{16}$	10^{12} to 10^{14}	1.22×10^{12}	10^{9} to 10^{10}
Dielectric strength				
(short time) volts/mil	900 to 1100	300 to 400	410 to 430	250 to 350
(step-by-step) volts/mil	2.4 to 2.5	250 to 300	280 to 320	200 to 300
Dielectric constant, 60 cycles	-	7.9 to 9.5	6.4 to 10.2	7.6 to 12.6
10^3 cycles	-	7.8 to 9.2	9.0	7.1 to 7.8
10^6 cycles	-	7.2 to 8.4	6.1 to 6.7	6.5 to 6.9
Dissipation (power) factor 60 cycles	-	0.030 to 0.083	0.07 to 0.17	0.07 to 0.34
10^3 cycles	-	0.015 to 0.036	0.07	0.03 to 0.05
10^6 cycles	-	0.027 to 0.045	0.041 to 0.050	0.036 to 0.041
Arc resistance, sec.	-	110 to 180	120 to 180	115 to 125
Water absorption, 24 hr., %	0.1 to 1.4	0.1 to 0.6	0.08 to 0.14	0.3 to 0.6
Burning rate (flammability, in./min.)	very slow	—— self-extinguishing ——		
Effect of sunlight	requires U.V. stabilizer	— slight color change —		slight discoloration
Effect of weak acids	resistant	none	none to slight	none
Effect of strong acids	attacked by oxidizing acids	decomposes	decomposes	decomposes
Effect of weak alkalies	very resistant	none	very slight attack	none
Effect of strong alkalies	very resistant	attacked	slight attack	attacked
Effect of organic solvents	very resistant @ 75°F	none	none	none
Machining qualities	fair	fair	fair	good

PROPERTIES	Nylons Type 6/6	Type 6	Type 6/10	20 to 40% Glass Filled
Specific gravity (density)	1.13 to 1.15	1.12 to 1.14	1.09	1.3 to 1.52
Specific volume, cu.in/lb.	24.2 to 25.5	24.2 to 24.5	25.5	21.7 to 25.4
Refractive index, n_D	1.53	-	-	-
Tensile strength, psi	9000-12000	7000-14000	8500-8600	14000-35000
Elongation, %	60 to 300	25 to 320	85 to 300	1.5 to 6
Tensile modulus, 10^5 psi	1.75 to 4.1	1.5 to 3.8	1.6 to 2.8	8.6 to 18
Compressive strength, psi $x10^{-3}$	6.7 to 12.5	7.2 to 13.0	-	15.0 to 24.0
Flexural strength, psi $x10^{-3}$	no break	no break	no break	18.0 to 40.0
Impact strength, ft.-lb/in.	1.0 to 2.0	1.0 to 4.0	1.2	2.5 to 6
Hardness, Rockwell	R108 to R118	R103 to R118	R111	M94 to E75
Thermal conductivity 10^{-4} cal./ sec./sq. cm., /1(°C./cm.)	5.85	5.85	5.16	1.5 to 1.7
Specific heat, cal./°C per gm.	0.4	0.38	0.4	0.3 to 0.35
Thermal expansion, 10^{-3} per °C	8	8.3	9	1.2 to 3.2
Resistance to heat, °F. (continuous)	180 to 300	175 to 250	-	300 to 400
Deflection temp., °F				
@ 264 psi fiber stress	150 to 186	152 to 167	-	498 to 502
@ 66 psi fiber stress	360 to 365	300 to 365	300	507 to 510

Volume resistivity, ohm-cm.	10^{14} to 10^{15}	10^{12} to 10^{15}	10^{14} to 10^{15}	1.53-5.5x 10^{15}
Dielectric strength				
(short time) volts/mil	385 to 470	440 to 510	-	408 to 503
(step-by-step) volts/mil	340 to 410	320 to 440	-	375 to 450
Dielectric constant, 60 cycles	4.0 to 4.6	3.9 to 5.5	3.9	4.0 to 4.6
10^3 cycles	3.9 to 4.5	4.0 to 4.9	3.6	3.9 to 4.4
10^6 cycles	3.4 to 3.6	3.5 to 4.7	3.5	3.4 to 3.9
Dissipation (power) factor 60 cycles	0.014 to 0.04	0.010 to 0.06	0.04	0.018 to 0.025
10^3 cycles	0.02 to 0.04	0.011 to 0.06	0.04	0.020 to 0.025
10^6 cycles	0.04	0.03 to 0.04	0.04	0.017 to 0.022
Arc resistance, sec.	130 to 140	-	-	92 to 148
Water absorption, 24 hr., %	1.5	1.6 to 1.88	0.4	0.2 to 1.1
Burning rate (flammability, in./min.)	— self-extinguishing —			non-burning
Effect of sunlight	— discolors slightly —			
Effect of weak acids	resistant	resistant	resistant	resistant
Effect of strong acids	attacked	attacked	attacked	attacked
Effect of weak alkalies	none	none	none	none
Effect of strong alkalies	none	none	none	surface only
Effect of organic solvents	— dissolved by phenols and formic acids —			resistant to most
Machining qualitites	excellent	excellent	excellent	fair

PROPERTIES	Polyacrylic Ester Molding Material	Phenol-Formaldehyde and Phenol-Furfural Molding Compounds No Filler	Woodflour and Cotton Flock Filler	Asbestos Filler
Specific gravity (density)	1.3 to 1.5	1.25 to 1.30	1.32 to 1.45	1.45 to 1.9
Specific volume, cu. in/lb.	18.5 to 21.3	21.3 to 22.2	17.8 to 20.9	11.9 to 20.9
Refractive index, n_D	-	1.5 to 1.7	-	-
Tensile strength, psi	1200-2000	7000-8000	6500-10000	5500-7500
Elongation, %	300 to 600	1.0 to 1.5	0.4 to 0.8	0.18 to 0.50
Tensile modulus, 10^5 psi	0.002 to 0.004	7.5 to 10	8 to 17	10 to 30
Compressive strength, psi $x10^{-3}$	-	10.0 to 30.0	22.0 to 36.0	20.0 to 35.0
Flexural strength, psi $x10^{-3}$	-	12.0 to 15.0	8.5 to 12.0	8.0 to 14.0
Impact strength, ft.-lb/in.	-	0.20 to 0.36	0.24 to 0.60	0.27 to 3.5
Hardness, Rockwell	40 to 90(Shore)	M124 to M128	M96 to M120	M95 to M115
Thermal conductivity 10^{-4} cal./sec./sq. cm., /1(°C./cm.)	-	3 to 6	4 to 7	8 to 22
Specific heat, cal./°C per gm.	-	0.38 to 0.42	0.35 to 0.40	0.28 to 0.32
Thermal expansion, 10^{-3} per °C	-	2.5 to 6.0	3.0 to 4.5	0.8 to 4
Resistance to heat, °F. (continuous)	250 to 350	250	350 to 360	350 to 500
Deflection temp., °F				
@ 264 psi fiber stress	-	240 to 260	260 to 340	300 to 400
@ 66 psi fiber stress	-	-	-	-

Volume resistivity, ohm-cm.	2×10^{11} at 70°C	[illegible] 10^{12}	10^{9} to 10^{13}	10^{10} to 10^{13}
Dielectric strength (short time) volts/mil	400 to 700 at 70°C	300 to 400	200 to 400	200 to 350
(step-by-step) volts/mil	-	250 to 350	100 to 375	150 to 300
Dielectric constant, 60 cycles	4 at 70°C	5 to 6.5	5.0 to 13	7.5 to 50
10^3 cycles	-	4.5 to 6.0	4.4 to 9.0	6 to 30
10^6 cycles	11	4.5 to 5.0	4.0 to 6.0	5.0 to 10.0
Dissipation (power) factor 60 cycles	2 at 70°C	0.06 to 0.10	0.05 to 0.30	0.1 to 0.3
10^3 cycles	-	0.03 to 0.08	0.04 to 0.20	0.1 to 0.4
10^6 cycles	-	0.015 to 0.03	0.03 to 0.07	0.4 to 0.8
Arc resistance, sec.	-	tracks	tracks	120 to 200
Water absorption, 24 hr., %	-	0.1 to 0.2	0.3 to 0.7	0.10 to 0.5
Burning rate (flammability, in./min.)	fast	very low	very low	none
Effect of sunlight	none	surface darkens	general darkening	general darkening
Effect of weak acids	swells	none to slight	none to slight	none to slight
Effect of strong acids	swells	— decomposed by oxidizing acids —		
Effect of weak alkalies	swells	slight	— slight to marked —	
Effect of strong alkalies	swells	decomposes	attacked	attacked
Effect of organic solvents	attacked by some	fairly resistant	fairly resistant	fairly resistant
Machining qualities	-	fair to good	fair to good	good to poor

Phenol-Formaldehyde and Phenol-Furfural Molding Compounds

PROPERTIES	Mica Filler	Glass Fiber Filler	Macerated Fabric and Cord Filler	Pulp Pre-formed and Molding Board
Specific gravity (density)	1.65 to 1.92	1.69 to 1.95	1.36 to 1.43	1.36 to 1.42
Specific volume, cu. in/lb.	14.3 to 15.8	14.1 to 15.8	19.4 to 20.4	19.6 to 20.4
Refractive index, n_D	-	-	-	-
Tensile strength, psi	6500-7000	5000-18000	3300-9000	4300-12000
Elongation, %	0.13 to 0.5	0.2	0.37 to 0.57	0.3 to 0.7
Tensile modulus, 10^5 psi	30 to 50	33	9 to 13	9 to 13
Compressive strength, psi $\times 10^{-3}$	25.0 to 30.0	17.0 to 70.0	15.0 to 30.0	16.0 to 35.0
Flexural strength, psi $\times 10^{-3}$	8.0 to 12.0	10.0 t[illegible].0	8.5 to 15.0	7.0 to 18.5
Impact strength, ft.-lb/in.	0.30 to 0.38	0.3 to 18	0.75 to 8.0	0.5 to 4.5
Hardness, Rockwell	M100 to M110	M95 to M100	M95 to M120	E60 to E85
Thermal conductivity 10^{-4} cal./sec./sq. cm., /1°C/cm.)	10 to 14	9 to 14.5	4 to 9	4 to 7
Specific heat, cal./°C per gm.	0.28 to 0.32	-	0.30 to 0.35	0.34 to 0.36
Thermal expansion, 10^{-3} per °C	1.9 to 2.6	0.8 to 1.6	1 to 4	3.0 to 4.5
Resistance to heat, °F. (continuous)	250 to 300	350 to 550	220 to 250	300 to 400
Deflection temp., °F				
@ 264 psi fiber stress	300 to 350	300 to 600	250 to 300	260 to 340
@ 66 psi fiber stress	-	-	-	-

Volume resistivity, ohm-cm	10^{12} to $>10^{14}$	7×10^{12}	10^{11} to 10^{12}	10^{10} to 10^{13}
Dielectric strength				
(short time) volts/mil	350 to 400	140 to 400	200 to 400	250 to 550
(step-by-step) volts/mil	250 to 390	120 to 270	150 to 300	200 to 450
Dielectric constant, 60 cycles	4.7 to 6.0	7.1	6.0 to 21	5.0 to 8.0
10^3 cycles	4.4 to 5.5	6.9	5.0 to 11	5.0 to 8.0
10^6 cycles	4.2 to 5.2	4.6 to 6.6	4.5 to 7.0	4.0 to 7.0
Dissipation (power) factor 60 cycles	0.03 to 0.05	0.05	0.08 to 0.64	0.04 to 0.30
10^3 cycles	0.03 to 0.04	0.02	0.04 to 0.20	0.02 to 0.20
10^6 cycles	0.005 to 0.01	0.012 to 0.026	0.03 to 0.09	0.03 to 0.7
Arc resistance, sec.	tracks	4 to 190	tracks	2 to 130
Water absorption, 24 hr., %	0.01 to 0.05	0.03 to 1.2	0.4 to 1.75	0.6 to 1.8
Burning rate (flammability, in./min.)	none	none	almost none	very low
Effect of sunlight	general darkening			
Effect of weak acids	none to slight			
Effect of strong acids	decomposed by oxidizing acids; reducing and organic acids none to slight effect			
Effect of weak alkalies	slight to marked			
Effect of strong alkalies	attacked	attacked	attacked	attacked
Effect of organic solvents	fairly resistant			
Machining qualities	poor	-	fair to good	fair to good

PROPERTIES	Phenol-Formaldehyde and Phenol-Furfural Compounded with Butadiene-Acrylonitrile Copolyner: Woodflour and Cotton Flock Filler	Asbestos Filler	Rag Filler	Phenoxy
Specific gravity (density)	1.24 to 1.35	1.60 to 1.65	1.38 to 1.4	1.17 to 1.18
Specific volume, cu. in/lb.	20.5 to 22.3	16.8 to 17.3	21.0 to 21.3	23 to 23.6
Refractive index, n_D	-	-	-	1.5978
Tensile strength, psi	4500 to 7000	3500 to 4500	6500 to 7000	8000 to 9500
Elogation, %	0.75 to 2.25	-	-	50 to 100
Tensile modulus, 10^5 psi	4.0 to 6.0	5.0 to 9.0	3.5 to 6.0	3.4 to 3.8
Compressive strength, psi $x10^{-3}$	11.0 to 20.0	10.0 to 20.0	20.0 to 25.0	10.4 to 12.0
Flexural strength, psi $x10^{-3}$	7.0 to 12.0	6.0 to 8.0	9.5 to 10.0	12.0 to 14.0
Impact strength, ft. -lb/in.	0.35 to 1.0	0.30 to 0.40	2.0 to 2.3	2.3 to 12
Hardness, Rockwell	M37 to M85	M50	M97	R118 to R123
Thermal conductivity 10^{-4} cal. / sec. / sq. cm., / 1(^oC. / cm.)	5	15	2.16	4.2
Specific heat, cal. / ^oC per gm.	0.33	-	-	0.4
Thermal expansion, 10^{-3} per ^oC	1.5 to 4.0	4.0	-	5.7 to 6.1
Resistance to heat, ^oF. (continuous)	200	225	200	170
Deflection temp., ^oF				
@ 264 psi fiber stress	230 to 260	275	300	175 to 188
@ 66 psi fiber stress	-	-	-	187 to 198

Volume resistivity, ohm-cm.	10^{10} to 10^{11}	10^{11}	10^{11}	10^{10} to 10^{13}
Dielectric strength				
(short time) volts/mil	300 to 325	275 to 350	250 to 325	404 to 520
(step-by-step) volts/mil	225 to 300	225 to 300	200 to 250	400 to 490
Dielectric constant, 60 cycles	9 to 15	15	11. 1 to 21	4. 1
10^3 cycles	-	-	-	4. 1
10^6 cycles	5	5	6. 5	3. 8
Dissipation (power) factor 60 cycles	0. 14 to 0. 50	0. 15	0. 06 to 0. 08	0. 0012
10^3 cycles	-	-	-	0. 002
10^6 cycles	0. 08 to 0. 10	0. 010 to 0. 15	0. 10 to 0. 11	0. 03
Arc resistance, sec.	tracks	tracks	tracks	-
Water absorption, 24 hr., %	1 to 2	0. 25 to 0. 5	0. 8 to 2	0. 13
Burning rate (flammability, in. /min.)	slow	very slow	slow	slow to self-extinguishing
Effect of sunlight	darkens	darkens	darkens	slight discolor embrittlement
Effect of weak acids	none to slight	none to slight	none to slight	none
Effect of strong acids	decomposed by oxidizing acids, reducing and organic acids none to slight effect			resistant
Effect of weak alkalies	slight to marked			resistant
Effect of strong alkalies	attacked	attacked	attacked	resistant
Effect of organic solvents	fairly resistant			soluble in aromatics and chlorinated hydrocarbons
Machining qualities	good	good	good	excellent

PROPERTIES	Phenolic Cost Resins: No Filler	Phenolic Cost Resins: Mineral Filler	Polycarbonate: Unfilled	Polycarbonate: 10 to 40% Glass Filled
Specific gravity (density)	1.30 to 1.32	1.68 to 1.70	1.2	1.24 to 1.52
Specific volume, cu. in/lb.	20.9 to 21.3	16.3 to 16.5	23	18.2 to 22.4
Refractive index, n_D	1.58 to 1.66	-	1.586	-
Tensile strength, psi	6000 to 9000	4000 to 9000	8000 to 9500	14000 to 20000
Elongation, %	1.5 to 2.0	-	60 to 100	0.9 to 5.0
Tensile modulus, 10^5 psi	4 to 5	-	3.5	12 to 18.5
Compressive strength, psi $x10^{-3}$	12.0 to 15.0	29.0 to 34.0	12.5	16.0 to 19.0
Flexural strength, psi $x10^{-3}$	11.0 to 17.0	9.0 to 12.0	13.5	22.5 to 30.0
Impact strength, ft.-lb/in.	0.25 to 0.40	0.35 to 0.50	12 to 16	1.2 to 4
Hardness, Rockwell	M93 to M120	M85 to M120	M70 to R118	M88 to M95
Thermal conductivity 10^{-4} cal./sec./sq. cm., /1(°C./cm.)	3.5	-	4.6	2.5 to 5.2
Specific heat, cal./°C per gm.	0.3 to 0.4	-	0.30	-
Thermal expansion, 10^{-3} per °C	6.8	7.5	6.6	1.2 to 3.8
Resistance to heat, °F. (continuous)	160	160	250	300
Deflection temp., °F				
@ 264 psi fiber stress	165 to 175	150 to 175	265 to 280	295 to 300
@ 66 psi fiber stress	-	-	285	308 to 315

Volume resistivity, ohm-cm	10^{12} to 10^{13}	10^{9} to 10^{12}	2.1×10^{16}	$1.4-1.52 \times 10^{15}$
Dielectric strength				
(short time) volts/mil	350 to 400	100 to 250	400	475
(step-by-step) volts/mil	250 to 300	75 to 200	364	475
Dielectric constant, 60 cycles	6.5 to 7.5	-	3.17	3.7
10^3 cycles	5.5 to 6.0	14 to 30	3.02	3.7
10^6 cycles	4.0 to 5.5	9 to 15	2.96	3.2 to 3.5
Dissipation (power) factor 60 cycles	0.10 to 0.15	-	0.0009	0.003 to 0.005
10^3 cycles	0.01 to 0.05	0.10 to 0.30	0.0021	0.002 to 0.004
10^6 cycles	0.04 to 0.05	0.07 to 0.20	0.010	0.009
Arc resistance, sec.	-	-	10 to 120	5 to 120
Water absorption, 24hr., %	0.3 to 0.4	0.12 to 0.36	0.15	0.07 to 0.10
Burning rate (flammability, in./min.)	very slow	almost none	self-extinguishing	non-burning
Effect of sunlight	colors may fade	darkens	slight color change and embrittlement	none
Effect of weak acids	none to slight	none to slight	none	none
Effect of strong acids	decomposed by oxidizing acids	attacked by oxidizing acids	attacked slowly	attacked by oxidizing acids
Effect of weak alkalies	slight to marked	nil	limited resistance	limited resistance
Effect of strong alkalies	decomposes	decomposed	attacked	attacked
Effect of organic solvents	attacked by some	attacked by some	soluble in aromatic & chlorinated solvents	soluble in chlorinated hydrocarbons
Machining qualities	excellent	good to fair	excellent	fair to good

Polyester and Alkyd Resins
Glass Reinforced

PROPERTIES	Cost Polyester Rigid	Preformed Chopped Roving	Premix Chopped Glass	Woven Cloth
Specific gravity (density)	1. 10 to 1. 46	1. 35 to 2. 3	1. 8 to 2. 3	1. 50 to 2. 1
Specific volume, cu.in/lb.	19. 0 to 25. 2	13. 9 to 20. 5	-	18. 5 to 13. 2
Refractive index, n_D	1. 523 to 1. 57	-	-	-
Tensile strength, psi	6000 to 13000	25000 to 30000	4000 to 10000	30000 to 5000
Elongation, %	<5	0. 5 to 5. 0	-	0. 5 to 2. 0
Tensile modulus, 10^5 psi	3. 0 to 6. 4	8. 0 to 20. 0	16 to 25	15. 0 to 45. 0
Compressive strength, psi $x10^{-3}$	13. 0 to 36. 5	15. 0 to 30. 0	20. 0 to 30. 0	25. 0 to 50. 0
Flexural strength, psi $x10^{-3}$	8. 5 to 23. 0	10. 0 to 40. 0	12. 0 to 20. 0	40. 0 to 80. 0
Impact strength, ft. -lb/in.	0. 2 to 0. 4	2 to 10	1. 5 to 16. 0	5 to 30
Hardness, Rockwell	M70 to M115	M70 to M120	60 to 80 (Barcol)	M80 to M120
Thermal conductivity 10^{-4} cal. / sec. / sq. cm. , / 1(°C. / cm.)	4	-	10 to 16	-
Specific heat, cal. /°C per gm.	-	-	0. 25	-
Thermal expansion, 10^{-3} per °C	5. 5 to 10	2 to 5	2. 5 to 3. 3	1. 5 to 3
Resistance to heat, °F. (continuous)	250	300 to 350	300 to 350	300 to 350
Deflection temp. , °F				
@ 264 psi fiber stress	140 to 400	-	>400	-
@ 66 psi fiber stress	-	-	-	-

Volume resistivity, ohm-cm.	10^{14}	10^{14}	10^{12} to 10^{15}	10^{14}
Dielectric strength				
(short time) volts/mil	380 to 500	350 to 500	345 to 420	350 to 500
(step-by-step) volts/mil	280 to 420	-	275 to 390	-
Dielectric constant, 60 cycles	3.0 to 4.36	3.8 to 6.0	5.3 to 7.3	4.1 to 5.5
10^3 cycles	2.8 to 5.2	4.0 to 6.0	4.68	4.2 to 6.0
10^6 cycles	2.8 to 4.1	3.5 to 5.5	5.2 to 6.4	4.0 to 5.5
Dissipation (power) factor 60 cycles	0.003 to 0.028	0.01 to 0.04	0.011 to 0.041	0.01 to 0.04
10^3 cycles	0.005 to 0.025	0.01 to 0.05	-	0.01 to 0.06
10^6 cycles	0.006 to 0.026	0.01 to 0.03	0.008 to 0.022	0.01 to 0.03
Arc resistance, sec.	125	120 to 180	120 to 240	60 to 120
Water absorption, 24 hr., %	0.15 to 0.60	0.01 to 1.0	0.06 to 0.28	0.05 to 0.5
Burning rate (flammability, in./min.)	1.1 to self-extinguishing	slow to self-extinguishing	slow to self-extinguishing	slow to self-extinguishing
Effect of sunlight	yellows slightly	slight	variable	slight
Effect of weak acids	none	slight	slight	slight
Effect of strong acids	none to considerable	attacked	attacked	attacked
Effect of weak alkalies	none to slight	slight to attacked	slight to attacked	attacked
Effect of strong alkalies	attacked	attacked	slight to attacked	attacked
Effect of organic solvents	attacked by ketones and chlorinated solvents	slight	none	slight
Machining qualities	good	good	good	good

PROPERTIES	Polyester and Alkyd Molding Materials: Granular and Putty Types Mineral Filled	Asbestos Filled	Synthetic Fiber Filled	Polyimides, Aromatic
Specific gravity (density)	1.60 to 2.30	1.65	1.24 to 1.40	1.43
Specific volume, cu. in/lb.	5.4 to 12.3	16.8	22.3	19.3
Refractive index, n_D	-	-	-	-
Tensile strength, psi	3000 to 8000	4500 to 7000	4500 to 6000	10500
Elongation, %	-	-	-	6 to 7
Tensile modulus, 10^5 psi	5 to 26	-	-	4.5
Compressive strength, psi $x10^{-3}$	18.0 to 25.0	22.5	20.0 to 30.0	>24.0
Flexural strength, psi $x10^{-3}$	6.0 to 10.0	8.0 to 10.0	10.0 to 12.0	-
Impact strength, ft.-lb/in.	0.30 to 0.50	0.45 to 0.50	0.55 to 4.5	1.1
Hardness, Rockwell	60 to 70 (Barcol)	M99	-	H85 to H95
Thermal conductivity 10^{-4} cal./sec./sq. cm., /1(°C./cm.)	15 to 25	-	-	-
Specific heat, cal./°C per gm.	0.25	-	-	0.27
Thermal expansion, 10^{-3} per °C	3.5 to 5	-	-	4 to 5
Resistance to heat, °F. (continuous)	300 to 350	450	300 to 430	500
Deflection temp., °F				
@ 264 psi fiber stress	350 to 425	315	240 to 290	650
@ 66 psi fiber stress	-	-	-	-

Volume resistivity, ohm-cm.	10^{14}	6.6×10^{8}	10^{8} to 10^{16}	$> 10^{16}$
Dielectric strength				
(short time) volts/mil	350 to 450	380	365 to 400	560
(step-by-step) volts/mil	300 to 350	290	330 to 350	-
Dielectric constant, 60 cycles	5.1 to 7.5	-	3.8	3.4
10^{3} cycles	5.0 to 6.2	5.2	3.7	-
10^{6} cycles	4.6 to 5.5	4.5	3.6	-
Dissipation (power) factor 60 cycles	0.009 to 0.06	-	0.026	-
10^{3} cycles	0.01 to 0.03	0.11	0.020 to 0.03	-
10^{6} cycles	0.015 to 0.04	0.04 to 0.06	0.01 to 0.016	-
Arc resistance, sec.	75 to 190	138	85 to 115	-
Water absorption, 24 hr., %	0.05 to 0.5	0.14	0.08 to 0.2	-
Burning rate (flammability, in./min.)	slow to non-burning	self-extinguishing	self-extinguishing	-
Effect of sunlight	none	none	none	-
Effect of weak acids	none	none	none	-
Effect of strong acids	attacked	slight	slight	-
Effect of weak alkalies	attacked	none	none	-
Effect of strong alkalies	decomposes	slight	slight	-
Effect of organic solvents	none	none	none	-
Machining qualities	fair	good	excellent	-

PROPERTIES	Poly-Phenylene Oxide	Poly-Sulfone	Polyethylene Low Density	Polyethylene High Density
Specific gravity (density)	1.06	1.24	0.910 to 0.925	0.941 to 0.965
Specific volume, cu. in/lb.	26.1	22.3	30.0 to 30.5	28.8 to 29.6
Refractive index, n_D	-	1.633	1.51	1.54
Tensile strength, psi	11000	10200 (at yield)	1000 to 2300	3100 to 5500
Elongation, %	50 to 80	50 to 100	90 to 800	15 to 100
Tensile modulus, 10^5 psi	3.8	3.6	0.17 to 0.35	0.6 to 1.5
Compressive strength, psi $x10^{-3}$	13.0	13.9 (at yield)	-	3.2
Flexural strength, psi $x10^{-3}$	15.0	15.4 (at yield)	-	1.0
Impact strength, ft. -lb/in.	1.5 to 1.9	1.2 (1/8" bar, -40°F)	no break	1.5 to 20
Hardness, Rockwell	R118 to R120	M69, R120	D41 to D46 (Shore)	D60 to D70 (Shore)
Thermal conductivity 10^{-4} cal./sec./sq. cm., /1(°C./cm.)	4.5	6.2	8.0	11 to 12.4
Specific heat, cal./°C per gm.	-	0.3	0.55	0.55
Thermal expansion, 10^{-3} per °C	2.7 to 3.1	5.6	16 to 18	11 to 13
Resistance to heat, °F. (continuous)	-	345	180 to 212	250
Deflection temp., °F				
@ 264 psi fiber stress	375	-	90 to 105	110 to 120
@ 66 psi fiber stress	-	358	100 to 121	140 to 180

Volume resistivity, ohm-cm	10^{17}	5×10^{16}	$> 10^{16}$	$> 10^{16}$
Dielectric strength				
(short time) volts/mil	400 to 500	425	460 to 700	450 to 500
(step-by-step) volts/mil	-	400	420 to 700	440 to 600
Dielectric constant, 60 cycles	2.58	3.14	2.25 to 2.35	2.30 to 2.35
10^3 cycles	-	3.13	2.25 to 2.35	2.30 to 2.35
10^6 cycles	2.58	3.10	2.25 to 2.35	2.30 to 2.35
Dissipation (power) factor 60 cycles	0.00035	0.0008	<0.0005	<0.0005
10^3 cycles	-	0.0011	<0.0005	<0.0005
10^6 cycles	0.0009	0.0056	<0.0005	<0.0005
Arc resistance, sec.	20 to 75	122	135 to 160	-
Water absorption, 24hr., %	0.06	0.22	<0.015	<0.01
Burning rate (flammability, in./min.)	— self - extinguishing	—	very slow (1.04)	very slow (1 to 1.04)
Effect of sunlight	-	strength loss	material crazes rapidly but resistant grades available	
Effect of weak acids	none	none	resistant	very resistant
Effect of strong acids	none	none	attacked by oxidizing acids	
Effect of weak alkalies	none	none	resistant	very resistant
Effect of strong alkalies	none	none	resistant	very resistant
Effect of organic solvents	soluble or swells in some	aliphatic-none aromatic-partly soluble	resistant (below 60°C)	resistant (below 80°C)
Machining alities	excellent	excellent	good	excellent

PROPERTIES	Polyethylene			Polypropylene
	Ethylene Ethyl Acrylate Copolymer	Ethylene-Vinyl Acetate Copolymer	High Molecular Weight	Unmodified
Specific gravity (density)	0.93	0.92 to 0.95	0.94	0.902 to 0.906
Specific volume, cu. in/lb.	-	-	29.8	30.4 to 30.8
Refractive index, n_D	-	-	-	1.49
Tensile strength, psi	800 to 2000	1400 to 3800	5400	4300 to 5500
Elongation, %	300 to 700	650 to 900	525	200 to 700
Tensile modulus, 10^5 psi	0.046 to 0.067	0.02 to 0.07	1.02	1.6 to 2.25
Compressive strength, psi $x10^{-3}$	-	-	-	5.5 to 8.0
Flexural strength, psi $x10^{-3}$	3.0 to 3.6	-	-	6.0 to 8.0
Impact strength, ft.-lb/in.	no break	no break	no break	0.5 to 1.5 @ 73°F
Hardness, Rockwell	D27 to D36 (Shore)	D30 to D95 (Shore)	55	R85 to R110
Thermal conductivity 10^{-4} cal./sec./sq. cm., /1(°C./cm.)	-	-	-	2.8
Specific heat, cal./°C per gm.	0.55	0.55	-	0.46
Thermal expansion, 10^{-3} per °C	16.23	16 to 20	7.2	5.8 to 10.2
Resistance to heat, °F. (continuous)	190 to 200	-	-	250 to 320
Deflection temp., °F				
@ 264 psi fiber stress	-	-	-	135 to 145
@ 66 psi fiber stress	-	140 to 147	163	205 to 230

Volume resistivity, ohm-cm.	2.4×10^9	1.5×10^8	$> 10^{16}$	$> 10^{16}$
Dielectric strength				
(short time) volts/mil	450 to 550	450 to 700	710	500 to 660
(step-by-step) volts/mil	-	450	680	450 to 650
Dielectric constant, 60 cycles	2.7 to 2.9	2.5 to 3.16	-	2.2 to 2.6
10^3 cycles	2.7 to 2.9	2.6 to 2.98	-	2.2 to 2.6
10^6 cycles	2.7 to 2.8	2.6 to 2.8	2.30	2.2 to 2.6
Dissipation (power) factor 60 cycles	0.01 to 0.02	0.003 to 0.02	-	< 0.0005
10^3 cycles	0.01 to 0.02	0.003 to 0.02	-	< 0.0005 to 0.0018
10^6 cycles	0.01 to 0.02	0.03 to 0.04	0.0002	< 0.005 to 0.0018
Arc resistance, sec.	-	-	-	185
Water absorption, 24 hr., %	0.04	0.03 to 0.05	< 0.01	0.03
Burning rate (flammability, in./min.)	very slow	very slow	very slow	slow
Effect of sunlight	—— very slight yellowing ——		-	crazes rapidly resistant grades available
Effect of weak acids	resistant	resistant	-	none
Effect of strong acids	attacked by oxidizing acids	attacked	-	attacked slowly by oxidizing acids
Effect of weak alkalies	resistant	resistant	-	none
Effect of strong alkalies	resistant	resistant	-	very resistant
Effect of organic solvents	soluble in aromatic attacked in chlorinated	solvents over 50°C soluble in chlorinated	-	resistant below 80°C
Machining qualitites	fair	fair	-	good

PROPERTIES	Polystrene Unfilled General-Purpose	Impact-resist Medium-impact High-impact	Special Heat and Chemical Resistant Type	Styrene-Acryloni-trile Copolyner Unfilled
Specific gravity (density)	1.04 to 1.09	0.98 to 1.10	1.05 to 1.11	1.075 to 1.10
Specific volume, cu. in/lb.	26.0 to 26.4	25.2 to 28.1	24.8 to 26.2	25.2 to 25.8
Refractive index, n_D	1.59 to 1.60	-	1.57 to 1.60	1.56 to 1.57
Tensile strength, psi	5000 to 12000	3000 to 6800	6500 to 12000	9500 to 12000
Elongation, %	1.0 to 2.5	5 to 8.0	1.4 to 2.5	1.5 to 3.5
Tensile modulus, 10^5 psi	4 to 6	2 to 4.5	4 to 6	4 to 5.6
Compressive strength, psi $x10^{-3}$	11.5 to 16.0	4.0 to 9.0	11.5 to 16.0	14.0 to 17.0
Flexural strength, psi $x10^{-3}$	8.7 to 14.0	5.0 to 10.0	10.0 to 17.0	14.0 to 19.0
Impact strength, ft. -lb/in.	0.25 to 0.40 1/4" bar	0.5 to 11.0	0.35 to 0.60 1/4" bar	0.35 to 0.50
Hardness, Rockwell	M65 to M80	M35 to M70	M65 to M90	M80 to M90
Thermal conductivity 10^{-4} cal./sec./sq. cm., /1(°C./cm.)	2.4 to 3.3	1.0 to 3.0	1.9 to 3.0	2.9
Specific heat, cal./°C per gm.	0.32	0.32 to 0.35	0.32 to 0.35	0.32 to 0.34
Thermal expansion, 10^{-3} per °C	6 to 8	3.4 to 21	6 to 8	3.6 to 8
Resistance to heat, °F. (continuous)	150 to 170	140 to 175	170 to 200	140 to 205
Deflection temp., °F				
@ 264 psi fiber stress	205 max.	205 max.	180 to 235	190 to 215
@ 66 psi fiber stress	-	-	-	-

Volume resistivity, ohm-cm.	$> 10^{16}$	$> 10^{16}$	10^{13} to 10^{17}	$> 10^{16}$
Dielectric strength				
(short time) volts/mil	500 to 700	300 to 600	400 to 600	400 to 500
(step-by-step) volts/mil	400 to 600	300 to 600	300 to 500	300 to 600
Dielectric constant, 60 cycles	2.45 to 2.65	2.45 to 4.75	2.45 to 3.4	2.6 to 3.4
10^3 cycles	2.4 to 2.65	2.4 to 4.5	2.4 to 3.2	2.5
10^6 cycles	2.4 to 2.65	2.4 to 3.8	2.4 to 3.1	2.75 to 3.1
Dissipation (power) factor 60 cycles	10^{-4} to $3x10^{-4}$	$4x10^{-4}$ to $2x10^{-3}$	$5 x 10^{-4}$ to $3 x 10^{-3}$	$4x10^{-3}$ to 10^{-2}
10^3 cycles	10^{-4} to $3x10^{-4}$	$4 x 10^{-4}$ to $2 x 10^{-3}$	$5 x 10^{-4}$ to $3 x 10^{-3}$	$7x10^{-3}$ to 10^{-2}
10^6 cycles	10^{-4} to $4x10^{-4}$	$4 x 10^{-4}$ to $2 x 10^{-3}$	$5 x 10^{-4}$ to $5 x 10^{-3}$	$7x10^{-3}$ to 10^{-2}
Arc resistance, sec.	60 to 80	20 to 100	60 to 135	100 to 150
Water absorption, 24 hr., %	0.03 to 0.10	0.05 to 0.6	0.05 to 0.40	0.20 to 0.30
Burning rate (flammability, in./min.)	slow	slow	slow	slow
Effect of sunlight	yellows slightly	strength loss	——→ yellows slightly ——	
Effect of weak acids	none	none	none	none
Effect of strong acids	——→ attacked by oxidizing acids ——			
Effect of weak alkalies	none	none	none	none
Effect of strong alkalies	none	none	none	none
Effect of organic solvents	soluble in aromatic and chlorinated hydrocarbons ——→			
Machining qualities	fair to good	good	fair to good	good

PROPERTIES	Silicones Cast Resin Flexible	Urea-Form-Aldehyde α-Cellulose Filler	Urethanes: Cast Liquid Urethane	Urethanes: Urethane Elastomer Texin
Specific gravity (density)	1.05 to 1.23	1.47 to 1.52	1.2 to 2.5	1.24 to 1.26
Specific volume, cu. in/lb	-	18.2 to 18.8	21 to 23	22.0 to 22.3
Refractive index, n_D	1.43	1.54 to 1.56	-	-
Tensile strength, psi	800 to 1000	5500 to 13000	175 to 10000	5000 to 8000
Elongation, %	100	0.5 to 1.0	100 to 1000	100 to 600
Tensile modulus, 10^5 psi	900	10 to 15	80	0.1
Compressive strength, psi $\times 10^{-3}$	0.10	25.0 to 45.0	20.0	20.0
Flexural strength, psi $\times 10^{-3}$	-	10.0 to 18.0	-	0.7 to 1.0
Impact strength, ft.-lb/in.	-	0.25 to 0.40	does not break	does not break
Hardness, Rockwell	40-45 (Shore A)	M110 to M120	M28 to R60	M28 to R60
Thermal conductivity 10^{-4} cal./sec./sq. cm., /1(°C./cm.)	3.5 to 7.5	7 to 10	5	5
Specific heat, cal./°C per gm.	-	0.4	0.42 to 0.44	0.42 to 0.44
Thermal expansion, 10^{-3} per °C	25 to 30	2.2 to 3.6	10 to 20	10 to 20
Resistance to heat, °F. (Continuous)	400	170	190 to 250	190
Deflection temp., °F				
@ 264 psi fiber stress	-	260 to 290	-	-
@ 66 psi fiber stress	-	-	-	-

Volume resistivity, ohm-cm.	2×10^{15}	10^{12} to 10^{13}	2×10^{11} to 10^{15}	2×10^{11}
Dielectric strength				
(short time) volts/mil	550	300 to 400	450 to 500	450 to 500
(step-by-step) volts/mil	550	220 to 300	450 to 500	450 to 500
Dielectric constant, 60 cycles	2.75 to 3.05	7.0 to 9.5	4 to 7.5	6.7 to 7.5
10^3 cycles	-	7.0 to 7.5	4 to 7.5	6.7 to 7.5
10^6 cycles	2.6 to 2.7	6 to 8	6.5 to 7.1	6.5 to 7.1
Dissipation (power) factor 60 cycles	0.007 to 0.001	0.035 to 0.043	0.015 to 0.017	0.015 to 0.017
10^3 cycles	-	0.025 to 0.035	0.050 to 0.060	0.050 to 0.060
10^6 cycles	0.001 to 0.002	0.25 to 0.35	-	-
Arc resistance, sec.	115 to 130	80 to 150	0.1 to 0.6	-
Water absorption, 24 hr., %	0.12 (7 days 77°F)	0.4 to 0.8	-	-
Burning rate (flammability, in./min.)	—— self-extinguishing	——	slow	slow
Effect of sunlight	none	pastels grey	none to yellow	none
Effect of weak acids	little or none	none to slight	slight	dissolves
Effect of strong acids	slight to severe	decomposes	attacked (moderate)	dissolves
Effect of weak alkalies	little or none	slight to marked	slight	dissolves
Effect of strong alkalies	moderate to severe	decomposes	attacked (moderate)	dissolves
Effect of organic solvents	attacked by some	none to slight	none to slight	resists most
Machining qualities	-	fair	excellent	fair to excellent

VINYL POLYMERS AND COPOLYMERS

PROPERTIES	Vinyl Butyral Molding Compounds Flexible Unfilled	Vinyl Chloride and Vinyl Chloride-Acetate	Vinylidene Chloride Molding Compounds	Polyvinyl Dichloride Compound
Specific gravity (density)	1.05	1.16 to 1.35	1.65 to 1.72	1.50 to 1.55
Specific volume, cu. in/lb.	26.2	20.5 to 23.8	16.1 to 16.8	17.8 to 18.4
Refractive index, n_D	1.47 to 1.49	-	1.60 to 1.63	-
Tensile strength, psi	500 to 3000	1500 to 3500	3000 to 5000	7500 to 9000
Elongation, %	150 to 450	200 to 450	up to 250	4.5
Tensile modulus, 10^5 psi	-	-	0.5 to 0.8	$4\text{-}4.5 \times 10^5$
Compressive strength, psi $\times 10^{-3}$	-	0.9 to 1.7	2.0 to 2.7	9.0 to 14.0
Flexural strength, psi $\times 10^{-3}$	varies	-	4.2 to 6.2	14.5 to 17.0
Impact strength, ft.-lb/in.	varies	varies	0.3 to 1.0	2.5 to 5.5
Hardness, Rockwell	10 to 100 (Shore)	-	M50 to M65	117
Thermal conductivity 10^{-4} cal./sec./sq. cm., /1(°C./cm.)	-	3.0 to 4.0	3.0	3.3×10^{-4}
Specific heat, cal./°C per gm.	-	0.3 to 0.5	0.32	3.3×10^{-4}
Thermal expansion, 10^{-3} per °C	-	7 to 25	19	7
Resistance to heat, °F. (continuous)	-	150 to 175	160 to 200	210
Deflection temp., °F				
@ 264 psi fiber stress	-	-	130 to 150	215 to 220
@ 66 psi fiber stress	-	-	-	247

Volume resistivity, ohm-cm.	5×10^{10}	10^{11} to 10^{15}	10^{14} to 10^{16}	$7\text{-}18 \times 10^{15}$
Dielectric strength				
(short time) volts/mil	350	300 to 1000	400 to 600	1220
(step-by-step) volts/mil	325	275 to 900	400 to 600	-
Dielectric constant, 60 cycles	5.60	5.0 to 9.0	4.5 to 6.0	3.08
10^3 cycles	5.10	4.0 to 8.0	3.5 to 5.0	-
10^6 cycles	3.92	3.3 to 4.5	3.0 to 4.0	-
Dissipation (power) factor 60 cycles	0.115	0.08 to 0.15	0.03 to 0.045	0.01887 - 0.02080
10^3 cycles	0.057	0.07 to 0.16	0.06 to 0.075	-
10^6 cycles	0.061	0.04 to 0.14	0.05 to 0.08	-
Arc resistance, sec.	-	-	-	-
Water absorption, 24 hr., %	1.0 to 2.0	0.15 to 0.75	0.1	0.15
Burning rate (flammability, in./min.)	slow	←— self - extinguishing —→		
Effect of sunlight	slight	slight	slight	-
Effect of weak acids	slight	none	none	none
Effect of strong acids	slight	none to slight	resistant	none
Effect of weak alkalies	slight	none	resistant	none
Effect of strong alkalies	slight	none	resistant	none
Effect of organic solvents	soluble or swells in ketones and esters and aromatic hydrocarbons		none to slight	resists most
Machining qualities	-	-	good	excellent

TABLE 11

PHYSICAL PROPERTIES OF PLASTICS USED PRIMARILY AS FILMS
NOT LISTED IN TABLE 10

From Reference 243:
Physical Properties of Plastics Used Primarily as Films not Listed in Table 10

PROPERTIES	Ethyl Cellulose	Polyester PE Terephthalate	Poly-Urethane Elastomer	Polyvinyl Fluoride
Specific gravity (density)	1.15	1.38 to 1.395	1.19 to 1.20	1.38
Tensile strength, psi	8000 to 10000	25000 40000 (Type T)	5000 to 9000	7000 to 18000
Elongation, %	20 to 30	100; 50 (Type T)	50 to 100	115 to 250
Resistance to heat, °F. (continuous)	250	300	190	220 to 250
Volume resistivity, ohm-cm.	10^{15}	10^{18}	2.0×10^{11}	3×10^{13}
Dielectric strength volts/mil	1500 (10-mil)	7000 (1-mil)	450 to 500	4100
Dielectric constant, 10^3 cycles	3.1	3.1	6.7 to 7.5	8.5
10^6 cycles	3.0	3.0	6.5 to 7.1	-
Dissipation (power) Factor 10^3 cycles	0.002 to 0.020	0.0047	0.050 to 0.060	1.6
10^6 cycles	0.010 to 0.060	0.016	-	-
Water absorption, 24 hr., %	2.5 to 7.5	0.8	0.55 to 0.77	< 0.5
Burning rate (flammability, in./min.)	slow burning	slow to self-extinguishing	slow burning	slow to self-extinguishing
Resistance to sunlight	good to fair	medium to excellent	fair to excellent	excellent
Resistance to strong acids	fair to poor	good	poor	excellent
Resistance to strong alkalies	excellent	good	poor	excellent
Resistance to organic solvents	poor	excellent	good	excellent

PROPERTIES	Vinyl Chloride-Acetate Copolymers Rigid	Nonrigid	Regenerated Cellulose (Cellophane)	Rubber Hydro-Chloride
Specific gravity (density)	1.30 to 1.59	1.20 to 1.45	1.40 to 1.50	1.11
Tensile strength, psi	5500 to 8000	1400	7000 to 18000	3500 to 5000
Elongation, %	2 to 10	150 to 500	10 to 50	200 to 800
Resistance to heat, °F. (continuous)	fair	150 to 200	300	180 to 205
Volume resistivity, ohm-cm.	10^{16}	10^{11} to 10^{14}	10^{11}	10^{13}
Dielectric strength volts/mil	425 to 1300	250 to 1000	2000 to 2500	-
Dielectric constant, 10^3 cycles	3.0 to 3.3	4.0 to 8.0	3.2	3
10^6 cycles	2.8 to 3.1	3.3 to 4.5	-	3
Dissipation (power) factor 10^3 cycles	0.009 to 0.017	0.070 to 0.160	0.015	-
10^6 cycles	0.006 to 0.019	0.04 to 0.140	-	0.006
Water absorption, 24hr., %	negligible	negligible	45 to 115	5
Burning rate (flammability, in./min.)	— slow to self-extinguishing —		slow	self-extinguishing
Resistance to sunlight	good	good	good	fair
Resistance to strong acids	excellent	good	poor	good
Resistance to strong alkalies	excellent	good	poor	good
Resistance to organic solvents	poor to good	poor to good	-	good

A.S.T.M. Test Methods for Physical Properties Appearing in Table

Specific gravity (density)	D 792
Specific Volume, cu. in/lb.	D 792
Refractive index, n_D	D 542
Tensile strength, psi	D 638 D 651
Elongation, %	D 638
Tensile modulus, 10^5 psi	D 638
Compressive strength, psi	D 695
Flexural strength, psi	D 790
Impact strength, ft. lb/in of notch (1/2 x 1/2 on. notched bar)	D 256
Hardness, Rockwell	D 785
Flexural modulus	D 790
Compressive modulus	D 695
Thermal conductivity, 10^{-4} cal./sec./ sq.cm., /1(°C./cm.)	C 177
Thermal expansion, 10^{-3} per °C.	D 696
Deflection temp., °F 264 & 66 psi fiber stress	D 648
Volume resistivity, ohm-cm. (50% RH and 23°C.)	D 257
Dielectric strength, short time, 1/8-in. thickness, volts/mil	D 149
Dielectric strength, step-by-step, 1/8-in. thickness, volts/mil	D 149
Dielectric constant, 60 cycles	D 150
Dielectric constant, 10^3 cycles	D 150
Dielectric constant, 10^6 cycles	D 150

Dissipation (power) factor, 60 cycles	D 150
10^3 cycles	D 150
10^6 cycles	D 150
Arc resistance, sec.	D 495
Water absorption, 24 hr., 1/8-in. thickness, %	D 570
Burning rate (or flammability, in. /min.)	D 635
Effect of weak acids	D 543
Effect of strong acids	D 543
Effect of weak alkalies	D 543
Effect of strong alkalies	D 543
Effect of organic solvents	D 543

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13. ABSTRACT

A comprehensive list of organic semiconductors has been prepared to include compounds having resistivities in the range 10^{-3} to 10^{20} ohm cm. Where electrical and mechanical properties were found, they were included. Five classes of compounds were reviewed and ten compounds were suggested as displaying electrical hysteresis effects due to mechanical loading. Included in the tables is a listing of physical properties of commercially available plastics.

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