RADIATION-RESISTANT Fluids



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As more and more emphasis is placed upon military and industrial use of the atom, the search widens for materials that can survive in a radiation environment. Monsanto research has developed a family of fluids which are outstanding in their ability to resist both radiation and thermal damage. These fluids are polyphenyl compounds and certain of their alkyl derivatives. Polyphenyls represent one of the most stable classes of organic compounds. Improvements in both low temperature and high temperature properties as well as increased range of fluidity can be obtained by alkylation of these pure polyphenyls or by mixing polyphenyls to obtain eutectic mixtures. Selected representatives of the alkyl derivatives are shown under the heading "Polyphenyl Alkyl Derivatives and Mixtures."

The inside chart shows the physical properties of these pure and alkylated products over a wide temperature range. Also shown are specific thermal and radiation damage rates and pyrolytic and radiolytic gas generation rates. Further information is given to show how radiation affects the physical properties of these fluids.

Several of the fluids listed are currently being evaluated as heat transfer media (coolants) for nuclear power reactors. Others are being evaluated as radiation-resistant impregnants for capacitors. Many other applications exist for these uniquely stable materials, either as pure compounds, mixtures of pure compounds or as base stocks.

Monsanto invites your inquiry on particular uses for these fluids for any application. Consultation with fluid specialists may be particularly valuable in the design stage of equipment that will place the fluid in a radiation environment.

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PHYSICAL PROPERTIES OF MONSANT(

POLYPHENYLS

PROPERTY	TEMP. (° F.)	BIPHENYL	SANTOWAX O	SANTOWAX
Density, gms./cc.	0	—	—	—
	100	—	—	—
	200	0.975	1.030	1.045
	300	0.930	0.983	0.999
	400	0.885	0.937	0.952
	500	0.838	0.891	0.907
	600	0.786	0.844	0.860
	700	0.727	0.80	0.815
	800	0.655	0.75	0.77
Viscosity, Centistokes	0	—	—	—
	100	—	—	—
	200	1.040	5.5	4.0
	300	0.616	1.75	1.6
	400	0.410	0.95	0.85
	500	0.300	0.63	0.57
	600	0.230	0.45	0.41
	700	0.186	0.34	0.30
	800	0.156	0.26	0.24
Specific Heat, Btu/lb., ° F.	0	—	—	—
	100	—	—	—
	200	0.422	0.438	0.438
	300	0.467	0.469	0.467
	400	0.512	0.500	0.497
	500	0.558	0.530	0.525
	600	0.603	0.561	0.554
	700	0.648	0.592	0.584
	800	0.693	0.623	0.613
Thermal Conductivity, Btu/Ft., ° F., hr.	100-450	0.076	0.060	0.063
Melting Point, ° F.	—	156	133	189
Boiling Point, ° F.	—	491	630	687
Vapor Pressure, mm. Hg	0	—	—	—
	100	—	—	—
	200	3.2	0.2	—
	300	36	3.7	1.2
	400	210	29	11
	500	850	145	63
	600	3.0(ATM)	500	250
	700	7.3(ATM)	1400	725
	800	15.8(ATM)	4.3(ATM)	2.5(ATM)
Flash Point, ° F.	—	235	340	405
Fire Point, ° F.	—	255	390	445
Autoignition Temperature, ° F.	—	> 1000	> 1000	> 1000
Thermal Damage Rate,** % Polymerized (decomposed)/hr.	700	0.00002	0.00007	0.00007
	800	0.0013	0.005	0.005
	900	0.10	0.35	0.35
Decomposition gas generation rate Ml. of Gas (STP)/Ml. of Fluid Decomposed	—	12	10	10
Radiolytic gas generation rate Ml. of Gas (STP)/Ml. of Fluid Exposed	10^6 R	0.014	0.0107	0.0091
	10^8 R	0.14	0.107	0.091
	10^{10}R	1.4	1.07	0.91
Radiation Damage Rate*** [%Polymerized (decomposed)/10^8R]	—	1.2	1.07	0.91
N_H Hydrogen Atoms/cc. x 10^{-22}	0	—	—	—
	100	—	—	—
	200	3.79	3.80	3.80
	300	3.61	3.66	3.66
	400	3.43	3.51	3.51
	500	3.23	3.37	3.37
	600	3.03	3.23	3.23
	700	2.81	3.09	3.09
	800	2.54	2.94	2.94

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*Biphenyl - 25 wt. %
Santowax O - 55 wt. %
Santowax M - 20 wt. %

**Thermal and Radiation Damage Rates are Additive.

***Damage produced by 10^8R (gamma) is approx. equivalent to 1×10^{18} NVT (Thermal Neutrons) or 2.5×10^{17} NVT (Fast Neutrons)

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RADIATION-RESISTANT FLUIDS

SANTOWAX P	SANTOWAX R	DIISOPROPYL-BIPHENYL	TERTIARY* EUTECTIC	MONOISOPROPYL-BIPHENYL	ISOPROPYL SANTOWAX
		POLYPHENYL ALKYL DERIVATIVES AND MIXTURES			
—	—	0.990	—	1.015	—
—	—	0.950	1.050	0.973	0.983
—	—	0.908	1.005	0.932	0.942
—	1.06	0.867	0.962	0.890	0.901
—	0.962	0.825	0.916	0.849	0.86
0.92	0.92	0.785	0.870	0.808	0.82
0.873	0.876	0.743	0.826	0.765	0.78
0.83	0.834	0.703	0.782	0.725	0.74
0.783	0.79	0.66	0.738	0.68	0.70
—	—	1000	—	75	—
—	—	12.5	6.5	4.6	254
—	—	2.55	2.20	1.5	9.5
—	1.60	1.15	1.10	0.84	2.5
—	0.87	0.70	0.62	0.55	1.2
0.62	0.55	0.49	0.41	0.39	0.74
0.46	0.38	0.36	0.29	0.30	0.53
0.36	0.28	0.29	0.22	0.24	0.42
0.29	0.21	0.24	0.17	0.20	0.34
—	—	0.385	—	0.371	—
—	—	0.431	0.366	0.418	0.450
—	—	0.476	0.410	0.464	0.480
—	0.467	0.522	0.454	0.512	0.511
—	0.497	0.568	0.499	0.557	0.541
0.520	0.525	0.614	0.542	0.604	0.571
0.547	0.554	0.660	0.586	0.649	0.602
0.575	0.584	0.705	0.631	0.697	0.632
0.603	0.613	0.750	0.675	0.742	0.662
0.070	0.063	0.068	0.070	0.070	0.068
415	293	−24	5†	−65	20
725	687-784	610-631	568	563-572	712-788
—	—	—	—	—	—
—	—	—	—	—	—
—	—	0.21	0.6	0.55	—
0.27	1.3	3.9	9.0	9.5	0.82
6.6	12	32	60	75	6.3
47	62	170	250	370	31
185	235	610	880	1300	110
600	715	1850	3.4(ATM)	5.3(ATM)	34
2.0(ATM)	2.5(ATM)	16.6(ATM)	8.3(ATM)	13.2(ATM)	900
405	375	340	270	315	400
460	460	365	440	340	450
> 1000	> 1000	~ 850	> 1000	~ 850	~ 850
0.00006	0.000065	0.007(EST.)	0.00004	0.007	0.007(EST.)
0.0045	0.0048	0.120(EST.)	0.0035	0.120	0.120(EST.)
0.28	0.32	2.00 (EST.)	0.21	2.00	2.00 (EST.)
10	10	15(EST.)	11	15	15(EST.)
0.0071	0.0095	0.092(EST.)	0.0121	0.092	0.092(EST.)
0.071	0.095	0.76 (EST.)	0.121	0.76	0.76 (EST.)
0.71	0.95	7.0 (EST.)	1.21	7.0	7.0 (EST.)
0.71	0.95	1.3 (EST.)	1.10	1.3	1.05
—	—	5.43	—	4.96	—
—	—	5.23	3.95	4.77	4.38
—	—	5.02	3.80	4.58	4.20
—	3.66	4.81	3.65	4.38	4.02
—	3.51	4.61	3.50	4.19	3.84
3.37	3.37	4.40	3.34	4.00	3.66
3.23	3.23	4.19	3.18	3.81	3.47
3.09	3.09	3.98	3.01	3.62	3.29
2.94	2.94	3.73	2.82	3.43	3.12

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The charts below show the effect of radiation damage on the fluid's physical properties. In the first chart, the change is expressed as a percentage related to the basic physical property data shown inside. Thus, as 200° F. the viscosity of any of the fluids listed will show an increase of approximately 28 per cent with a 10 per cent concentration of decomposition products. Radiation damage has a greater effect on viscosity than on any other property. Flash, fire and autoignition temperature remain unchanged up to 20 per cent decomposition products. While data does not exist on all of the fluids at all percentages of decomposition products, enough has been accumulated to show that these percentages apply fairly well for all of the fluids. More detailed data will be supplied upon request.

EFFECT OF DECOMPOSITION PRODUCTS ON PHYSICAL PROPERTIES

	PER CENT CHANGE IN PHYSICAL PROPERTIES*											
	200° F.			400° F.			600° F.			800° F.		
PROPERTY	10% D.P.	20% D.P.	30% D.P.	10% D.P.	20% D.P.	30% D.P.	10% D.P.	20% D.P.	30% D.P.	10% D.P.	20% D.P.	30% D.P.
Specific Gravity	+0.5	+1.1	+1.6	+1.0	+2.0	+3.0	+1.8	+3.6	+5.4	+2.4	+4.8	+7.2
Viscosity	+28	+55	+83	+17	+34	+51	+13	+26	+40	+12	+24	+37
Specific Heat	−0.3	−0.7	−1.0	−0.3	−0.7	−1.0	−0.3	−0.7	−1.0	−0.3	−0.7	−1.0
Thermal Conductivity	−1.0	−2.5	−4.0	−1.6	−3.2	−4.6	−3.0	−6.0	−9.0	−4.6	−9.0	−13.4
N_H (Hydrogen Atoms/cs.)	+0.6	+1.2	+1.8	+0.9	+1.8	+2.7	+1.2	+2.4	+3.6	+1.8	+3.6	+5.4

*These percentages apply to the physical data shown on the inside pages.

EFFECT OF DECOMPOSITION PRODUCTS ON POUR POINT

MATERIAL	Normal Melting Point (° F.)	POUR POINT (° F.) FOR VARIOUS WT. % DECOMP. PRODUCTS						
		0%	10%	20%	30%	40%	50%	100%
Commercial Products								
Biphenyl	156	156	150	142	134	124	110**	130
Santowax O (*o*-Terphenyl)	133	133	70	___	___	___	___	___
Santowax M (*m*-Terphenyl)	189	189	178	157	112	15	___	___
Santowax P (*p*-Terphenyl)	415	415	400	376	346	303	254	___
Santowax R (Mixed Terphenyls)	293	310	302	290	276	260	240	___
Development Products								
Tertiary Eutectic Mixture of: Biphenyl - 25 wt. %, Santowax O - 55 wt %, Santowax M - 20 wt. %	51	5	10	23	36	46	59	___
Monoisopropylbiphenyl	−65	−70	−55	−40	−25	−10	5	___
Diisopropylbiphenyl	−24	−30	−15	1	18	32	48	___
Isopropyl-Santowax R	20	0	16	31	47	62	78	___

**Minimum Pour Point = 50° F. @ 75% D.P.

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The information contained in this bulletin is to our best knowledge true and accurate, but all recommendations or suggestions are made without guarantee, since the conditions of use are beyond our control. Furthermore, nothing contained herein shall be construed as a recommendation to use any product in conflict with existing patents covering any material or use.

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