A Study on the Several Characteristics and Applications of Whale and Sperm Oils, Polymerized by Silent Electric Discharge*

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The preceding report¹⁾ dealt with the research on the silent discharge polymerization (Voltolization) reaction of Whale and Sperm oils (both brain and skin) and discussed the reaction process and the changes in these oils involved with polymerization in a comparative study. As its sequence the author carried out several tests on the characteristics of the polymerized products and their applications.

(1) High vacuum distillation of voltolized Sperm oil.

Sperm oil, when subjected to mere polymerization by discharge, is supposed to contain considerable amounts of monomers. To what extent the viscosity of such oil when its monomer contents have been eliminated through high vacuum distillation, has been tested. Fractions up to 200°C were removed under high vacuum about 10^{-3} mm Hg from samples (A) No. 6, (B) No. 5 and 6 (see Table 1 in previous report). As the results, low acid value, high viscosity oils were gained, no gelation having taken place thereby.

Table 1

Samp. No.	Materials for distillation*		Viscosity Temp.	st.	Intrinsic Vis. $[\eta] \times 10^2$ 25°C	Iodine value	Acid value	Yield %	Mol. Weights
1	Voltolized Sperm skin oil No. 5	original oil	100°F	37.3	11.0	87.5	4.2	0	1090
		distillate	—	—	—	75.0	16.0	31	—
		residue	{100°F 210°F	{84.3 5.9	13.7	83.6	2.5	69	1905
2	Voltolized Sperm skin oil No. 6	original oil	100°F	72.0	12.2	89.3	**	0	—
		distillate	—	—	—	71.6	19.1	24	—
		residue	{100°F 210°F	{102.0 5.5	15.0	67.6	2.7	76	1540
3	Voltolized Sperm brain oil No. 5	original oil	100°F	32.3	10.6	76.0	5.0	0	1110
		distillate	—	—	—	60.9	24.0	48	—
		residue	{100°F 178°F 210°F	{very sticky 123.5 85.0	—	48.3	2.8	52	2500
4		original oil	210°F	32.3	10.6	76.0	5.0	0	1110
		distillate	—	—	—	52.0	16.5	20	—
		residue	100°F	45.0	10.2	74.5	3.2	80	1910

* Sample Nos. of these materials denote that of those in Table 1 of the preceding report.

** This value is estimated about equal to that of voltolized Sperm skin oil No. 5.

(2) Application of Voltolized Sperm oil as plasticizer.

In recent years, so-called high polymer plasticizers, for example, polyesters, have come to be used to impart improved cold resistance to P.V.C. resins. In order to check the validity of such plasticizers for that purpose, part of the D.O.P. in the D.O.P. plasticized P.V.C. was replaced by the earlier-mentioned vacuum distilled voltolized Sperm oil (Sample No. 1 in Table 1) and the resulting film was measured for the change in mechanical properties. For the measurement, tensile tests, using K.S. type Senimeter, were carried out at 25~40°C on filament specimens prepared from a thin film that had been made by the Solvent method developed by Tsuji²⁾ and Murai³⁾; in these tests temperature change

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Table 2 Tensile Test Results of the Plastisized PVC Resin.

Sample No.	Composition			Tensile strength (kg/cm ²)				Cold proofness*	Elongation (%)			
				Temp. °C					Temp. °C			
	P.V.C	D.O.P	Voltolized oil	25	5	−15	−40		25	5	−15	−40
1	10	2	0	284	346	479	631	5.4	166	20	13	10
2	10	3	0	229	312	389	460	3.5	228	21	29	12
3	10	2	1	169	263	322	380	3.1	36	12	6	6
4	10	1	2	183	273	316	450	3.9	9	5	5	4
5	10	4	0	175	238	290	350	2.6	291	75	40	23

* Cold proofness = $\frac{\sum t_i \sum X_i - n \sum t_i X_i / (\sum t_i)^2 - n \sum t_i^2 (\text{kg/cm}^2 / ^\circ\text{C})}{\sum t_i^2}$, t_i = temp. X_i = Tensile strength at t_i .

was also investigated. The results are given by Table 2 and Fig. 1, and the values of cold proofness listed in the Table are given in terms of the increase of tensile strength of the sample film versus temperature decrease. According to these values, it is clear that a considerable decrease of ductility occurs through replacement of D.O.P. with voltolized sperm oil; strength, too, falls but not to the same extent as ductility; and there is no large variance in cold resistance. On the whole it can be stated that they might be used as compounding agent so long as such decrease in ductility is allowable.

(3) Usefulness as lubricant additives.

The effectiveness of each voltolized Whale oil when it was added to diesel-engine oil was checked for the purpose of ascertaining its characteristics (mainly with respect to increase of viscosity, increase of viscosity index, and pour point depressing) as lubricant additive; for the measurement of melting point, Levin and others' microanalytical method⁽⁴⁾ was adopted.

Table 3 lists the results of 5 % additions of vacuum distilled voltolized Sperm oil (Table 1, No. 1) to paraffin base, naphthene base, and mixed base diesel-engine oils respectively.

Table 3 Addition Effect of Voltolized Sperm oil to Diesel Engine Oil

Diesel engine oil composition	Addition %	Viscosity cps		Vis. Index	Pour Point °C
		100°F	210°F		
Paraffinic base	0	140.9	11.3	64.0	-14.0
	5	200.0	15.6	84.5	-14.5
Mixed base	0	127.8	9.8	40.0	-26.0
	5	181.0	13.5	69.0	-27.0
Naphthenic base	0	151.6	9.9	9.9	-23.0
	5	228.4	14.7	55.3	-26.0

Effectiveness was manifest, though to different extents depending on the base oil, but no effects on the pour point depression were established.

Fig. 1 Change of tensile strength with temp. for plastisized P.V.C. films.

Table 4 represents the results of 10% additions of Sample No. 5 of Sperm oil in Table 1 and sample No. 5 of Whale oil in Table 1 to naphthene base diesel-engine oil; it is revealed that there is no great change in characteristics related to viscosity.

Table 4 Addition Effects of Voltolized Whale & Sperm
Oils to Diesel Engine oils

Sample	Viscosity St.		Viscosity Index	Pour Point °C
	100°F	210°F		
Diesel Engine oil	151.6	9.9	9.9	-23
ditto, added 10% with Voltolized Sperm oil	230.2	16.2	70	-21
ditto, added 10% with Voltolized Whale oil	226.5	16.2	76	-24

It is known⁵⁾⁶⁾ that the viscosity of such additives has a high dependency on shear rate and so with the last two samples listed in the same Table, the dependence of apparent viscosity on the shear rate was measured by Green type viscometer⁷⁾ in the range of about 0~1000 sec⁻¹. In the case of non-addition, no shearing rate dependency was exhibited. In the case when additions were made, both samples attested to such dependency, and no large difference was observed between the two, as shown by Fig. 2.

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Literature;

- 1) Masao Gotoda, *J. Electrochem. Soc. Japan*, **27**, 608 (1959).
- 2) Waichiro Tsuji, Studies on the plastisizers (Japan) **2**, 21 (1950).
- 3) Koichi Murai, Rubber Digest (Japan) **9** (No. 6) 2 (1957).
- 4) H. Levin et al, *Anal. Chem.* **22**, 188 (1950).
- 5) A. Bondi, Physical Chemistry of lubricating oils, p. 15 (1951).
- 6) W. Ostwald et al, *Kolloid Z.* **45**, 166, 266 (1928).
- 7) H. Green, Industrial Rheology and Rheological Structure, p. 99 (1949).

Fig. 2 Viscosity vs. rate of shear,
for lubricating oils, blended
with voltolized oils.

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