MONSANTO CHEMICALS

AROCLORS

as Co-Plasticizers for Polyvinylchloride

Monsanto Technical Bulletin No. P-131 · May 1, 1948

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Selected AROCLORS* (chlorinated biphenyls) used as co-plasticizers with tricresyl phosphate, dioctyl phthalate and other plasticizers for polyvinylchloride impart good qualities to the plastics at a substantial reduction in cost.

This bulletin describes the practical use of Aroclors with tricresyl phosphate and dioctyl phthalate in polyvinylchloride plastics.

In each case the saving in cost of the finished plastics is illustrated.

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*Registered in U.S. Patent Office

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AROCLORS As Co-Plasticizers for Polyvinylchloride { Monsanto Tech. Bul. No. 131, May 1, 1948

I. INTRODUCTION

Under our present economy the selling price of plasticizers such as tricresyl phosphate, dibutyl phthalate and dioctyl phthalate used for polyvinylchloride plastics are substantially higher than in former years. Aroclors (chlorinated biphenyls), also used as plasticizers for polyvinylchloride, are relatively inexpensive and their use results in substantial savings.

Studies of the properties and economies of Aroclor--tricresyl phosphate mixtures for polyvinylchloride--have been made particularly in France at the Chemical and Electrometallurgies Products Company's Central Laboratory at Salindres.

The following data indicates the high efficiency of Aroclors mixed with tricresyl phosphate and dioctyl phthalate as plasticizers for polyvinylchloride and the attractive economies offered by using such mixed plasticizers.

II. AROCLOR-TRICRESYL PHOSPHATE MIXTURES COMPARED WITH TRICRESYL PHOSPHATE

PREPARATION OF THE PLASTICS

The plasticizer mixture was composed of equal parts by weight of Aroclor 1254 and tricresyl phosphate. Polyvinylchloride varying in molecular weight from 45,000; 70,000 to 105,000 stabilized with one percent of lead stearate was used.

Conditions for mixing the plastics and working it on the rolls were similar to conditions normally used when tricresyl phosphate or dibutyl phthalate, or mixtures of these plasticizers, are used. The temperature of mixing and rolling the plastics was 140-145°C. for 45,000 molecular weight polyvinylchloride and 160°C. for 70,000 and 105,000 molecular weight material. Duration of plastic mixing was 5 to 10 minutes and duration of rolling was 18 minutes.

The plastics sheets were molded into test pieces 130x130x3.1 mm. using a pressure of 142 lbs/sq. in. during 13 minutes and then 3,130 lbs/sq. in. during 5 minutes of the molding operation.

COMPARATIVE EVALUATION OF THE PLASTICS

The tensile strength and elongation of the finished plastics are given in the following comparative Table I.

TABLE I.

Plasticizer Composition	Plasticizer Percent	Molecular Weight	Tensile Strength Lbs/sq. in.	Elongation Percent
Mixture 50 parts of Aroclor 1254 and 50 parts tricresyl phosphate	50	105,000	2,987	290
		70,000	2,631	300
Tricresyl phosphate		105,000	2,278	340
		70,000	1,779	300
Mixture 50 parts of Aroclor 1254 and 50 parts tricresyl phosphate	45	45,000	2,631	265
		70,000	3,130	285
Tricresyl phosphate		45,000	1,991	295
		70,000	2,349	305
Mixture 50 parts of Aroclor 1254 and 50 parts tricresyl phosphate	35	45,000	3,912	120
		70,000	4,057	180
Tricresyl phosphate		45,000	3,060	210
		70,000	3,415	230

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These results show that Aroclor 1254 can be used advantageously as a plasticizer for polyvinylchloride provided that tricresyl phosphate is added to it. This is especially true when the plasticizer mixture is used at a level of at least 45 to 50 percent.

COST COMPARISONS OF THE PLASTICS

In computing costs the specific gravity and current selling price for each material as listed were used.

Material	Specific Gravity	Selling Price Per Pound In Carload Quantity
Polyvinylchloride	1.35	$ .33
Tricresyl phosphate	1.17	.36
Aroclor 1254	1.54	.18

Assuming that the manufacturer desires to make a sheet of the plastics five feet wide, 0.01 feet thick and whatever length can be obtained from 100 pounds of polyvinylchloride, the cost per running foot for each plastics is given in the comparative Table II.

TABLE II.

Plasticizer Composition	Plasticizer Percent	Plastics Materials Cost Per Running Ft. for a Sheet 5 Feet Wide and 0.01 Foot Thick
Tricresyl phosphate	50	$ 1.350
Mixture 50 parts Aroclor 1254 and 50 parts tricresyl phosphate		1.253
		$ 0.097 Savings
Tricresyl phosphate	45	$ 1.355
Mixture 50 parts Aroclor 1254 and 50 parts tricresyl phosphate		1.266
		$ 0.089 Savings
Tricresyl phosphate	35	$ 1.360
Mixture 50 parts Aroclor 1254 and 50 parts tricresyl phosphate		1.302
		$ 0.058 Savings

The results indicate that the Aroclor-tricresyl phosphate plasticizer combination offers a saving of 10 cents a running foot when 50 percent plasticization is used. At 45 percent plasticization the saving is about 9 cents and at 35 percent the saving is about 6 cents a running foot. Use of increased amounts of Aroclor result in greater savings.

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III. AROCLOR-TRICRESYL PHOSPHATE MIXTURES COMPARED WITH DIBUTYL PHTHALATE-TRICRESYL PHOSPHATE MIXTURES

Frequently, to accomplish better low temperature flexibility and "hand" dibutyl phthalate or dibutyl sebacate plasticizers are added to tricresyl phosphate.

The data given in Table III shows the effectiveness of a dibutyl phthalate-tricresyl phosphate mixture as compared with a mixture of Aroclor 1254-tricresyl phosphate based on tensile strength and elongation characteristics.

TABLE III.

Molecular Weight of the Polyvinyl-chloride	Plasti-cizer Percent	Mixture of Dibutyl Phthalate and Tricresyl Phosphate 23 parts - 77 parts		Mixture of Aroclor 1254 and Tricresyl Phosphate 50 parts - 50 parts	
		Elongation Percent	Tensile Strength Lbs/sq. in.	Elongation Percent	Tensile Strength Lbs/sq. in.
105,000	50	370	2,205	295	2,987
	40	285	3,558		
70,000	50	360	1,850	300	2,631
	45	335	2,419	285	3,130
	40	300	2,987	240	3,558
45,000	45	310	1,778	265	2,631
	43			220	2,848
	40	250	2,349	170	3,272
	35	225	2,848	120	3,911

Comparison of the underlined values in Table III indicates that provided a greater percentage of the Aroclor-tricresyl phosphate mixture is used, it is possible to obtain tensile strength and elongation qualities similar to those offered by using the dibutyl phthalate-tricresyl phosphate plasticizer combination.

COST COMPARISON OF THE PLASTICS

In the cost computations given in Table IV the current selling price for dibutyl phthalate at 35.5 cents a pound in carload quantity was used. The specific gravity value used for this plasticizer was 1.046.

The table compares the cost of the plastics in terms of running feet for a sheet five feet wide and 0.01 foot thick. The cost comparisons are made against the efficiency of the plasticizer mixtures with reference to tensile strength and elongation qualities of the finished plastics as shown in Table III.

TABLE IV.

Polyvinyl-chloride Molecular Weight	Plasticizer Composition	Plasticizer Percent	Plastics Materials Cost Per Running Foot for a Sheet 5 Feet Wide and 0.01 Foot Thick
105,000	23 Parts dibutyl phthalate and 77 parts tricresyl phosphate	40	$ 1.339
	50 Parts Aroclor 1254 and 50 parts tricresyl phosphate	50	1.252
			$ .087 Savings
70,000	23 Parts dibutyl phthalate and 77 parts tricresyl phosphate	40	$ 1.339
	50 Parts Aroclor 1254 and 50 parts tricresyl phosphate	50	1.252
			$ .087 Savings
45,000	23 Parts dibutyl phthalate and 77 parts tricresyl phosphate	35	$ 1.345
	50 Parts Aroclor 1254 and 50 parts tricresyl phosphate	43	1.272
			$ .073 Savings

While more Aroclor 1254-tricresyl phosphate mixture was required to give the same plasticization as accomplished with dibutyl phthalate-tricresyl phosphate, the cost figures in Table IV show a decided economy in favor of using the Aroclor plasticizer combination. The economic advantage is about 9 cents a running foot of plastics when the plasticizers are used at a level of about 50 percent. At lower plasticizer concentrations this advantage is about 7 cents a running foot.

IV. AROCLOR-DIOCTYL PHTHALATE MIXTURE COMPARED WITH DIOCTYL PHTHALATE PLASTICIZER FOR POLYVINYLCHLORIDE

In the following Table V the composition and comparative physical properties of polyvinylchloride plasticized with dioctyl phthalate and a 50-50 mixture of Aroclor 1262 and dioctyl phthalate are given. The formulations are typical wire coating compositions. Each contained 100 parts of polyvinylchloride. The amount and type of stabilizer and clay used in each formula was identical.

TABLE V.

PROPERTIES OF TYPICAL PVC WIRE COATING COMPOSITIONS

Properties	Dioctyl Phthalate	50-50 Aroclor 1262-Dioctyl Phthalate
Parts Plasticizer/100 Resin	50	80
Plasticizer, Percent	33.3	44.4
Shore A Hardness	82	79
Tensile Strength, Lbs/sq. in.	2710	2475
Elongation, Percent	385	375
Modulus of Elasticity at 100 Percent Elongation, Lbs/sq. in.	1660	1475
Flex. Temp., °C.	-19	-15
% Water Absorption (24 Hrs.)	.34	0.33
% Extracted	.02	0.05
Flammability, sec.	75	3
Volume Resistivity, 50°C.	5.0×10^{13}	8.8×10^{13}
% Volatile (24 Hr. 105°C.)	4.1	6.8

The composition containing Aroclor 1262 plasticizer is far superior to the similar composition plasticized with dioctyl phthalate with reference to resistance to burning. Also, the Aroclor composition offers improved insulation resistance. In other respects the properties of the two compositions appear similar.

COST COMPARISON OF THE WIRE COATING COMPOSITIONS

The comparative costs of the compositions in terms of a cubic foot of plastics are given in Table VI. The specific gravity value for dioctyl phthalate was taken as 0.980 and the current selling price of 42.5 cents a pound in carload quantities was used.

TABLE VI.

Plasticizer Composition	Percent Plasticizer	Plastics Costs Per Cubic Foot
Dioctyl Phthalate	33.3	$ 27.04
50-50 Aroclor 1262-Dioctyl Phthalate	44.4	25.34
		$ 1.70 Savings

The comparative cost figures given in Table VI reflect a saving of $1.70 per cubic foot of plastics or per 100 pounds of polyvinylchloride when the Aroclor-dioctyl phthalate plasticizer mixture is used.

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V. CONCLUSIONS

1. It is definitely indicated to utilize Aroclors (chlorinated biphenyls) as plasticizers for polyvinylchloride provided that tricresyl phosphate or dioctyl phthalate plasticizers are added to it.

2. In using Aroclor combination plasticizers the total plasticizer content of the plastics material will be increased. The use of Aroclors offers attractive savings in the costs of the finished plastics materials and results in a substantial saving of tricresyl phosphate, dibutyl phthalate and dioctyl phthalate.

3. In our present economy, and probably for sometime to come, these ester type plasticizers are both short in supply and substantially more expensive than they were in former years.

4. Aroclors are relatively inexpensive and the materials are immediately available in large quantity. When used in the suggested combinations with other plasticizers, the Aroclors are efficient and economical for manufacturing polyvinylchloride plastics materials.

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