



# AROCLORS

## as Co-Plasticizers for Polyvinylchloride

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Monsanto Chemical Company, St. Louis 4 Mo.

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

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.

| <u>Material</u>              | <u>Specific Gravity</u> | <u>Selling Price Per Pound In Carload Quantity</u> |
|------------------------------|-------------------------|----------------------------------------------------|
| 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.

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

### 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<br>of the Polyvinyl-<br>chloride | Plasti-<br>cizer<br>Percent | Mixture of Dibutyl Phthalate<br>and Tricresyl Phosphate<br>23 parts - 77 parts |                                    | Mixture of Aroclor 1254<br>and Tricresyl Phosphate<br>50 parts - 50 parts |                                    |
|---------------------------------------------------|-----------------------------|--------------------------------------------------------------------------------|------------------------------------|---------------------------------------------------------------------------|------------------------------------|
|                                                   |                             | Elongation<br>Percent                                                          | Tensile<br>Strength<br>Lbs/sq. in. | Elongation<br>Percent                                                     | Tensile<br>Strength<br>Lbs/sq. in. |
| 105,000                                           | 50                          | 370                                                                            | 2,205                              | 295                                                                       | 2,987                              |
|                                                   | 40                          | <u>285</u>                                                                     | <u>3,558</u>                       |                                                                           |                                    |
| 70,000                                            | 50                          | 360                                                                            | 1,850                              | 300                                                                       | 2,631                              |
|                                                   | 45                          | 335                                                                            | 2,419                              | 285                                                                       | 3,130                              |
|                                                   | 40                          | <u>300</u>                                                                     | <u>2,987</u>                       | 240                                                                       | 3,558                              |
| 45,000                                            | 45                          | 310                                                                            | 1,778                              | 265                                                                       | 2,631                              |
|                                                   | 43                          |                                                                                |                                    | <u>220</u>                                                                | <u>2,848</u>                       |
|                                                   | 40                          | 250                                                                            | 2,349                              | 170                                                                       | 3,272                              |
|                                                   | 35                          | <u>225</u>                                                                     | <u>2,848</u>                       | 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-<br>chloride<br>Molecular<br>Weight | Plasticizer<br>Composition                                        | Plasticizer<br>Percent | Plastics Materials<br>Cost Per Running Foot<br>for a Sheet 5 Feet<br>Wide and 0.01 Foot<br>Thick |
|-----------------------------------------------|-------------------------------------------------------------------|------------------------|--------------------------------------------------------------------------------------------------|
| 105,000                                       | 23 Parts dibutyl phthalate<br>and 77 parts tricresyl<br>phosphate | 40                     | \$ 1.339                                                                                         |
|                                               | 50 Parts Aroclor 1254 and<br>50 parts tricresyl phosphate         | 50                     | 1.252                                                                                            |
|                                               |                                                                   |                        | \$ .087 Savings                                                                                  |
|                                               |                                                                   |                        |                                                                                                  |
| 70,000                                        | 23 Parts dibutyl phthalate<br>and 77 parts tricresyl<br>phosphate | 40                     | \$ 1.339                                                                                         |
|                                               | 50 Parts Aroclor 1254 and<br>50 parts tricresyl phosphate         | 50                     | 1.252                                                                                            |
|                                               |                                                                   |                        | \$ .087 Savings                                                                                  |
|                                               |                                                                   |                        |                                                                                                  |
| 45,000                                        | 23 Parts dibutyl phthalate<br>and 77 parts tricresyl<br>phosphate | 35                     | \$ 1.345                                                                                         |
|                                               | 50 Parts Aroclor 1254 and<br>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

| <u>Properties</u>               | <u>Diethyl Phthalate</u> | <u>50-50 Aroclor 1262-<br/>Diethyl Phthalate</u> |
|---------------------------------|--------------------------|--------------------------------------------------|
| 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.       | $5.0 \times 10^{13}$     | $8.8 \times 10^{13}$                             |
| % Volatile (24 Hr. 105°C.)      | 4.1                      | 6.8                                              |

The composition containing Aroclor 1262 plasticizer is far superior to the similar composition plasticized with diethyl 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 diethyl phthalate was taken as 0.980 and the current selling price of 42.5 cents a pound in carload quantities was used.

TABLE VI.

| <u>Plasticizer<br/>Composition</u>                 | <u>Percent<br/>Plasticizer</u> | <u>Plastics Costs<br/>Per Cubic Foot</u> |
|----------------------------------------------------|--------------------------------|------------------------------------------|
| Diethyl Phthalate . . . . .                        | 33.3 . . . . .                 | \$ 27.04                                 |
| 50-50 Aroclor 1262-<br>Diethyl 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-diethyl phthalate plasticizer mixture is used.

## 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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