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CHEMICAL SPECIALTIES DATA REPORT

The information in this report was compiled to assist you in your evaluation and development of special uses for Monsanto products. Every effort has been made to include pertinent material bearing on the subject. This information is intended to guide your development work, but Monsanto cannot take part in the specific formulation or evaluation of any finished product... since knowledge of such should be reserved to yourself and is often your most valuable trade secret.

NO. CS-18

DATE November, 1963

R AROCLOR COMPOUNDS

Unique Property-Improving Additives

...for wax formulations,
...for investment castings waxes,
...for binding matrices for powdered glass and metals

The Aroclor compounds are a series of utterly inert, highly stable, low cost "sirups" and resins that are compatible with an exceptionally wide variety of organic systems, including the various commercial waxes. The Aroclor compounds range from thin liquids to hard, crystal-like resins. They are mutually compatible in all proportions. They can impart a most amazing variety of physical effects to a particular kind of formulation. They possess -- and impart to formulations containing them -- great resistance to chemical attack, to heat degradation, to oxidation. Because of their physical inertness, Aroclor compounds enable wax compounders to "custom-build" formulations and virtually to "tailor precisely" the characteristics of wax (as well as asphalt, resin, and gum) products for specific applications.

Chemically, the Aroclor compounds di- and poly-phenyl molecules that have been chlorinated to provide a definite per-cent-by-weight of inert, bound chlorine in each Aroclor compound. Physically, they range in

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[R] Aroclor is a trademark of Monsanto Chemical Company for its chlorinated aromatic hydrocarbons and their derivatives, including chlorinated diphenyl. Reg. U. S. Pat. Office.

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form and appearance from Aroclor 1221, a mobile oily liquid, to Aroclor 5460, a hard transparent resin. Intermediate Aroclor compounds include viscous fluids and soft resinous solids. The Aroclor compounds are impervious to moisture, acids and alkalis; they are extremely heat stable and will not support combustion.

This report describes some of the values of Aroclor compounds when added to commercial waxes; in investment casting waxes and in binder formulations for making powdered glass and metal products

HOW AROCLOR ADDITIVES FUNCTION IN WAX, BINDER, AND SEALANT FORMULATIONS

The aroclor compounds serve a variety of uses; primarily as a physical property modifier and performance improver When put into formulations, Aroclor compounds can be depended upon to impart chemical and oxidation resistance; to increase fire-resistance and often, to lower the cost of the finished product They have various unique properties, such as high boiling points, no flash points, and will volatilize in "fired compositions" without burning or ashing.

Aroclor compounds are compatible with a wide range of natural waxes such as Carnauba. By blending these expensive waxes with Aroclor resins, properties can be improved although raw material costs are lowered.

When blended with waxes used to formulate casting wax, Aroclor compounds help impart to the finished formulation a number of desirable properties. hardness without brittleness; resistance to shrinkage; sharp definition; sharp melting point; and fire resistance. Waxes formulated with Aroclor resins are non-tacky and highly stable.

Aroclor-containing waxes are widely used in making dental castings, in the precision casting of aircraft parts, and for casting costume jewelry. Aroclor 1254, 4465, and 5460 are the ones most frequently used, the proportions (as described later) depending upon the properties required in the finished wax.

WHY AROCLOR COMPOUNDS ARE VALUABLE ADDITIVES FOR WAX AND BINDER FORMULATIONS

Aroclor compounds span a wide range of physical properties. Over the series, the properties vary in a regular gradient. The properties that make the Aroclor series so valuable as additives for wax or binders for powdered materials are

Chemical Resistance: Aroclor compounds are remarkably resistant to either alkaline or acid hydrolysis. Boiling

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with sodium hydroxide solution or sulfuric acid produces no hydrogen chloride in experiments designed to test the stability of typical Aroclor compounds

Prolonged heating of an Aroclor in a closed system even at 600° F. produces no decomposition.

Oxidative Resistance: Bomb tests at 140°C in oxygen pressure of 240 psi fails to develop acidity or sludge -- demonstrating the remarkable inertness of Aroclor compounds.

Adhesion: Aroclor compounds contribute excellent adhesive properties to formulations used as coatings. This is important in glass or metal formulations that are subsequently fired to volatilize away the carrier portion (wax-Aroclor).

Flame-Retardancy: With their high chlorine content, Aroclor compounds contribute "built-in" fire resistance to any formulation into which they are incorporated.

Volatilization Without Ashing: Investment wax castings, marking inks, and powdered metal binder formulations are used in processes that ultimately require firing. It is extremely important that such formulations volatilize without residual ash or undesirable residues interfere with color or subsequent processing.

Melting Point. The melt point of the individual Aroclor compound varies in a regular gradient over the entire series. This gives a formulator a wide choice for picking the Aroclor (or Aroclor combination) that fits his requirement. The individual melting points are listed in the table of properties.

Compatibility: Aroclor compounds are compatible with a wide variety of resins utilized in special formulations. This property enables researchers to blend and homogenize other mutually incompatible materials into a stable composition. For practical use, Aroclor compounds are compatible with the following:

Asphalt
Benzyl Cellulose
Carnauba Wax
Cellulose Acetate Butyrate
Chlorinated Rubber

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Coumarone-indene Resins
Dammar Resin
Ester Gum
Ethyl Cellulose
Epoxy Resins
Manilla Gum
Nitrocellulose
Paraffin
Phenolic Resins
Polyester Resins
Polyethylene
Polystyrene Resins
Polyisobutylene
Polyurethanes
Polyvinyl Acetate
Polyvinyl Chloride and Polyvinyl Butyral
Polyvinylidene Chloride
Rosin
Rubber
Styrene Butadiene Co-polymers
Vinyl Resins

USE OF AROCLOR COMPOUNDS IN WAX POLISHES

Blends of inexpensive waxes in Aroclor have been used successfully to replace a portion of expensive carnauba wax. *

The following characteristic properties are necessary for a good carnauba wax substitute.

Hardness or penetration value should be at least equal to that of natural wax.

Texture should be homogeneous, preferably non-crystalline and somewhat brittle.

Melting point should be similar to natural wax and the setting point should be within 6°C. of this point (to avoid protracted cooling phenomena)

Performance must duplicate that of natural wax; especially in the working characteristics needed for the particular end-use application.

* See Carnauba Wax Substitutes by G. W. Wood (Maxwaxa, Ltd.), Manufacturing Perfumer, 1948, Vol. XIX.

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The following wax-Aroclor-Carnauba combinations compare properties and characteristics with those of 100% carnauba wax

Table I
CHARACTERISTICS OF AROCLOR-WAX BLENDS

No.	Composition	Parts by Weight	Color	Texture	Softening Point	Melting Point
(1)	Carnauba wax	100	Prime Yellow	Ringed surface	--	84 1-91°C
(2)	Aroclor 1268 Aroclor 1242 Carnauba wax Ceresin Paraffin	5.0) 2.5) 2.5) 20.0) 70.0)	Light cream	Smooth, hard non-tacky	58°C	67.5°C
(3)	Aroclor 1268 Aroclor 1242 Carnauba wax Ceresin Paraffin	10.0) 5.0) 5 0) 20 0) 60.0)	Pale yellow, white	Similar to above	60°C.	78°C.
(4)	Aroclor 1268 Aroclor 1242 Carnauba wax Ceresin Paraffin	19.6) 4 0) 6 8) 19.6) 49.0)	Pale yellow	Similar to above	77°C	79°C.
(5)	Aroclor 1268 Aroclor 1242 Carnauba wax Ceresin Paraffin	30.0) 5.0) 10.0) 20.0) 35 0)	Pale yellow	Smooth, hard, slightly brittle	78°C	78°C.
(6)	Aroclor 1268 Aroclor 1242 Carnauba wax Ceresin Paraffin	35 0) 5.0) 30.0) 20.0) 10 0)	Pale cream	Slight surface crystallinity	79°C.	86°C
(7)	Aroclor 1268 Aroclor 1242 Carnauba wax Ceresin	35 0) 5 0) 40 0) 20.0)	Cream	Similar to above	81°C.	86.5°C

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No.	Composition	Parts by Weight	Color	Texture	Softening Point	Melting Point
(8)	Aroclor 1268 Aroclor 1242 Carnauba wax Ceresin	35.0) 5.0) 50.0) 10.0)	Cream	Smooth; carnauba ringed surface	80.5°C.	88°C.
(9)	Aroclor 5460 Aroclor 1242 Ouricury wax Ceresin Paraffin	30.0) 5.0) 30.0) 20.0) 15.0)	Light buff	Very smooth, hard	60°C.	78.5°C.

Note that a liquid, plasticizing type Aroclor (1242) is mixed with a resinous or solid type Aroclor (1268 or 5460) in the above blends. This combining technique insures the compatibility of the solid Aroclor compounds with the wax and increases the solubility of the blend in such inexpensive solvents as mineral spirits.

Some suggested wax polish formulations, based upon the above compositions are the following:

Household Polish

Composition	Parts by weight
Composition No. 5 (Table I).....	1
Natural ozokerite.....	3
Paraffin, hard	26
Mineral spirits.....	70

Characteristics. This is a smooth, soft paste possessing very good polishing properties on wood and linoleum.

Car Polish

Composition	Parts by weight
Composition No. 5 (Table I)	15
Candelilla wax.....	2
Natural ozokerite.....	3
Mineral spirits.....	80

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Characteristics. This is a smooth paste possessing good polishing properties on all automobile paints and on leather upholstery.

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Car Polish (Ouricury)

Composition	Parts by weight
Wax blend (as prepared above)...	8
Natural ozokerite.....	2
Paraffin, hard.....	10
Aroclor 1242.....	5
Mineral spirits.....	75

In this formulation, the Aroclor 1242 is dissolved with agitation in the mineral spirits before adding to the molten waxes. It is noteworthy that aluminum stearate should not be used in this composition. Characteristics. The color of this composition is a light brownish-tan similar to polishes made from fatty gray carnauba wax. It has good polishing properties on all types of surfaces.

USE OF AROCLOR WITH ETHYLENE/VINYL ACETATE

The ethylene vinyl acetate copolymer must be plasticized to serve as an effective base for pressure sensitive adhesives. Aroclor compounds are recommended as a plasticizer for this application. Blends of this copolymer with Aroclor can be "tackified" with Aroclor products.

Following are starting formulations for various applications:

Non-Skid Rug Backing

Composition	Parts by weight
Ethylene/vinyl acetate copolymer	50
Aroclor 1254	50

Strong Pressure Sensitive Adhesive

Composition	Parts by weight
Ethylene/vinyl acetate copolymer	30
Aroclor 5460	45
Aroclor 1254	25

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USE OF AROCLOR IN INVESTMENT CASTING WAX

"Investment Casting," "Lost Wax Process," and "Precision Wax Casting" are terms that refer to the same casting technique in which the properties of the wax are critical. The process is especially useful where castings are made of high melting alloys and when the castings require close tolerance, smooth finish and possess intricate shape. Basically, the process consists of surrounding a wax model with plaster, melting out the wax model (hence the name "lost wax"), leaving a clean plaster mold that is then used for the metal casting.

For the investment process, a wax is required that possesses the following characteristics:

*Hardness without brittleness
*Sharp melting point
*Non-tackiness
*Low volatility
*Stability
*Good wax machinability
*Non-shrinking
*Sharp definition
*Fire resistance
*Fast setting
*Toughness

Since they are compatible with various natural waxes, Aroclor compounds are widely used in the formulation of investment casting waxes. The Aroclor imparts to the finished formulation hardness without brittleness; resistance to shrinkage; sharp definition; sharp melting point; fire resistance; high stability; non-tackiness; and fireability without ashing.

Investment casting waxes formulated with Aroclor compounds are widely used in making precision metal parts, dental castings, aircraft parts and custom jewelry. Aroclor compounds 1254, 1262, 4465, and 5460 are most commonly used -- the proportions and particular Aroclor combination selected depend upon the properties required in the finished wax. The usual proportion of Aroclor may vary between 5.0-60.0% -- with the balance of the formulation a combination of natural waxes.

AROCLOR COMPOUNDS IN IMPREGNATING COMPOUNDS

a) Electrical Hot Melt Impregnants

Non-flammability, high resistivity and high dielectric strength with low power factor make resinous Aroclor compounds extremely useful

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in the electrical industry. Aroclor 4465 and 5460 are used in coatings for wire and cable and as impregnants for cotton or asbestos braided insulation. Normally, in this application, they are formulated with natural waxes and phosphate esters to create a balanced formulation. With their high resistance with moisture, Aroclor compounds make excellent sealants for closing the "pores" of carbon resistors, ceramic parts, and to seal electrical bushings and terminals.

b) Wood Impregnant

Wood treated with a formulation of 70% Aroclor 4465, 20% microcrystalline wax and 10% sulfur by the vacuum-pressure method is tougher, harder, and more resistant to chemical attack. The residual surface coating is very resistant to acid and alkali; however, it is attacked by aromatic, aliphatic and chlorinated hydrocarbons.

The surface of the treated wood can be painted. The hardness and adhesion of the residual surface coating can be varied by changing the Aroclor-wax sulfur ratios.

c) Impregnants and Sealants for Paper, Concrete and Brick

An Aroclor combined with a paraffin or carnauba wax and mixed with mineral or drying oil and synthetic resin produces an excellent impregnant for paper and masonry products.

The simplest sealant composition contains an Aroclor compound and paraffin wax. For example, a highly efficient moisture proofing formulation is composed of 96% (weight) of Aroclor 5460 and 4% paraffin (m. p. 54° C.); it has an ASTM softening point of about 82 °C. Substitution of Aroclor 4465 for Aroclor 5460 produced a compound with a softening point of about 58°C. A very soft wax composition can be prepared by mixing 40% Aroclor 1260, 56% Aroclor 5460 and 4% paraffin. Increasing the paraffin content produces a softer material.

d) Fabric Impregnant

A rot-proof, water-repellent and fire-retardant composition for olive drab coatings for tents and other canvas items consists of:

Modified phenol formaldehyde resin	4%
Tricresyl phosphate	1.5%
Chrome orange	2%
Aroclor 1254	6%
Chlorinated paraffin (42% chlorine)	10%

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Aroclor 5460	4%
Copper naphthenate (8% copper)	8%
Aluminum stearate	0.5%
VM&P naphtha	40%
Iron oxide yellow	7%
Ground limestone	8%
Ground mica	3%
Antimony oxide	6%

e) Inks and the Decorative Arts

Marking & Printing Inks. Aroclor 4465 is an excellent resin for compounding marking, rotogravure, and general printing inks. A formulation for mimeograph ink, for example, contains:

Aroclor 4465	40%
Lubricating Oil (SUV 1200 @ 100°F.)	35%
Paraffin Oil (SUV 76 @ 100°F.)	20%
Carbon Black	4%
Oil Soluble Dye	1%

Vitreous Products. In glass decorating processes, Aroclor compounds are used as vehicles for carrying the pigments. After the decorations are applied, the glass is fired; the Aroclor volatilized without carbonization, avoiding discoloration of the glass and the decoration. Aroclor 1254, Aroclor 4465 and Aroclor 5460 are all used in this application. The usual technique involves grinding a low colored glass in a medium of Aroclor 4465 and inorganic pigments along with other carriers. The formulation can be silk-screened or printed on china, bottles, or various kinds of glass containers.

The low-melting glass frit pigment formulated with the Aroclor compound has excellent adhesion. On passing through the high temperature zones of the furnace, the Aroclor volatilizes and the glass frit melts into the higher melting point glass or ceramic material.

f) Binders for Powdered Metals, Glass and Ceramics

The ability of Aroclor compounds to volatilize without ashing makes them excellent binders for formulations used in metal fusion. Aroclor 4465 and Aroclor 5460 are the materials of choice for such formulations. The high tackiness, oxidation stability, and volatilization without ashing make Aroclor compounds ideal for compositions used for "forming" powdered metal parts.

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Dermatology and Toxicology

At ordinary temperatures, Aroclor compounds have not presented industrial toxicological problems. Where Aroclor vapors may be encountered in workrooms, local exhaust ventilation together with general workroom exhaust is essential.

Skin patch tests with a polyvinyl chloride free film plasticized with 11.5% by weight of Aroclor 1254 (about 25% based on the weight of the vinyl resin) and a similar amount of dioctyl phthalate showed that this film was not a primary irritant or a sensitizer. Skin patch tests with Aroclor 1254 alone applied to gauze and placed in contact with the skin showed no primary irritancy or sensitization. Other skin patch tests using canvas coated with Aroclor 5460 and an oil modified alkyd resin, in such a manner that the Aroclor concentration in the paint film on the fabric was about 17% by weight of paint solids and the finished coated fabric contained approximately 7% by weight of Aroclor 5460 showed that this painted fabric did not produce a primary irritancy or sensitization of the skin.

If Aroclor compounds are spilled on the skin, the skin should be washed in the usual manner with soap solutions. If accidental burns occur from contact with hot Aroclor, the burn should be treated the same as any ordinary burn. Aroclor adhering to the burned area need not be removed immediately unless treatment of the burn demands it, in which case use soap and water or repeated washings with a vegetable oil.

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