JOURNAL OF
ARBORICULTURE

July 1980
Vol. 6, No. 7

SPRAY OILS AS INSECTICIDES

by Warren T. Johnson

Petroleum oils have been used in agriculture for about 100 years. They are *contact insecticides* that interfere, physically rather than chemically, with respiration. They affect only insects present at the time of application, those migrating to a treated plant will not be affected by oil residues. Oils continue to be the best available pesticides to control scales, mites, plant bugs, psyllids and certain moths in the dormant or semi-dormant season, and are competitors of the synthetic organic insecticides (also petro chemicals) for use on trees in the verdant condition. Horticultural oils like other insecticides must be formulated with a surfactant or emulsifying agent so that it can be diluted with water.

The greatest activity in improved spray oil technology and application came in a 25-year period between 1945 and 1970, but long before this era there was a basic understanding that certain oil components were responsible for phytotoxicity and other factors were responsible for insecticidal efficiency. Oil company specialists seeking new uses for their product and applied entomologists seeking more effective means of pest control worked together during these years to develop many oil products for use on trees and shrubs, but particularly on fruit trees.

Many general descriptive terms were used to imply a degree of refinement and plant safety. At that time such designations as dormant type, summer and regular type, medium, light medium and unclassified were acceptable to the agriculturist and petroleum chemist. Today these terms continue to be used on labels and in state pesticide recommendations, but to the person reading the label for information such terms are practically meaningless.

In 1947 Dr. P.J. Chapman and co-workers at the New York State Agricultural Experiment Station coined the term "Superior" spray oil. This is a major landmark because clearly attainable specifications had to be followed for the spray oil to be described as a "Superior Type" oil. These oils were designed primarily for use on trees in the verdant condition; but they retained the needed properties for a dormant type oil.

Nature of Spray Oils

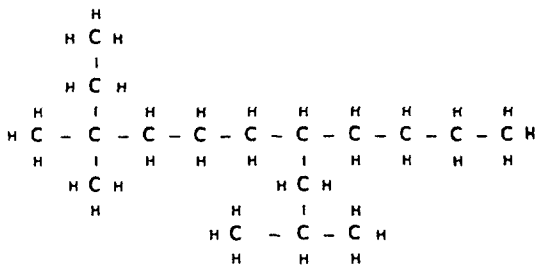
Horticultural spray oils are a complex mixture of petroleum hydrocarbons with no precise formula. The final product that comes from the refinery depends largely on the nature of the "raw" product, i.e., the nature of the crude oil. Horticultural oils are made from paraffinic and asphaltic base or naphthenic crude types. The paraffinic types are best for the refining of lubricating products such as motor oils, white mineral oil for pharmaceutical purposes, leaf polish, baby oil and petroleum jelly for external medicinal purposes. Naphthenic and asphaltic crudes can be made into oil or converted into diesel fuel and gasoline.

The oils most useful to urban forestry and ornamental horticulture are produced from paraffinic crude oil. The petroleum chemist describes paraffinic oils as long chain petroleum products that have the configuration shown in Figure 1A. As the chain increases in length heaviness (viscosity) increases, e.g., the transition from baby oil to petroleum jelly. Figure 1 also illustrates a pure, saturated paraffinic oil. White mineral oil is an example of a paraffinic product that is completely saturated.

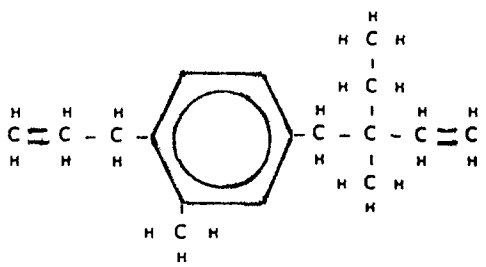
Because economically feasible spray oils are not "pure" single formula products it is necessary to define them in another way, thus specifications have been established. Specifications for several

Superior oils are given in Table 1. Included also are specifications for the oil being advised officially in New York in 1980. A short statement about the major properties follows.

Fig. 1. Hydrocarbon structures



A. Paraffinic, saturated, safe



B. Aromatic, unsaturated, injurious

Unsulfonated residue. Sixty-five years ago two workers in California (Gray and DeOng) discovered that injury to plants in leaf was related to the percentage of unsaturated components in an oil. An unsaturated oil might be a paraffinic, naphthenic or aromatic type oil, but in any case the structure (Figure 1) would contain one or more carbon atoms (C) double bonded (C=C) to another in a carbon chain (Figure 1B). These are the unsaturated components described by Gray and De Ong. Oil with unsaturated components will react with concentrated sulfuric acid and can be separated from the part that does not react. The oil component that does not react is called the unsulfonated residue (U.R.). If the U.R. is 96% the remaining 4% will be sulfonated compounds. Hence, the U.R. value is an index of the amount of the product free from unsaturated hydrocarbons. An oil with a U.R. of less than 92% would be considered unsafe on verdant plants.

Viscosity. This is a time-honored property used to define oil heaviness. In horticultural spray oils it is expressed in terms of seconds, which refers to the time required for a sample in a viscometer to pass from one chamber to another when the test equipment is held in a water bath at 100°F. Spray oils fall into a 60 to 200 second range. As would be expected the heavier oils (100 seconds and higher) lay down more persistent deposits on plants in spraying. Dormant or semi-dormant trees will tolerate at least moderate deposits of such oils, but not trees in leaf. Growth is slowed in the

Table 1. Specifications for Superior Type Plant Spray Oils

Property[a]	*Typical 60-Second Oil*	*Volck Supreme+ Chevron*	*Volck 70* Supreme Chevron*	*Orthol-D Chevron*	*Orchex 796 Exxon*	*Orchard Spray 70 Gulf*	*Sun Spray* Sun*	*Superior 70 Shell Canada*
Saybolt Universal Viscosity[1] at 100°F, seconds (Maximum)	63	140	—	89	73	83.9	—	70
Gravity,[2] °API (Minimum)	35	33-35	30	34	35.3	32.7	30	32-33
Unsulfonated residue[3] (minimum)	94	92	92	94	92+	96.5	92	92+
Pour point[4] °F (maximum)	20	20	20		15	0	20	0
Distillation[5], at 10 mm Hg, °F 50% point	412 ± 8	—	412 ± 8	—	440	—	412 ± 8	420(max.)
10-90% range (maximum)	65	—	80	—	70	—	80	—

[a]The following ASTM methods are to be used: (1) D-445-65 and D-2161-66; (2) D-287-67; (3) D-483-63; (4) D-97-66; (5) D-1160-61.

+Western Markets

*New York State minimum standards for 1980

The oil companies named are the basic refiners in the U.S. and Canada with their trade name products as registered with E.P.A. in the U.S. or with Pesticide Section of Agriculture Canada.

latter situation and even though the oil is highly refined it still may cause a yellowing or chronic type of injury to the foliage. While viscosity readings may provide a good general indication of desired oil heaviness, more universally reliable information may be obtained on this property from an oil's distillation profile. As will be seen, oil heaviness is defined by distillation only in the product suggested for use in New York in 1980 (Table 1).

Gravity. When related to viscosity and U.R., the gravity test provides a practical index to oil paraffinicity. Thus, the higher the gravity reading the more paraffinic the oil.

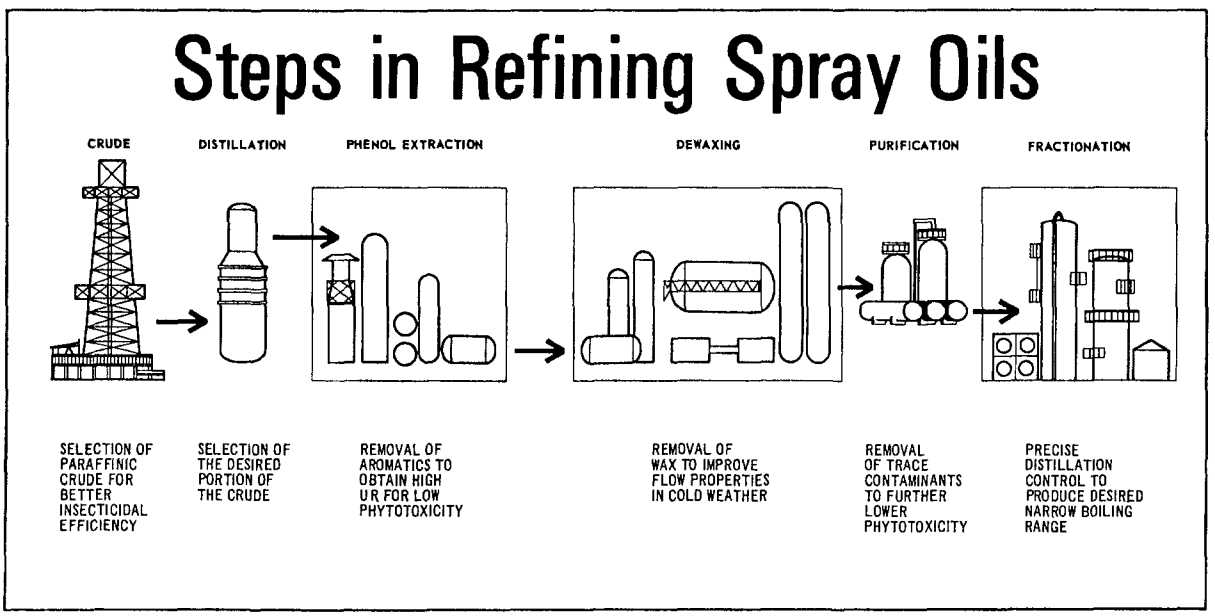
Pour point. This property is included to insure having the oil in a liquid state during early season use in northern climes.

Distillation at 10 mg Hg. The superior oils were designed to combine full pesticidal action with minimum plant injury hazards. To meet these objectives the deposit of oil on a plant laid down in spraying should be persistent enough to achieve kill of the pests but not so persistent as to interfere with respiration of the plant to the point that injury is caused. This is an exacting requirement. It can be achieved, however, by holding to the distillation pattern shown, i.e. a narrow 50% point and 80% of the product distilling over a 80°F or a narrower range.

The horticultural spray oils made in 1980 may or may not meet all of the standards given for the superior oils. Viscosity is such a variant. No viscosity standard was included in oil suggested for use in 1980. Justification for doing this rests on the belief that other property standards given, especially U.R. and the distillation pattern, should provide an acceptable spray oil.

Problems with Labels

Parts of the label statements on many horticultural oils range from meaningless to fairly useful. When the potential user of a pesticide product reads the label he/she expects to be reading the truth and in jargon associated with the spray business. The first label pitfall is in the ingredient statement. There appears to be no federal re-



Modified and used with permission of Exxon Company U.S.A. and Farm Chemicals, Journal in article titled Those Durable Oils, Sept. 1969.

Figure 2. The acid treatment described above as phenol extraction is being replaced by a hydrogenation technique described as hydrofining.

quirement for uniformity or content. For example, note the following ingredient statements.

Active Ingredients	By Weight
Petroleum Oil	98%
Inert Ingredients	2%
	Total 100%

Active Ingredients	By Weight
Paraffinic Oil*	98.8%
Inert Ingredients	1.2%
	Total 100.0%

*Unsulfonated Residue 94% min.
Grade of oil 60 Superior
Gravity API 30° min.

The first statement of ingredients might be for motor oil for all the reader can tell. The second statement reveals the essential information, provided the reader is familiar with terms used by the petroleum industry.

Caution statements applicable to the arborists and nurseryman usually result in confusion. Many caution statements currently promulgated originated 30 or more years ago when there were few meaningful standards. During those earlier years if an oil application resulted in measurable phytotoxicity to a plant the name of the plant species eventually was placed in the caution statement. When the new superior oils were developed some of the agricultural chemical formulators and suppliers continued to call their sales product Dormant Oil, declaring their product for dormant use. For lack of information they also found it easier to make no adjustments in their caution statements. Today should an EPA registrant, through misinformation or for whatever reason, decide to add the name of a plant to their caution statement they do so without the need of research evidence or documentation. Contrary to the statements made on many horticultural oil labels, there are no currently refined spray oils that are limited to dormant use, except the Shell product NEDSO used in western Canada.

To date, the writer has found no published literature that claims phytotoxicity to any species of deciduous tree or shrub, in the U.S. or Canada, from using a superior oil in the dormant stage. The same is true for conifers, however there will be a cosmetic and perhaps an economic effect if oil is sprayed on glaucus conifers such as Colorado blue spruce. Oil sprayed on such trees will result in removal of the bluish frosted material from the needles. Two or three years may pass before normal color returns.

Labels for summer oils, likewise, have erroneous caution statements, again based upon "ancient" information not applicable to 60 and 70 second superior oils. Data from New York, Delaware and elsewhere indicate that light grades of superior oil are safe on sugar maple, *Acer saccharum;* red maple, *A. rubrum,* European beech, *Fagus sylvatica;* American beech, *F. grandifolia* and birch of all species although these species are commonly listed in the caution statements. Similarly, superior oils are routinely used on walnut, *Juglans regia,* in California at a rate higher than normally recommended in the east for summer sprays. There is no supporting evidence either for or against using oil on black walnut or butternut in the east. Likewise, published evidence is lacking about phytotoxicity to *Acer palmatum* and *Cercis canadensis.* As an opinion, I doubt that there are any deciduous trees that are sensitive to light superior oil if the dosages are in line with prescribed rates and the plant is not under moisture stress.

Temperature cautions are also misleading. Many label statements say, "Do not use when temperature is below 40°F or above 90°F." The caution about low temperature is a concern about excessive oil deposition. Low temperature is of no significance in a practical sense for I doubt anyone would be out spraying when the temperature was below freezing. If spraying occurs at temperatures near the freezing point of water and the temperature drops to or below 32°F before evaporation takes place, it is possible, but highly unlikely, that there will be a small overdose of oil on some parts of the plant. Field studies at the New York Agricultural Experiment Station have yielded no evidence that low temperature oil applications, per se, will cause damage to dormant fruit trees. Where oils are used on citrus, present evidence indicates the possibility of reduced frost resistance. As a safety factor, *Pour Point* is added

to the specifications. Any superior oil that remains in the liquid state at 20°F should be safe for all routine field applications.

High temperature concern is about the increased potential for the oil interfering with plant respiration. It remains a valid concern. Climatic conditions which cause an increase in respiration or demand for water in a tree (such as heat or dry winds) may create the conditions for leaf damage if the replacement moisture is not available in the root zone. The symptoms are usually described as "scorch." Oil on the leaf will aggravate the situation. There are plenty of examples where oil has been applied to shade trees when the temperature was over 90°F without injury symptoms. By understanding the diverse conditions that may bring about "high temperature" scorch, the applicator will understand that there is no distinct thermometer reading where phytotoxicity will occur.

Compatability

There is some uncertainty and a lot of timidity on the part of those responsible for pesticide recommendations on the matter of compatability. When a synthetic organic insecticide is known to cause phytotoxic symptoms when used alone, we can assume that when combined with oil the injury will be intensified. This is the case with oil and dimethoate. The Sevin 50-W label under the section headed Compatability states, "Do not use with summer oils on deciduous fruits". Also, in the Ortho Volck Supreme spray label (a superior oil) the caution statement says, "Do not use (Volck) in combination with crops other than citrus". These cautions about Sevin are presumed to be related to phytotoxicity. At this time the writer is unable to ascertain the validity of the statement with respect to woody ornamental plants. However, thousands of gallons of Sevin-4-oil have been sprayed by aircraft over hardwood forests and shade trees to control defoliating insects with no reported phytotoxicity.

There is excellent potential for improved efficiency when superior oil is mixed with synthetic organic insecticides. Such combinations make possible the advantages of two modes of insecticidal action. At present we have label approval for Ethion-Oil for use on dormant trees. Arborists now commonly add superior oil to summer sprays containing malathion. This practice has evolved from field experience rather than from published research.

The label admonition, "Do not combine oil and surfur sprays" is one that has no degrees of freedom. It means what it says. Likewise there is danger of phytotoxicity with other fungicides such as captan and Karathane in combination with oil.

Oils for 1980

Horticultural oils refined for 1980 sales will be made by the Sun Oil Company for eastern markets, Exxon (Houston) for markets in the south and Mississippi Valley, Gulf Oil (Port Arthur, Texas) for bulk sales in tank car or barges, Chevron for the west coast, and Shell Canada for Canadian markets. With the possible exception of oils made by Chevron for west coast fruit, and the product NEDSO from Shell Canada also for west coast marketing, all other horticultural oils will be of the superior (paraffinic) type with their specifications falling within the range of those given earlier (Table 1). Chevron products sold on the east coast will be made under contract with the Sun Oil Company and formulated at their South Plainfield, New Jersey facility. Most oil commonly bought by arborists and nurserymen comes from Agricultural Chemical Companies who purchase from the basic refineries and sell it, unchanged, under their own labels for various uses.

As in past years, many common product names will be used such as Dormant Oil, Dormant Spray, Spray Oil, Miscible Oil, Emulsive Mineral Oil and a multitude of trade names such as Volck Supreme, Acme Dormant Oil, Scalecide, Orthol-D, Orchex, Bonide Dormant Spray Oil, E & B Dormant and Unico Spray Oil. Most of these products are the same as they were when they came from the refiner; yet their labels are not consistent in respect to ingredient, and caution statements. All will have the full range of uses unless an Ag Chemical company has its own formulation specifications which are usually only a modification of the inert ingredients. Under present E.P.A. regulations emulsifiers and other "inert" ingredients remain unspecified on the label. Obviously,

confusion will continue to exist in 1980 largely because of label inconsistencies.

Conclusions

Since *Integrated Pest Management* (IPM) has come of age, additional considerations must be given to all of the pest control tools. Superior oil is one of our best, safest, and least expensive insecticides, and much under-utilized. Rank confusion exists among arborists and nurserymen as well as federal; and provincial or state agricultural and forestry advisors about the proper use of oils. Confusion will continue until the oil specifications appear on *all* labels and in terms that the spray contractor can understand. Responsibility for label improvement rests with three groups: agricultural experiment station researchers, agricultural chemical suppliers and formulators and the Environmental Protection Agency; in Canada, Pesticide Section Agriculture Canada. Much of the information for label improvement already exists and would be a fairly simple matter to modernize.

Acknowledgments:
Thanks to Dr. Paul Chapman who was both consultant and reviewer of this paper.

Selected References

Anon. circa 1955. Volck 70 Supreme. Ortho Technical Service, Pesticides. Research and Development. Chevron Chem. Co. San Francisco. 5p.

Chapman, J.P., G.W. Pearce and A.W. Arens 1941. The use of petroleum oils as insecticides II. Some factors affecting the amount of oil deposited on apple bark in dormant spraying. Jour. Econ. Ent. 34 (2): 207-212.

Chapman, J.P, S.E. Lienk, A.W. Arens, and R.W. White 1972. Selections of a plant spray oil combining fuel pesticidal efficiency with minimum plant injury hazards. Jour. Econ Ent. 55(5): 734-744.

Chapman, J.P. 1967. Petroleum oils for the control of orchard pests. N.Y. State Agr. Exp. Sta. Bul. No. 814. 43p.

Gambrell, F.L. and F.Z. Hartzell. 1939. Dormant spray mixtures on conifers. Jour. Econ. Ent. 32:206-9.

Gray, G.P. and E.R. DeOng, 1926. California Petroleum Insecticides. Ind. Engineer. Chem. 18: 175-80.

Hammond, J.W. 1967. Those durable oils: Part II Insecticides. Farm Chemicals, Sept. 1967. p. 16-21.

Kelsey, L.P. 1960. Preliminary studies on the summer application of oil and oil-phosphate combinations to ornamental plants. Mimeograph publication Dept. of Ent. U. of Delaware.

Matthysse, J.G. and J.A. Naegele. 1950. Mites on woody plants and their control Proceedings 26th Ann. Meeting National Shade Tree Conference pp. 78-90.

Pearce, G.W., and P.J. Chapman. 1947. Improved spray oils for fruit trees. New York State Agr. Exp. Sta. Farm Research 13(2): 1.

Smith, E.H. and G.W. Pearce. 1948. The mode of action of petroleum oils as oxicides. Jour. Econ. Ent. 41(2): 173-80.

Smith, E.H. 1952. Tree Spray Oils. Agricultural Applications of Petroleum Products. Am. Chem. Soc. pp. 3-11.

Smith, E.H. and J.H.H. Phillips 1961. The influence of oil viscosity and timing of treatment on semidormant control of European fruit lecanium. Jour. Econ. Ent. 54(6): 1165-1171.

Wheeler, E.H. and G.D. Oberle 1948. Oils in dormant sprays to control European fruit lecanium and cottony peach scale. Jour. Econ. Ent. 41(2): 186-189.

Professor of Entomology
Woody Ornamentals Project
Cornell University
Ithaca, NY