

VOLATILIZATION STUDIES OF SPRAY OILS

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VOLATILIZATION STUDIES OF SPRAY OILS

INTRODUCTION

The use of the kerosene fraction of petroleum oils to control insects began with the use of kerosene as an illuminant. This was over seventy years ago. C.V. Riley ⁽⁹⁾ one of the pioneers in the use of kerosene in 1880 published his formula for the preparation of kerosene emulsion using milk as an emulsifying agent. Kerosene emulsions, however, had been used ten years previously. Heavier fractions of petroleum than kerosene gradually began to supplant kerosene largely because of their toxicity to insects until by 1913 light lubricating oils were quite generally used. The use of oil sprays has rapidly increased in recent years. De Ong ⁽¹⁾ in 1931 estimated that approximately five million gallons of petroleum oils were used annually on the Pacific Coast.

The insect pests in the Pacific northwest upon which oil sprays have proved particularly effective are the San Jose Scale, orchard Leaf Roller, Rosy Apple Aphis, Green Apple Aphis, Black Cherry Aphis, Peach Aphis, Red

Spider and various Tree Hoppers (15)

Swingle and Snapp (16) have shown the disagreement existing among investigators as to the mode of action of mineral oil in killing insects. Some investigators believe that death is caused by vapors or gases given off by oil in contact with the insect, other investigators are inclined to believe that death is caused by suffocation due to blocking of tracheae. Both theories apparently are backed by experimental evidence.

The ovicidal action of petroleum oils is probably due to disorganization of protoplasm in the insect egg by oil that has penetrated the chitinous covering of the egg.

BRIEF DISCUSSION OF PETROLEUM

The origin of petroleum has caused much speculation. The theory most universally held is that petroleum has been formed from masses of decomposing organic matter of animal and vegetable origin (5). The fact that hydrocarbons have been formed from either plant or animal sources under laboratory conditions supports this theory.

COMPOSITION OF PETROLEUM

Petroleum varies in its composition depending to some extent where it is found. Petroleums from Eastern United States are called "paraffin-base" oils because

their predominant hydrocarbons are of the C_nH_{2n+2} or paraffin series. In addition to the paraffins, eastern oil contains smaller amounts of naphthenes (C_nH_{2n}) and traces of oxygen, nitrogen and sulfur.

Western oils are characterized by the comparative absence of the paraffin series in their higher boiling fractions. Naphthenes and aromatic hydrocarbons are found in larger amounts than in eastern oils. The heavy residue remaining after distillation is a black asphaltic material hence the name "asphalt-base" oil. Western oils contain a higher percentage of impurities as sulfur and nitrogen compounds.

REFINING OF PETROLEUM

As petroleum comes from the wells it is allowed to stand to let water and other impurities settle out. The crude petroleum is then ready for distillation. Distillation is done in large stills that are heated directly by fire or by superheated steam. Usually both methods are used. The distillate is collected according to gravities, the lightest petroleum distillate being benzine, the next lightest gasoline, then kerosene, stove and furnace distillates and then the light to heavy lubricating oils. It is from these latter fractions that spray oils come.

Purification of the oils is ordinarily done with

either sulfuric acid or a lead reagent. Sulfuric acid removes undesirable unsaturated compounds and other compounds of complex and unknown composition. The excess sulfuric acid is removed by treatment with caustic soda solution. Hydrogenation may be used to reduce the unsaturates and at the same time remove sulfur as hydrogen sulfide. Taken on the whole, the chemistry of purification is still imperfectly understood.

PHYSICAL AND CHEMICAL CONSTANTS OF SPRAY OILS

There are numerous specifications and constants used in the petroleum industry that are not of particular importance in regard to spray oils. Some of them are flash point, fire point, color and amount of sulfur present. The more important specifications as far as spray oils are concerned are density, unsulfonated residue, viscosity, volatility and distillation range.

Density or specific gravity probably has the least use as far as evaluating spray oils (2). It is used principally to differentiate between oils from different fields and to separate the different fractions of oils as for instance, kerosenes and light lubricating oils. When comparing naphthene-base oils with paraffin-base oils of the same viscosities the naphthene-base oils will be denser than the paraffin-base oils. Density varies directly with increased viscosity, molecular

weight and boiling-point.

SULFONATION

Much work has been done in recent years on the sulfonation values of spray oils. In nearly all lubricating oils there is a varying proportion of chemically active unsaturated compounds, undesirable aromatics and sulfur compounds that are soluble in sulfuric acid. It has been shown that these compounds are quite toxic to plants (14). Refinement of these oils consists of treatment of the oil with sulfuric acid or liquid sulfur dioxide.

The determination of the sulfonation value of a spray oil consists of shaking a measured amount of oil with a definite proportion of sulfuric acid and noting the percent decrease in volume of the oil due to part of it (the sulfonated portion) being removed by the acid. A sulfonation value of 95 would mean that 95 percent of the oil will not react with sulfuric acid under ordinary conditions.

VISCOSITY

At present viscosity, as measured in seconds by the flow of 60 cubic centimeters of oil at 100^oF. from a Saybolt Universal viscosimeter is one of the most widely used specifications for grading spray oils as to their heaviness. Viscosity becomes greater as the percentage of

high molecular weight compounds increase. Increased viscosity results from decreased temperature and increased boiling point. De Ong (1) has pointed out the large change in viscosity of a spray oil with change in temperature. A light oil of viscosity 57 seconds as measured by the Saybolt Universal viscosimeter has a viscosity of 105 seconds at 60°F. A heavy oil of 105 viscosity will have a viscosity of 325 at 60°F. This indicates the importance of taking orchard temperature into consideration when applying an oil spray. Spreading power of an oil varies inversely as the viscosity.

An arbitrary classification of oils that has been generally adopted is as follows: Light oils viscosity 50-60, light-medium oils viscosity 60-70, medium oils 70-80 and heavy oils viscosity over 100.

DISTILLATION RANGE

Distillation range is a measure of the percentage of oil that will distill off at a definite temperature in a definite time. The oils used in this research were distilled at a temperature range of 575°F. to 700°F. Distillation range is now considered a more important specification for grading a spray oil as to heaviness than is viscosity (12). Distillation range is a measure of the volatility of an oil as well as a measure of its composition. An oil with a large fraction distilling at a low temperature will have a corresponding large amount of low

molecular weight hydrocarbons in it.

VOLATILITY

Volatility of an oil will be considered its evaporation rate under field conditions. Distillation point range gives a fairly close indication of volatility but, as de Ong⁽³⁾ points out is not an accurate indicator of volatility, especially at field temperatures. Distillation takes place at sufficient temperature to cause some cracking of the oil and a consequent change in composition.

As I have already pointed out, viscosity and distillation point range are two very important specifications in evaluating a spray oil. The present tendency, however, is to make volatility of an oil one of the most important means of evaluation. Viscosity is not necessarily a measure of the volatility. Refinement may markedly change the viscosity of an oil but not its volatility⁽³⁾. A spray oil may be made by blending a light oil and a very heavy fraction. Obviously the volatility of this oil will differ from that of an oil of same viscosity but composed of oil between the light and heavy fraction.

Oils prepared from different petroleums may have the same volatility and different viscosities⁽¹³⁾. This is due to the difference in composition of oils from different sources.

STATEMENT OF PROBLEM

Because of the increased use of oil sprays to combat insect pests a number of problems coincident with the use of oil have become of great importance.

The most serious problem at present is complication of lead arsenate removal due to use of oil spray (10) (4) (6) (8) (13) (14). Coating fruit with a film of oil after it has previously been sprayed with lead arsenate tends to create a situation whereby the surface of the fruit is more resistant to the action of cleansing agents. Since the Food and Drug Administration has proposed a lead tolerance of .014 grains per pound of fruit for the 1934 season the problem of spray removal has become very acute particularly in the case of oil sprayed fruit.

Wax exudation is stimulated by application of summer oils to apples nearing maturity (7). This also complicates spray removal.

The aforementioned complications may be lessened to a very considerable extent by applying an oil that will in a large measure volatilize before harvest time. Robinson (11) has very aptly summarized the whole problem of oil complication of residue removal (12) as follows:

"When certain grades of oil spray are applied in combination with or after heavy application of lead arsenate, the combined residues form a compact mass especially in the calyx and stem end of the fruit. Unless sufficient time before harvest is allowed for

volatilization of the oil the residue can not be dissolved effectively. How near harvest time oils may be used without interfering with the removal of the residue can't be definitely stated. This depends upon the grade of oil, weather conditions and amount of oil used. The proper use of the correct grade of oil will, however, prevent complications in its effect upon the removal of spray residue."

The above problems suggested volatilization studies of different spray oils in attempt to evolve a method that would effectively evaluate oils as to their volatility under orchard conditions and to try and correlate this method with a proposed A.O.A.C. method, and with physical constants determined for the oils studied.

PLAN OF ATTACK ON PROBLEM

Two plans of attack on the problem of attempting to approximate volatilization under orchard conditions were decided upon. The first was to determine rates of evaporation of different oils in the laboratory under controlled conditions, and the second was to determine rates of evaporation of these same oils under the same conditions except to run them out-of-doors where conditions of temperature and air currents would be somewhat similar to orchard conditions.

The original intention of the research was to make volatility tests of spray oils with an anticipated A.O.A.C. method. Publication of the method by the time the research had gotten under way had not appeared so a short oven method was devised to determine volatility of

of spray oils, the purpose being to correlate this method with the long cabinet methods previously mentioned.

MATERIALS

Three Associated Oil Company spray oils, Avon 60, Avon 65 and Avon 70, light, light-medium and medium respectively, three Standard Oil Company of California spray oils, Calol #1 light 90, Calol #2 light-medium 90 and Calol #4 medium 93 and four Shell Oil Company oils, Shell 315 a light oil, Shell 548 a fairly light oil, Shell 331 a light-medium oil and Shell 322 a medium oil were tested. In addition, Oronite Technical a heavy, highly refined oil and two oils used in the 1933 season, Standard oil #4 a light oil and Standard oil #6 a medium oil were tested for volatility. Shell 315 and Calol #4 medium 93 were run in duplicate. Specifications as obtained from the oil companies furnishing the oils are shown in table I.

EXPERIMENTAL

De Ong (2) in 1928 in cooperation with the Shell Oil Company proposed a method for determining volatility of oils which consisted of adding a weighed amount of oil to a sheet of asbestos paper three inches square and suspending the sheet in a thermostatically controlled oven at from 50°C. to 100°C. depending on the oil used, and weighing at definite intervals to determine evaporation

TABLE I
SPECIFICATIONS FURNISHED BY OIL COMPANIES

Associated Oil Co. Oils

	Avon 70 Neutral X	Avon 65 Neutral X	Avon 60 White neutral
Grav. API	27.9	28.3	28.6
Flash C.L. o.c.	320	315	293
Vis. S.U. 100°F	73	66	58
Color Astm.	1+	1+	1-
Unsulphonation % distilling	91.6%	91.6%	91.5%
at 636°F	52	61	---

Shell Oil Co. Oils

	Shell 315	Shell 321	Shell 322	Shell 548
Grav. API°	30.5	29.4	28.8	25.4
Color ASTM	1+	1-1/2-	1-1/2	2+
Vis S.U. at 100°F	55	63	74	62
Unsulphonated Res. % 575°F	90.7	91.1	91.0	73.0
Distilling 636°F	24	17.5	11	23.5
700°F	75	63	49	65
	90(over)	88	80	86

Stand. Oil Co. Oils

	Calol #1 Lt. 90	Calol Lt. M. 90	Calol #4M92
Grav. API	30.3	30.1	29.8
Flash-Cleveland	295	295	305
Vis at 100°F	59	63	72
Color-Saybolt	-6	--	--
ASTM	--	1	1
Unsul. Res.	91	90	93
% at 575°F	14.5	6.5	2.5
Distilling 636°F	67.5	60	44
Distilling 700°F	94.0	90	84.5

rate. The method I used was somewhat modified.

Th more nearly approximate orchard conditions it was necessary to have the oil exposed to the air in a comparatively thin film. Preliminary work in 1933 indicated that .20 gram of oil spread evenly over both sides of a filter paper strip measuring five inches by seven inches gave good results. Blue-gray sugar paper was cut into strips five by seven inches, 1.25 grams oil was weighed accurately into a 25 cubic centimeter volumetric flask and made to volume with petroleum ether. Two cubic centimeters of this ether-oil mixture was pipetted to each side of the strip making four cubic centimeters or .20 grams of oil on each sheet. Three sheets were coated with each oil studied.

In order to learn what difference if any surface made on oil evaporation glass plates with the same dimensions as the sugar paper sheets were coated with oil. Experimenting showed that .10 gram of oil was all that would adhere to the glass without dripping off. Less than .10 gram of oil made the experimental error too great in subsequent oil recovery. As soon as the paper strips were prepared the remaining ether-oil mixture was diluted to twice its original volume with petroleum ether and four cubic centimeters or .10 gram of oil pipetted to each of three glass plates. When the ether had evaporated leaving the oil, the sheets and plates were suspended from wires in a wooden cabinet measuring approximately two feet square

and three feet high. Half-inch holes were bored at intervals around the bottom and on the top to provide ventilation.

A study of temperature records made during the summer of 1932 in Medford indicated that 80°F. would probably be a fair estimate of an average summer's day, consequently the cabinet was maintained thermostatically at from 79°F. to 83°F. Crude apparatus prevented a closer regulation.

After some preliminary trials the best method for determining evaporation loss of the oils was to extract the sugar paper strips in asbestos extraction thimbles with petroleum ether, transfer the ether and oil to weighed three and one-half inch flat aluminum dishes and weigh the oil remaining after the ether had evaporated.

Oil loss on the glass plates was determined by washing the oil with ether from the plates through a small filter (to remove dust and lint) into a weighed dish and weigh as with oil from the sheets.

At the end of two weeks, four weeks and eight weeks, the oil remaining on one sheet and one plate was determined and the volatilization calculated.

At conclusion of the first eight week's run a duplicate run was begun to try and learn if the same

results could be obtained a second time. At the present time the second run has only progressed four weeks. Summary of the data obtained up to the present is shown in Table II.

The first series of volatilization determinations were started out-of-doors on April 26, 27 and 28. The roof of the Pharmacy building was chosen as the most convenient place to make the studies. All conditions of the experiment were the same except, of course, the climatic conditions. A thermograph was placed in the cabinet with the oiled sheets and plates to keep an exact temperature record. Poor weather was encountered the first two weeks of the run. The temperature varied from below 42^oF. to over 80^oF. Rain and high wind accompanied the comparatively low temperature. It was hoped that fair weather would prevail so that summer conditions would more nearly be duplicated. A summary of the data taken is shown in Table III.

Swingle and Snapp (16) give a method for determining volatility which they credit to the United States Bureau of Chemistry and Soils as follows:

"Place 20 grams of oil in a three and one-half inch crystallizing dish and heat at 105^oC. for four hours in an electric oven. Reweigh and report loss in weight as percent volatility."

An examination of their data by this method showed that the percentage of oil lost was small. To show greater

TABLE II

DUPLICATE VOLATILIZATION DETERMINATIONS IN CABINET AT 80°F.

No.	Oil	2 Week's Run				4 Week's Run				8 Week's Run	
		Paper Sheets Loss		Glass Plates Loss		Paper Sheets Loss		Glass Plates Loss		Paper Sheets Loss	Glass Plates Loss
		1st Run	2nd Run	1st Run	1st Run						
1	Avon 60	53.7	49.8	68.1	67.3	66.8	68.0	77.0	74.7	80.9	86.2
2	Std #1 Lt.	44.5	47.2		52.2	52.9	56.0	56.9	67.0	71.6	77.7
3	Shell 315	55.7	56.2	69.5	68.3	61.6	60.8	70.8	65.0	74.8	87.0
4	Std. #4 1933	54.0	47.0	67.7	66.8	59.8	62.0	68.0	69.1	73.5	78.0
5	Avon 65	38.8	38.0	57.0	47.1	48.4	53.5	60.8	55.1	62.8	71.9
6	Std. Lt. Med.	38.1	38.4	49.3	46.0	47.2	51.8	57.3	59.3	61.9	66.9
7	Shell 321	44.1	44.5	59.0	55.3	47.9	54.3	61.2	59.6	68.8	71.1
8	Std. Med.	30.0	32.6	47.0	42.8	55.9	43.8	49.7	43.2	48.5	50.1
9	Avon 70	39.1	38.4	54.7	51.5	41.4	44.9	48.4	50.7	57.5	59.3
10	Shell 548	50.5	45.9	68.8	55.9	55.8	57.6	54.1	61.8	66.8	68.6
11	Std. Med. Dup#8)	29.1	29.1	40.9	32.9	38.0	41.9	54.1	51.2	50.6	57.4
12	Std. #6 1933	34.8	35.3	43.2	41.4	40.2	43.6	54.3	50.6	43.0	57.6
13	Shell 322	34.2	35.9	48.3	41.9	41.0	44.5	53.5	50.2	49.6	56.0
14	Cronite Tech.	11.6	14.8	22.3	20.4	18.1	21.6	26.0	26.3	25.0	34.8
15	Shell 315 (Dup#3)	52.4	53.0	66.1	62.7	52.5	58.1	76.3	72.9	72.0	82.0

°Result High

differences in volatility a method was devised whereby 10 grams of Ottawa sand was weighed into three and one-half inch flat aluminum dishes, the dishes plus sand being carefully weighed. One gram of oil was weighed into a small beaker and then washed into the flat aluminum dishes with petroleum ether. When the ether had completely evaporated the dishes were placed in an electric oven at 95°C. The dishes were subsequently weighed at the end of two hours, four hours, eight hours, twenty-four hours and forty-eight hours. Volatilization loss is shown in table IV.

DISCUSSION OF RESULTS

Before going into a discussion of results it is well to restate the purpose of this research. The primary object was to study volatilization of different spray oils by a laboratory method that would determine which oils would be suitable for spray purposes. To be suitable, an oil should be volatile enough not to complicate residue removal and still be heavy enough to give satisfactory pest control. It had previously been determined that the oils studied were sufficiently heavy.

During the 1933 fruit season, pear trees in the vicinity of Medford, Oregon were sprayed with oil spray in addition to lead arsenate at intervals throughout the growing season. Analysis of the pears for lead and

TABLE IV
VOLATILIZATION IN ELECTRIC OVEN AT 95°C.

	Vis- cosity	%Loss 2 Hrs.	%Loss 4 Hrs.	%Loss 8-1/2 Hrs.	%Loss 24 Hrs.	%Loss 48 Hrs.
1. Avon 60	58	24.10	37.50	57.60	87.00	97.00
2. Std. #1 Lt.	59	15.40	25.60	41.40	68.00	84.90
3. Shell 315	55	18.70	31.00	44.50	74.00	85.50
4. Std. #4, 1933	53	27.90	38.60	51.70	69.10	84.70
5. Avon 65	66	18.20	29.00	44.80	68.90	83.60
6. Std. Lt. Med.	63	15.10	24.50	40.90	65.00	79.80
7. Shell 321	63	18.40	29.00	44.60	64.00	72.20
8. Std. Med.	72	12.20	19.40	31.70	54.30	73.00
9. Avon 70	73	11.80	20.30	32.70	55.20	66.30
10. Shell 548	62	20.50	28.90	40.20	57.50	81.30
11. Std. #6, 1933	75	14.70	21.70	30.60	44.80	58.60
12. Shell 322	74	16.50	23.90	35.80	53.30	72.70
13. Oronite Tech		6.00	10.50	16.00	29.90	37.90

arsenic after harvest indicated that oil could be applied as late as one month before harvest and still not complicate lead and arsenic removal. The oils used in these tests were Standard Oil #4, (1933) and Standard Oil #6, (1933). These oils therefore, are used as a basis of comparison for the other oils studied.

VOLATILIZATION STUDIES IN CABINET IN THE LABORATORY

Examination of the data in Table II shows that definite differences in volatility of the different oils are shown by the cabinet method. In all cases the oil on the glass plates showed a greater percentage volatility than the same oil on the sugar paper sheets in a given length of time. Ten to fifteen percent more oil was usually lost. Two explanations may account for this. First, half as much oil was put on the glass as was put on the paper. This would make a thinner film of oil. The other explanation may be that oil is held by adsorption in the pores of the coarse sugar paper. Oil absorbed by the paper can not come in contact with air currents as readily as can oil held right at the surface, consequently less evaporation would take place.

Some inconsistencies are apparent from the data obtained from the glass plates. These are due to errors from several sources, the first being loss of oil from the glass plates by contact with hands in handling the plates

and from insects such as moths and flies flying against the plates. A second source of error is from droplets of oil that may drip from the plates. Dust and lint that adhered to the plates constituted an error in the first cabinet run but this was eliminated by filtering all oil as it was washed from the plates to the dishes when recovered.

After considering the difficulty involved in quantitatively recovering a few centigrams of oil on the plates it is concluded that the use of glass plates as a means of measuring volatility of spray oils is impractical as a laboratory method.

More accurate results were obtained with the sugar paper strips. Using more oil originally, decreased the percent error as did absence of lint and dirt in the dishes into which the extracted oil was washed. Plotting percent volatilization against time in weeks in the case of all oils gave a smooth curve indicating accuracy in analysis. The curves were parabolas. At the end of the first two weeks all light oils showed approximately 50% volatilization, light-medium oils approximately 40% loss and medium oils from 30% to 35% loss. At the end of four weeks approximately 60% of the light oils had evaporated, 50% of the light-medium and 40% of the medium oils had volatilized. Individual differences between oils were more apparent. At the end of eight weeks approximately 75% of the light

oils was lost, 60% of the light-medium and 50% of the medium oils.

It is noticed that a large amount of oil is lost the first two weeks. To learn how rapid evaporation was two oils were run at the end of two day, four days and one week in the cabinet. Results indicated that by the end of the first week the evaporation rate had reached its maximum and from then on volatilization proceeded at a slower and slower pace.

Shell Oil 315 and Standard Oil medium were run in duplicate. In each case results checked closely. At the end of the first eight week's run in the cabinet another complete run was started. At present the run has only progressed four weeks but results indicate that data over the entire run will check that obtained from the first series of determinations.

Oronite Technical, a heavy oil used as a dormant oil showed very low volatility compared with the summer oils, only 35% volatilizing in eight weeks.

The first run out-of-doors was begun on the roof of the Pharmacy building the last of April. Cool rainy weather prevailed the first two weeks of the run resulting in a slower loss of oil. The results shown in Table III can only be considered as preliminary because an entirely new determination will be made in June when summer temperatures prevail.

The data so far obtained however indicate that out-of-door determinations of volatility will give more reliable results than determinations indoors because of the more uniform distribution of temperature and air currents on the sugar paper strips.

As was stated previously Standard Oil #4, (1933) and Standard Oil #6, (1933) are taken as standards of comparison because they have been used in field tests. Successful residue removal resulted when the oils were used as late as one month before harvest. On the basis of comparative results of the volatilization studies made by the cabinet method in the laboratory and out-of-doors it can be concluded that any of the oils studied may be used as late as one month before harvest with the exception of Oronite Technical and possible the Standard medium oil.

DISCUSSION OF RESULTS OBTAINED FROM OVEN METHOD

The cabinet method of determining volatility while satisfactory as a method for evaluating spray oils consumes too much time. A determination taking only a few days to complete is much more desirable.

Table IV summarizes the data obtained by the oven method. The figures are the average of the two nearest determinations of three runs. For some reason not yet clarified only two runs out of three checked each other in the case of the heavier oils. As far as known,

all experimental conditions were the same for each series of determinations.

The results show the same differences between oils of a type as light, light-medium, and medium as do the results from the cabinet method in the laboratory and out-of-doors. The data also show in nearly all cases the same individual differences between oils. Where the correlation between comparative results by the two methods has not been exact it has been close enough for all practical purposes.

A comparison of Table II and Table IV shows one interesting thing, i.e., that the actual percentage of volatilization from the paper sheets at the end of two weeks very closely paralleled that in the oven at the end of eight and one-half hours and that percent volatilization at the end of eight weeks was very similar to that in the oven at the end of twenty four hours.

The preliminary work done on the oven method while not entirely satisfactory, indicates that for ordinary comparisons of spray oils it may supplant the longer cabinet methods. More work is to be done in the future on perfecting the oven method to the point where a series of determinations can be duplicated more closely than they have been up to the present.

The following is a tentative oven method that will

evaluate spray oils as to volatility. It must be remembered that the spray oils should always be compared to oils that have been tested under field conditions.

Accurately weigh 10 grams of fine sand in a weighed three and one-half inch flat aluminum dish. Weigh one gram of oil in a small beaker and wash into the dish with petroleum ether. As soon as the ether has evaporated place the dish in an electric oven at 95°C. At the end of two, four, eight, twenty-four and forty-eight hours remove and weigh. Calculate loss in weight as percent volatility.

CORRELATION OF VOLATILITY WITH VISCOSITY

The results of the volatility determination bear out the statements made in the introduction that viscosity is not necessarily a measure of volatility. Avon 60 with a viscosity of 58 was more volatile under all conditions than was Shell 315 with a viscosity of 55. However in all cases with exception of the one just mentioned, volatility did show a very close positive correlation with viscosity. This indicates that all the oils tested were what is known as "closely cut" oils. Closely cut oils are oils that have not been prepared by blending a very light lubricating oil with a heavy one to get an oil of desired heaviness. They are oils which have been separated by narrow limits during the fractionating process giving an oil of desired specifications without extensive blending.

SUMMARY

1. A brief review of the history, origin and properties of spray oils has been given.
2. Application of oil spray to fruit before harvest complicates residue removal unless the greater part of the oil volatilizes before picking.
3. Two methods for evaluating spray oils as to volatility were worked out. One method consisted of applying a known quantity of oil to sugar paper strips and glass plates and suspending them in a thermostatically controlled constant temperature cabinet in the laboratory. In addition to determining volatility in the laboratory, volatility was determined out-of-doors.
4. Results from the cabinet method show that the use of glass plates to determine volatility was impractical.
5. The use of oil-coated sugar paper strips as a means of determining volatility in the laboratory and out-of-doors has proven to give an accurate means of comparing oils of different volatilities.
6. By field tests on a pear orchard near Medford it was shown that Standard Oil #4 and Standard Oil #6 could be applied as late as one month before harvest and still not complicate residue removal. These oils were chosen as a basis for comparison. Comparing volatility of these oils with that of the other oils tested by the cabinet

method indicated that all of the oils tested with the exception of Oronite Technical and possibly Avon 70 and Standard Oil medium could be applied to pear orchards in the vicinity of Medford one month before harvest without unduly complicating residue removal.

7. A short oven method for determining volatility was devised and the results obtained from it were compared with those obtained with the cabinet method. A close correlation in volatility as determined by the two methods indicated that the oven method can supplant the longer cabinet method as a means of evaluating oils as to volatility.

8. A close correlation between volatility and viscosity of the oils tested was shown to hold.

9. Experimentation is still in progress on the oven method and on the cabinet method out-of-doors and in the laboratory. Sufficient data have been obtained, however, to indicate the value of these methods as a means of evaluating spray oils as to volatility,

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