TESTING WOOD OIL AND WOOD OIL EMULSION

BY

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Introduction

The wood creosote used in this test was supplied by the Tennessee Eastman Corporation. Very little is known about the fungicidal and insecticidal value of wood creosote as only a limited amount of work has been done in this field.

Tar oils have already been proved to be efficient in controlling apple aphis eggs during the dormant season, and have also been used extensively as a wood preservative.

Wood creosote also has great penetrative properties and has been effectively used as a means of protection against termites. The purpose of this project is to extend our knowledge of this material in the fungicidal and insecticidal field.

Acknowledgments

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Historical

The amount of work that has been done with wood creosote as a means of control for insects and diseases is very limited. Therefore, the writer shall confine the majority of his historical information to tar oils, which are somewhat similar to wood oils in regard to toxicity.

Winslow (8) in his book on Commercial Creosotes states that wood tar is produced in a manner somewhat similar to that in which the by-product coal tar is formed. Wood is destructively distilled in retorts, and charcoal is produced, together with gas and a liquid distillate which consists largely of pyroligneous acid and a product called crude tar. The tar and acid are separated by settling and by further distillation. Wood tars are different from coal tars and contain less hydrocarbons.

According to Hurt (3) tar distillate sprays had their origin in Germany, but the first commercial tar oils came into England from Holland in about 1922. This was a Dutch preparation called Carbo-krimp. Since the introduction of tar oil distillates a great many of them have been developed in England and are now in use in that country.

In 1931 Hurt made several applications of tar oils to apple trees for the control of aphis in the egg stage. He compared commercial tar oil spray known as "Barko" with different concentrations of a local tar emulsion made with redistilled tar oil distillate. Two concentrations of stock emulsion were made; namely, a 77 per cent stock and a 68 per cent stock. His results show that where 7 gallons of tar oil was used in each 100 gallons of spray solution of the 68 per cent stock, only 1.5 per cent of the apples were affected by the aphis. Where 5 gallons of Barko was used in each 100 gallons of spray solution 1.4 per cent of the apples were infested by aphis. On the plots where 5 gallons of tar oil emulsion from the 77 per cent stock was applied 9.5 per cent of the apples were damaged by aphis.

Hough (4) in 1931 after investigating the killing properties of thr brought out some very interesting facts where he used 10 gallons of tar oil in each 100 gallons of spray solution, 79 per cent control was obtained against San Jose Scale. Tar distillate "Ovicide" used at the rate of 10 gallons in each 100 gallons of spray solution secured 99 per cent control for the same insect. Strengths below the amount mentioned gave less control. For scurfy scale where 10 gallons of tar distillate Barko was used in each 100 gallons of spray solution resulted in 97 per cent of the scales being killed. With 6 2/3 gallons of tar oil distillate emulsion in each 100 gallons of spray solution, 100 per cent of the solution, 100 per cent of the scales were destroyed.

Workers in the New York Agricultural Experiment Station (2) investigated a number of brands of tar washes and home made emulsions of American creosote as regards to their constitution, effects on insects and toxicity to trees. At proper dilutions these emulsions were effective against rosy aphis, oyster shell scale, San Jose scale and Pear psylla. Tar oil emulsion used at 10 per cent against rosy aphis gave 90 per cent control. Against San Jose scale tar oils gave as good results as lime sulphur when used at 10 per cent. Barko used at

$7\frac{1}{2}$ per cent gave good control of oyster shell scale. Leafroller, plum curculio, apple seed chalcid were not controlled by any of the tar oils used. Mixtures of over 8 per cent were quite destructive to swelling buds. Mixtures of less than 8 per cent tar oils varied in destructiveness to buds according to dillution and variety of apple, but in no instance was the damage severe as regard to the set of fruit.

Discussion of Materials and the Methods used in the Preparation of Wood Creosote

The oils used in the manufacture of wood creosote are formed during the destructive distillation of hardwoods. The main hardwoods used are the oaks, beech, birch, and maple. There are a considerable number of other hardwood trees growing that could be used but the ones mentioned above are principally employed. The materials used in this experiment both base oil and emulsions were as follows;

A. Base oil, Base oil A and B - unemulsified.

B. TEC spray oil Numbers 52, 52A, 115, 117 and 123 - emulsified.

C. TEC termi A and TEC oil No. 5.

D. Heavy wood oil - for banding purposes.

E. Wood creosote oil Number 35.

All the emulsions used in this project were emulsified by the manufacturer.

Process employed in the destructive distillation of woods:

Hardwood Distillation (1)

Most of the hardwood distillation factories now employ similar plants and carry on their processes according to similar operations. Very likely no two factories conduct all their operations in the same way. However, in most cases the end products are calcium acetate, wood alcohol, charcoal, and wood tar oils. The calcium acetate is known as "grey acetate of lime" or "brown acetate of lime" according as the pyroligneous acid from which it is taken is somewhat free from tar. The grey acetate is much the purer of the two. The wood alcohol is a mixture consisting of methyl alcohol, acetone and water, with very small amounts of aldehydes, ketones, and other impurities.

In Figure 1 a flow sheet for the modern hardwood distillation factories is shown. This flow sheet is used mainly by those plants producing charcoal, pyroligneous acid, and wood oils. The wood after being delivered to the factory is stacked for seasoning. After it has thoroughly seasoned, the wood is placed into the retort. The distillation heat is obtained from a furnace, using coal, coke or wood.

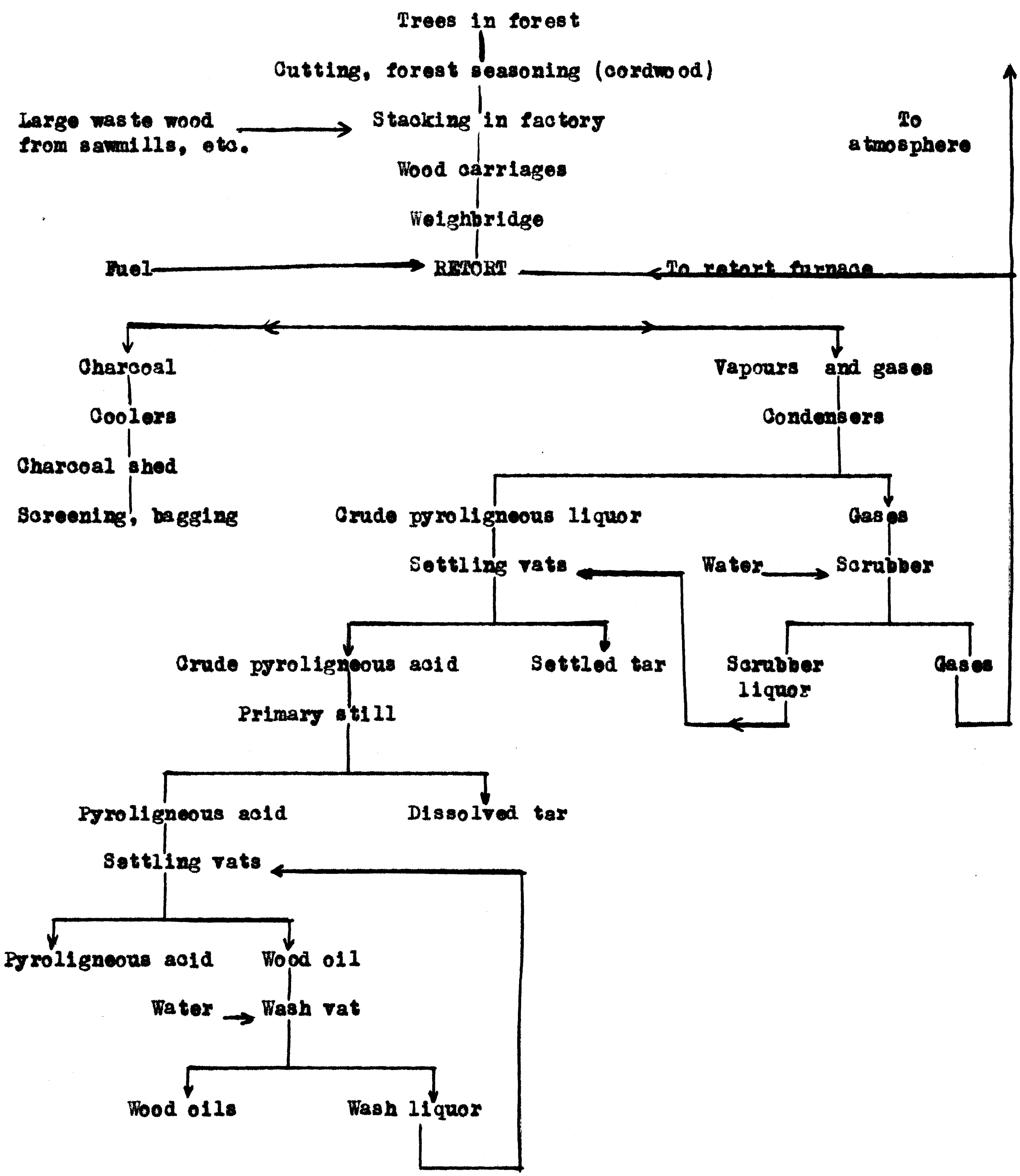

Figure 1.—Flow sheet for hardwood distillation.

The gases and vapors that are secured from the decomposition of the wood pass through watercooled condensers, where the vapors are condensed to crude pyroligneous liquor, which runs into large wooden vats, where it is allowed to settle. The uncondensible gases leave the condenser and are scrubbed to remove vapors of acetic acid, methyl alcohol, and acetone which have escaped from the condenser. The gases are usually burnt in the retort furnace, being by-passed into the air if not required. When the material has settled, the crude pyroligneous liquor has deposited a layer of tar and oils; most of these are drawn off after settling to the bottom. The pyroligneous acid now free from settled tar is distilled. Many types of plants are used for this operation, the main object of which is to remove dissolved tar. The distilled liquor is now nearly free from any form of tar, but on further settling allows the oils to be separated off. The oils and tar often contain slight amounts of acetic acid and methyl alcohol. The tar is subjected to steam distillation and the oils are washed with water. The distillate from the former and the washings from the latter are then added to the settled liquors. The wood oils are worked up separately or added to the tar when the latter is worked up for the manufacture of oils, crude wood creosote, heavy wood oils and pitch. On completing the distillation of the wood, the retort is opened and the charcoal left in the cars is run into the coolers, where it is allowed to cool before being stored.

Figure 1 shows two kinds of tar produced by the distructive distillation of wood; namely, (1) settled tar and (2) dissolved tar. As wood creosote is only made from settled tar, the writer shall confine his discussions to this one type of tar.

Settled tar is usually subjected to a process of distillation for the manufacture of wood oils, wood creosote, pitch, and for the recovery of acetic acid and methyl alcohol. No two factories follow the same plan and there are not any set rules and regulations for the manufacture of these materials. Some factories only produce crude creosote, while others recover only the acetic acid.

The Production of Wood Creosote (1)

When a good quality creosote is desired only the heavy oils, especially those that are collected between 190 and 240^{o}, are employed. A dilute solution of caustic soda is given the oils as a first treatment in a container provided with an agetator, as it is very important to produce through stirring during the process of solution of the phenols. When allowed to stand, a layer of neutral oils separates out on the surface of the alkaline solution. These oils are poured off and the alkaline solution is subjected to a steam distillation to take away any oils that are left, air being passed through the boiling alkaline liquor in order to remove impurities. When the distillate is free from oil, distillation is stopped, the liquor is allowed to cool and is neutralized with dilute sulfuric acid, The phenols are given off in the form of an oil. The oil is washed with water and distilled until only a tarry residue is left in the still. The entire operation just described is repeated twice more. The final oil obtained is then fractionally distilled from a copper still, provided with a short copper plate column and reflux condenser. There are three fractions taken; namely, up to 200°, 200-220°, and 220° upwards. The 200°-220° fraction is a partially refined creosote.

Collecting between narrower temperatures ranges gives a more distinct separation of the individual phenols. The best grades of creosote give a large fraction distilling between 200 and 210°. Hawley suggests on partial solution of the phenols with caustic soda in order to obtain a high quality creosote. Therefore, 400 parts by volume of heavy oils are treated with 500 parts of caustic soda solution of specific 1.06, this amount being able to dissolve about two-fifths of the total phenols present. This being the case about 270 parts of oil remain undissolved. The alkaline liquor is distilled and air blown. The distillation is continued until 250 parts of distillate are obtained, which contains about 10 parts neutral oil. After neutralization, the residue yields about 90 parts of oil, which is washed with an equal volume of water and then redistilled. The distillate is again treated with a sufficient amount of caustic soda to dissolve all the phenols, which is about 280 parts. The same operations are then repeated and this is followed by a third complete treatment. The first distillation should have a maximum temperature of about

235°; in the second 230°, and in the third 220°.

Characteristics of the Wood Oils

Chemically they are a complex mixture of phenals, cresals, guaiacols, xylenols and ethers of pyrogallol. In their crude form they are brownish black in color and have a characteristic, burnt phenalic odor. At 15.6° C the specific gravity varies between 1.060 and 1.090. (6).

Toxicity - poisonous if taken internally but no harmful effects will result by handling the oils.

Moisture Content - Free from water.

Miscibility - Miscible with alcohol and ether but immiscible with water.

Viscosity - 120 seconds at 100° F.

Caustic solubility (indicates phenol content) 46.60%.

Chemical Compounds Associated with Wood Creosote are Listed Below

Alcohols.—Isoamyl and isobutyl alcohol.

Phenols and derivatives.—Phenol, ortho cresol, meta cresol, para cresol, 1:3:4 xylenol, 1:3:5 xylenol, guaiacol, cresol, ethyl guaiacol, propyl guaiacol, dimethyl guaiacol, catechol, methyl catechol dimethyl ether, pyrogallol dimethyl ether, methyl pyrogallol dimethyl ether and propyl pyrogallol dimethyl ether.

Aldehydes.—Propaldehyde and valeraldehyde.

Ketones.—Methyl N-propyl, methyl N-butyl Ketone, diethyl Ketone, cyclopentanone, cyclohexanone, and methyl cycloheptanone.

Acids.—Palmitic, oleic, abietic, arachidic and lignoceric.

Bases.—Beta-methyl pyridine and dimethyl pyridine.

Hydrocarbons.—Benzine toluene, meta-xylene, cumene, cymene, and retene.

Furnans.—Furan, 1 methyl furan, 2 methyl furan, dimethyl furan and tri methyl furan.

Experiments with Wood Oil

Base Oil Applications on Apple Trees

Base oil or crude wood creosote is a very strong unemulsified liquid. In order to determine its effects on the functions of apple trees several applications were made while the trees were in their rest period.

This material was sprayed on six apple trees at full strength during the dormant season in order to determine whether or not it is harmful to the tree tissues. It was applied by means of a compressed air sprayer. Observations made several days after the trees were sprayed indicated some burning where only the trunks were treated. However, where the entire tree was given an application of base oil, more pronounced results were noted. A large majority of the buds were killed and the wood tissues were slightly injured. The rest period of the tree was prolonged, consequently causing blooming to be greatly retarded with those buds that were not actually killed. The following tabulated facts show the effects of base oil on apple trees when examined microscopically.

<u>Treated</u>.—1. Coloring matter absent.

2. Cambium slightly browned.

3. Pith rays and pith somewhat discolored.

4. Phloem slightly colored.

5. Little or no change in starch content.

<u>Untreated</u>.—1. Collenchyma contains reddish coloring matter.

2. Cambium light healthy colored.

3. Pith rays and pith natural (unchanged).

4. Phloem normal color (not browned).

5. Starch storage unchanged.

Base Oil Applications on Peach Trees

The same investigations were carried out with peach as with apple trees. All the applications were made with full strength oil while the plant was in complete dormancy. The conclusions with the peach show even more marked results than does the apple. The buds of the peaches were practically 100% killed and the wood tissue severely injured. This particular oil seems to have great penetrative power and when applied to a tree goes immediately into the tissue. A microscopic examination of the wood resulted in the following observations:

<u>Treated</u>.—1. No coloring matter present.

2. Cambium browned.

3. Pith rays, pith and phloem browned.

4. Starch storage same.

Untreated.—1. Collenchyma contains reddish coloring matter.

2. Cambium light healthy colored.

3. Pith and pith rays unchanged.

4. Phloem and starch storage normal.

Figure 2.—Showing injury caused by full strength base oil when applied to peach trees during the dormant season. Showing contrast between a sprayed and unsprayed peach twig.

These two comparisons between the sprayed and unsprayed trees clearly indicate that base oil has more injurious effects on the functions of tree tissue on the peach than it does on the apple. The very few buds that survived the base oil treatment came out in an exceedingly weakened condition. The blooming period of these buds was greatly retarded.

Creosote Emulsion on Aphis Eggs Sprayed in the Laboratory

Apple twigs containing aphis eggs were collected in the college orchard, taken to the laboratory, and prepared to spray. After the eggs were gathered, they were carefully examined with the aid of binoculars and all injured or dead eggs were removed. The twigs were then cut into lengths of about three or four inches and fastened on cardboard by means of pins. Each board when filled had approximately ten twigs. The eggs were then sprayed with different strengths of creosote and other standard materials used for the control of apple aphis eggs. After the spraying was completed the twigs containing the eggs were placed in the insectary to await hatching. Three different lots of eggs were sprayed at three different times. When hatching was completed the twigs were brought into the laboratory and each twig was carefully examined to determine the number of eggs dead, living and hatching. All the eggs were collected at about the same time but were sprayed at different intervals. Table 1 shows the results of the first lot of aphis eggs sprayed.

Table 1.—Results of first lot of aphis eggs sprayed at Blacksburg, Virginia. 1933.

Spray Used	Sprayed January 23		
	No. eggs Sprayed	No. eggs Hatching	% of eggs Hatching
Taroline 5%	108	8	7.4
Oil 3%, Cresylic acid ½%	111	33	29.7
Lime Sulphur 1-8 Nicotine 1-800	131	2	1.5
2% Creosote	108	13	12.0
5% Creosote	124	7	5.6
8% Creosote	212	2	0.94
12% Creosote	218	6	2.7
Check	203	95	46.7

Both 5 and 8 per cent creosote emulsion gave fairly good control. With 5 per cent we notice 5.6 per cent of the eggs treated hatched. The eggs sprayed with 8 per cent had a much lower hatching percentage which was only 0.94 per cent. These two strengths proved to be the most effective of the creosotes used. The 2 per cent twigs had a rather high hatching percentage in 12 per cent. Of the other materials used only lime sulphur 1-8 combined with nicotine 1-800 gave satisfactory results. This combination had a hatching per cent of only 1.5. Oil 3% and cresylic acid ½% gave the poorest results of the standard materials used by allowing 29.7 per cent of the eggs to hatch.

Table 2.—Results of second lot of aphis eggs sprayed at Blacksburg, Virginia, 1933.

Spray Used	Sprayed February 11 No. eggs Sprayed	No. eggs Hatching	% of eggs Hatching
Taroline	136	6	4.4
Oil 3%, Cresylic acid ½%	134	38	28.3
Lime sulphur 1-8 Nicotine 1-800	112	4	3.5
2% Creosote	106	10	9.4
5% Creosote	159	10	6.2
8% Creosote	139	3	2.1
12% Creosote	118	5	4.2
Emulso 4½%, Base oil 3%	111	16	14.4
Check	96	59	61.4

In Table 2 the results of the second lot of aphis eggs are given. These eggs that were sprayed on the 23rd of February, showed that 8 per cent was the best of the creosotes used. The other creosote sprays, as the table shows, failed to effectively control the hatching of aphis eggs. Of the other materials applied, lime sulphur and nicotine used at the same strength as in Table 1 again proved to be very effective. Taroline used at 5 per cent was not far behind, getting about 96 per cent control, while with lime sulphur and nicotine only 3.5 per cent of the eggs hatched. In this lot of eggs 4½ per cent emulso, a summer oil, was combined with base oil with the result that 14.4 per cent of the eggs sprayed hatched.

The third and last lot of aphis eggs were sprayed on March 23. In this application 8 per cent creosote again proved to be very good, for only 1 per cent of the eggs hatched. Table 3 shows that lime sulphur 1-8 and nicotine 1-800 were effective as no eggs hatched. Emulso 4½ and Base oil 3% were again combined in this lot with practically the same number of eggs hatching as in the same spray of the second lot. A combination of 4½ per cent emulso and 3% cresylic acid was applied and resulted in only 1.6 per cent of eggs hatching. Cresylic acid has often been used as insecticide for the control of aphis eggs during the dormant season. Good results were obtained by its combination with emulso. The checks of all three of the lots were handled in the same manner as the other eggs except they were not sprayed.

Table 3.—Results of third lot of aphis eggs sprayed at Blacksburg, Virginia, 1933.

Spray Used	Sprayed March 3		
	No. eggs Sprayed	No. eggs Hatching	% of eggs Hatching
Taroline	51	0	0.0
Oil 3%, Cresylic acid ½%	82	17	20.7
Lime sulphur 1-8 Nicotine 1-800	71	0	0.0
2% Creosote	85	18	21.0
5% Creosote	64	3	4.6
8% Creosote	96	1	1.0
12% Creosote	76	3	3.9
Emulso 4½%, Base oil 3%	110	16	14.5
Emulso 4½%, Cresylic acid 3%	65	1	1.5
Check	81	45	55.0

Effects of Creosote Emulsion on Oyster Shell Scale.

<u>First application</u>.—Some willow trees very heavily loaded with oyster shell scale were sprayed on two different dates. Table 4 shows the results of the first application which was made on January 30. The twigs that were sprayed were so heavily infested that an accurate count was made practically impossible, therefore, only an estimate could be made. Three different strengths of creosote emulsion, along with lime sulphur 1-8, nicotine 1-800 and oil 3 per cent and cresylic acid ½ per cent were used.

With 2 per cent creosote a majority of the scales were alive. On the 8 per cent trees most of the scales hatched and the larva escaped. With 12 per cent creosote most of the scales were dead with some few living. The nicotine and lime sulphur combinations proved very ineffective, for practically all the scales were alive and healthy when examined. Cresylic acid and oil allowed the scales to hatch and consequently the larva escaped.

Table 4.—Result of one lot of oyster shell scale sprayed at Blacksburg, Virginia. 1933.

Date sprayed	Spray used	Results
January 30	Nicotine 1-800 and lime sulphur 1-8	Alive
	Oil 3%, Cresylic acid ½%	Hatched, larva escaped
	2% Creosote emulsion	Alive
	8% Creosote emulsion	Hatched, larva escaped
	12% Creosote emulsion	Mostly dead, some alive

Second application.—Table 5 gives the results of the second spraying for oyster shell scale. Taroline 5 per cent, and TEC spray oil 52 were used in the place of cresylic acid and creosote emulsion respectively.

The results show that with 2 per cent TEC oil most of the insects hatched with only a very few being killed. On the 5 and 8 per cent trees a large number of the insects were also alive. However, where 12 per cent TEC oil was used much better control was secured. Only a few of the insects were alive with a majority of them being dead. Nicotine-lime sulphur and taroline were not effective in the least. When the twigs were examined almost all of the scales were found to be alive and in a healthy condition.

Table 5.—Results of second lot of oyster shell scales sprayed at Blacksburg, Virginia. 1933.

Date sprayed	Spray used	Results
April 5	Nicotine 1-800 and Lime sulphur 1-8	Many alive
	5% Taroline	Many alive
	2% TEC spray oil 52	Mostly hatched, few dead
	5% TEC spray oil 52	Many alive
	8% TEC spray oil 52	Many alive
	12% TEC spray oil 52	Mostly dead, few alive

Oyster shell scale is very hard to kill with any type of spray material. The insects seem to be able to develop a covering that is impregnable to most liquids. However, when a toxic spray material gets into the scale the insect is usually destroyed. In regard to the materials used in these two tables, it seems that of the creosote products used only 12 per cent proved to be any where near effective. Anything less than this strength allowed a too great a per cent of hatching. Of the other materials used not any of them were effective in controlling scale. In each case the insects were either alive or they hatched and the larva escaped.

Wood Creosote Emulsion on San Jose Scale

Several Pyrus Japonicae or Japanese flowering quince bushes were sprayed with different strengths of creosote to determine its effect on San Jose scale. Due to the exceedingly scarcity of this kind of scale only a very limited amount of work was done. The shrubs that were sprayed were located on the Virginia Polytechnic Institute campus. Table 6 shows that three applications were made and where 2 per cent creosote was used, 89 per cent of the insects were killed. On the 3 per cent bushes, 97 per cent of the scales were found to be dead when examined. A still stronger application was made when 6 per cent emulsion was used and resulted in 97 per cent of the scales being destroyed. On the 3 and 6 per cent bushes the check wood was so heavily infested with scale that the wood failed to live. However, on the 2 per cent shrubs the check wood lived with 31 per cent of the scales being destroyed.

Table 6.—Results of San Jose scale sprayed at Blacksburg, Virginia. 1933.

Date Sprayed	Spray Used	Living Scale	Dead Scale	Per cent Dead
March 18	2% Creosote emulsion	7	61	89.7
Check		24	11	31.4
March 28	3% TEC oil 52	3	138	97.87
Check		Wood died		
March 18	6% Creosote emulsion	1	42	97.67
Check		Wood died		

San Jose scale is somewhat less difficult to control than oyster shell. The coating of the former is not as repulsive to liquid materials as the latter, therefore, much better results are expected. The applications of these creosote materials were made when the plants were coming into foliage. On the 2 per cent shrubs no injury was noted from burning. Where the 3 per cent material was applied some burning was noted as Figure 3 indicates. The amount of burning was not severe enough, however, to cause the plant to be retarded in its growth.

Figure 3.—Pyrus Japonicae leaves showing amount of injury when sprayed with 3% creosote emulsion.

Effect of Wood Creosote on Pear Borer and Trunk Tissue

Effect on Pear borer.

A number of different creosote materials used at full strength were tried on this insect. This particular borer is one that burrows into the trunk or limbs of a tree and eats the wood tissue. In

Table 7, results of a few of the oils applied are tabulated. The bark of the tree was not scraped off. Wherever the bark was removed and the worms exposed, all the borers were killed when covered with any of the materials mentioned in Table 7. The worms throw out a frass material when they bore their way into the bark and wherever this was noticed oil was applied. After these various materials had been put on for some time, the trees were closely examined to determine the number killed. Where the bark was not removed and base oil applied, two larva were found to be living with none dead. TEC oil A when sprayed on under the same conditions killed one with two remaining alive. Number 5 oil destroyed 2 worms with four remaining alive when applied with bark not exposed.

Table 7.—Results of apple trees treated with creosote to kill pear borers, Andrews orchard, Hollins, Virginia. 1933.

Date applied	Material used	Living	Dead	
May 11	Base oil	2		Bark not exposed
	TEC oil A	2	1	" " "
	No. 5 oil	4	2	" " "

These oils did not penetrate very deeply into the trunk tissue. In a large number of cases the worms pupated and escaped after the oils were put on. Where the bark was removed and the larva exposed all the worms were killed, while on the other hand where the bark was not removed a very small number of the larva were destroyed.

Effects on trunk tissue.

A number of applications of these oils were made on trunk tissues not infested with pear borer to determine their effects on the tissue. As far as the writer has been able to observe no detrimental effects resulted where these materials were applied to the trunk tissue only. However, when base oil was applied to the dormant buds as it has been shown resulted in some injury.

Creosote Oil Emulsion on Apple Foliage in the Greenhouse

In order to determine just what strengths of creosote emulsion that could be used on the foliage with a minimum amount of burning several applications were made on apple leaves in the greenhouse. A number of different strengths were used including 1, 2, 3, 4, 6, and 8 per cent. The results of these applications are shown below.

1% - Did not produce burning.

2% - No noticeable burning.

3% - Showed some injury at base of leaves. Small brownish dots were noticed scattered throughout the leaves. The majority of the burning occurred along the midrib toward the base of the leaves.

4% - A large amount of burning along side of leaves and at the tips. Much more injury resulted with this strength than did with 3 per cent.

6% - Considerable burning along outer edge of the leaves. A few very young leaves were browned all over and curled.

8% - Leaves practically killed. All had a dark brown color and were very much distorted. These leaves were so severely damaged that they soon dropped off.

From these results it can be readily seen that any strength above 2 per cent is undesirable and strengths beyond 3 per cent are dangerous. Leaves sprayed with 3 per cent showed some injury but those above this strength produced too much injury to be considered.

Effect of Creosote Emulsion on Apple Foliage

A large group of apple trees were sprayed with different strengths and with different materials to determine its effect on the foliage. All the trees were sprayed with a double action sprayer, capable of producing 400 pounds pressure.

Figure 4—Apple leaves showing amount of burning caused by 2 % TEC oil 52A.

TEC Spray Oil 52A

TEC spray oil 52A was used at 1, 2 and 3 per cent. The trees that were sprayed with 1 per cent did not show any burning whatever. However, with 2 and 3 per cent a very decided amount of injury resulted as Figures 4 and 5 indicate. The 3 per cent solution produced a large amount of injury; on one of the leaves over one-half was completely browned. The damage was less severe with 2 per cent only the tip end shows any appreciable amount of injury.

Figure 5.—Apple leaves showing amount of burning caused by 3% TEC oil 52A.

TEC Spray Oil 52

This material did not produce any injury to the leaves when used at 1 per cent. This group of trees was heavily infested with caterpillars and when the applications of creosote were made the worm development was checked. The 2 per cent trees were slightly damaged by this product but the damage was of no consequence. On the 3 per cent plots a more pronounced amount of injury was produced as

Figure 6 indicates. Where 3 per cent oil emulsion was applied to trees infested with caterpillars, they were completely repelled and were not seen on the trees any more during the season.

Figure 6.—Apple leaves showing the amount of burning caused by TEC spray oil 52 when applied at 3%.

TEC Spray Oil 115

This material which is slightly different from any of the other emulsions used, in that it contains sulphur compounds with 82 per cent total oil, when used at 1 per cent caused only a very slight amount of burning. Where 2 per cent was applied plots showed a considerable amount of injury due to burning. Figure 7 indicates the amount of injury that is produced when trees are sprayed with a 3 per cent solution of this material.

Figure 7.—Apple leaves showing amount of injury caused by burning when sprayed with 3% TEC spray oil 115.

TEC Spray Oil 117

This particular oil emulsion contains copper compounds, combined with a total of 76 per cent oil. Only two strengths were used; namely, 1 and 2 per cent. On the 1 per cent trees, a small amount of injury was caused by burning, however, not enough to cause any serious damage to the plants. Where 2 per cent emulsion was applied, considerable burning resulted. There was more burning than an ordinary apple tree,growing under average conditions, could stand.

Figure 8.—Apple leaves showing amount of burning caused by 3% TEC spray oil 123.

TEC Spray Oil 123

This oil was applied to a group of trees during the latter part of the summer. An application of three different strengths was made. The 1 per cent plot showed only a trace of injury caused by burning. Where 2 per cent was used a few burned leaves were noticed. On the 3 per cent trees a great deal of injury was produced. Figure 8 shows the amount of damage done to the leaves.

Figure 9.—Apple leaves showing amount of injury caused by burning when sprayed with 2% TEC spray oil 123.

TEC Spray Oil 125

This oil, which was applied at the same time as oil 123, was also used at three different strengths. The injury caused by 1 per cent was only very slight but with 2 per cent a more pronounced amount of injury was noticed. Where 3 per cent was used the leaves were severely burned. In Figures 9 and 10 the amounts of burning produced by 2 and 3 per cent TEC spray oil 125 is shown.

Figure 10.—Apple leaves showing amount of burning caused by 3% TEC spray oil 125.

The Effect of Creosote Emulsion on Living Aphis on Foliage

Two mock orange bushes very heavily infested with living aphis were located and sprayed. One was sprayed with 1 per cent, while the other received an application of 2 per cent. This material was applied when the shrubs were in full foliage. The 1 per cent solution killed approximately 50 per cent of the insects with no foliage burning. While 2 per cent destroyed about 95 per cent of the living aphis, but a considerable amount of burning was noticed. This strength was entirely too strong for the plant. The two plants were so heavily loaded with the insects that the majority of the stems were a black mass.

Oil Emulsion on Potato Beetle

Since the potato beetle was one of our most common insects, it was decided to try several different emulsions on this insect to determine its killing power, and to find out whether or not burning would result. Several rows of healthy looking potatoes heavily infested with beetles were selected. Table 8 shows that four different emulsions were used at the same strengths. One type of oil was applied to each row, which was about 150 feet long. As the table indicates these results were not very satisfactory. TEC oil 52A produced some burning of the foliage and did not kill the insects. TEC oil 52, 115 and 117 all showed the same results as did 52A. All of these materials were used at 1 per cent. Anything above this strength is liable to prove very harmful to the plant because of burning. Potatoes seem to be very sensitive to creosote materials, and strengths strong enough to kill the insects would injure the potato plant entirely too much to be of any value for the control of this insect.

Table 8.—Result of potatoes sprayed at Blacksburg, Virginia, 1933.

Date sprayed	Spray used	Strength used	Results
June 8	TEC spray oil 52A	1%	Foliage slightly burned. No insects killed
	TEC spray oil 52	1%	Some burning. No insects killed
	TEC spray oil 117	1%	Slight burning. No change in number of insects present
	TEC spray oil 115	1%	Slight burning. No insects killed

Oil Emulsions on the Mexican Bean Beetle

Wood creosote emulsions were used on beans to secure data on its value as a control measure for the bean beetle. Four different materials were sprayed on the vines using them at strengths of 1, 2, and 3 per cents. All the emulsions were applied by means of a compressed air sprayer when both adults and larva were present. Each row which was about seventy-five feet long was sprayed with one gallon of spray solution.

Table 9.—Results of Beans sprayed at Blacksburg, Virginia, 1933.

Date sprayed	Spray used	Strength used	Results
June 7	TEC spray oil 52A	1%	Leaves severely burned Bean beetle killed
	TEC spray oil 52A	2%	Majority of plants killed
	TEC spray oil 52A	3%	All plants killed
	TEC spray oil 52	1%	Leaves badly burned. Bean beetle killed
	TEC spray oil 52	2%	Majority of plants killed
	TEC spray oil 52	3%	All plants killed
	TEC spray oil 117	1%	Leaves severely burned Bean beetle killed
	TEC spray oil 117	2%	Beans killed
	TEC spray oil 117	3%	Beans killed
	TEC spray oil 115	1%	Severely burned. Bean beetle killed
	TEC spray oil 115	2%	Beans killed
	TEC spray oil 115	3%	Beans killed

In Table 9 the results of these various materials are given. Each strength for different oils produced about the same results.

In the 1 per cent rows the bean beetles were killed but the leaves were severely burned. With 2 per cent most of the plants were killed and with 3 per cent all the plants were destroyed. Therefore, it is not likely that wood creosote can be used as a means of controlling the Mexican bean beetle because of the injury the oil produces to the plant.

The Use of Wood Creosote as a Fungicide

A group of trees that had not been sprayed for several seasons were selected for this experiment. Trees that were known to have been previously infested with frog eye and scab were sprayed with several different emulsions. These applications were made with various strengths usually 1, 2 and 3 per cent. The results of three applications of TEC oil 52A used at the above named strengths show that the control for both scab and frog eye was only very slight. There was a considerable amount of scab and frog eye present, and on comparing these sprayed trees with the unsprayed ones the difference was hardly noticeable. TEC spray oil 115 and 117 when applied to apple trees also failed to control these two diseases. The spring of 1933 was a most favorable season for the development of scab, with plenty of moisture at about the time scab spores began to shoot.

Wood Creosote on Old House Borer

Some joists infested with old house borer (*Hylotrupes bajulus* Linn) were given an application of creosote oil No. 35. The oil was put on damaged wood and also wood that had not been infested. The borers before the oil was applied made a great deal of noise inside the wood tunneling their way through, and after the oil was applied no further noise or damage was noticed. The oil seemed to have penetrated through the wood and either destroyed or repelled the borers, for no further trouble resulted from these wood eating insects.

The Use of Wood Creosote for Banding Purposes

For the past several years banding apple trees for the purpose of combating the spread of the codling moth has proved to be very popular. There are a number of chemically treated bands on the market for this purpose which are definitely known to be effective in killing the worms.

A large number of corrugated bands about three inches wide were treated with heavy wood oil and base oil. These bands were dipped in the oil by the writer and put on apple trees located at different places. In conjunction with these bands chemically treated ones were used to serve as a check. Wherever the bands were used, care was taken that all loose bark be scraped off and that the band be fitted tightly around the trunk of the tree. The results of these bands are given in the following tables:

Table 10—Results of one lot of bands on apple trees for codling moth larva in the Broce Orchard, Blacksburg, Virginia, 1933.

Material bands treated with	No. trees Banded	Date put on	Date removed	No. dead larva	No. living larva	% dead larva
Base oil	4	June 30	Sept. 21	0	2	0.0
Heavy wood oil	7	June 30	Sept. 21	3	2	60.0
Bata-napthol	12	June 30	Sept. 21	13	3	85.0

Table 11.—Results of one lot of bands on apple trees for codling moth larva in the college orchard, Blacksburg, Virginia. 1933.

Material bands treated with	No. trees banded	Date put on	Date removed	No. dead larva	No. living larva	% dead larva
Base oil	2	June 22	Sept. 21	6	3	66.67
Heavy wood oil	2	June 22	Sept. 21	4	2	66.67
Base oil B	3	June 22	Sept. 21	14	2	87.50
Termi A	2	June 22	Sept. 21	15	2	88.24
No. 5 oil	2	June 22	Sept. 21	18	27	40.00

Table 12.—Showing results of one lot of bands on apple trees for codling moth larva in Niningers Orchard, at Cloverdale, Virginia, 1933.

Material bands treated with	No. trees banded	Date put on	Date removed	No. dead larva	No. living larva	% dead larva	Location on tree *
Heavy wood oil	4	Sept. 14	Nov. 22	2	37	5.13	above
Base oil	5	Sept. 14	Nov. 22	17	83	17.00	above
Heavy wood oil	3	Sept. 14	Nov. 22	3	23	11.54	below
Base oil	7	Sept. 14	Nov. 22	13	79	14.13	below
Bata-napthol	4	Sept. 14	Nov. 22	236	2	99.16	

* - Whether above or below chemically treated bata napthol bands.

Table 13.—Showing results of one lot of bands put on apple trees for codling moth larva in the Dove Orchard, Cloverdale, Virginia. 1933.

Material bands treated with	No. trees banded	Date put on	Date removed	No. dead larva	No. living larva	% dead larva	Location on tree*
Heavy wood oil	1	Sept. 14	Nov. 20	1	53	1.85	above
Heavy wood oil	2	Sept. 14	Nov. 20	0	5	0.00	below
Base oil	10	Sept. 14	Nov. 20	4	172	2.27	below
Base oil	5	Sept. 14	Nov. 20	8	118	6.35	above
Bata napthol	1	Sept. 14	Nov. 20	149	71	67.73	

* - Whether above or below chemically treated Bata napthol bands.

Table 14.—Showing results of one lot of bands on apple trees for codling moth larva in Markley's Orchard, Salem, Virginia. 1933.

Material bands treated with	No. trees banded	Date put on	Date removed	No. dead larva	No. living larva	% dead larva	Location on tree*
Heavy wood oil	8	Sept. 14	Nov. 22	0	27	0.0	above
Base oil	46	Sept. 26	Nov. 22	135	1044	11.31	no other bands on tree
Heavy wood oil	32	Sept. 25	Nov. 22	3	228	1.29	no other bands on tree
Base oil	4	Sept. 14	Nov. 22	4	142	2.74	below
Base oil	10	Sept. 14	Nov. 22	0	42	0.0	above
Bata-napthol	6	Septem. 14	Nov. 22	179	5	97.28	below
Bata-napthol	2	Sept. 14	Nov. 22	207	1	99.52	above

* - Whether above or below chemically treated bata-napthol bands.

Table 15.—Results of one lot of bands sprayed in Markley's Orchard for the control of codling moth larva, Salem, Virginia. 1933.

Material bands treated with	No. trees banded	Date put on	Date removed	No. dead larva	No. living larva	% dead larva
Wood creosote No. 35	10	Oct. 24	Dec. 2	365	2	99.46

Figure 11.—Showing burlap band infested with codling moth larva before it was sprayed with creosote oil 35.

These bands which were sprayed with creosote oil No. 35 were made of ordinary burlap sacks. The oil in order to reach the trunk of the tree had to penetrate through three thickness of this sack. Many of the bands were lined with paper. The oil was applied with a compressed air sprayer. The only two insects that survived were located where the oil did not penetrate. Every worm that the oil touched was killed. Where the creosote was applied to the trunk of the tree there was apparently no harmful effects. Figure 11 shows a band infested with codling moth larva before it was sprayed. Some bands in this orchard were found to contain as high as 1500 worms.

General Discussion of Results

The future of wood creosote as a spray material seems to lie in its possibilities as a dormant spray. Very good results were secured when this oil was applied at strengths of 5 and 8 per cent for aphis and 2 and 3 per cent for San Jose scale.

Base oil applied at full strength to apple and peach trees during the dormant season severely damaged the wood tissue.

Creosote emulsions when applied to trees infested with oyster shell scale gave very poor results. Only those trees that were sprayed with 12 per cent gave effective control. A much weaker solution of creosote emulsion was applied on San Jose scale with satisfactory control. This insect is much easier to kill than oyster shell scale.

Various oils applied at full strengths to the bark of apple trees did not satisfactorily control the pear borer. However, when the insects came in contact with the oil they were killed.

All the oil emulsions beyond 1 per cent strength used on apple trees while they were in foliage showed considerable burning. It is very evident that solutions stronger than 1 per cent are undesirable for the foliage sprays.

Oil emulsions of 1 per cent sprayed on potatoes resulted in considerable burning. The insects were not killed. The same emulsions with strengths of 1, 2, and 3 per cent applied to beans caused a large amount of burning. The injury due to burning was so severe on the 2 and 3 per cent rows that it was necessary to replant the entire rows.

Wood creosote sprayed on apple trees to control scab failed to satisfactorily control this disease. The various emulsions used at 1, 2 and 3 per cent did not prevent the development of the disease.

Wood creosote oil showed some merit when it was sprayed on burlap sacks to kill codling moth larva. This oil was very toxic to the worms and destroyed practically 100 per cent of the larva. This same oil when applied to joists infested with old house borers completely checked the advancement of this insect. Before the oil was applied the borers could be heard working inside the wood, but soon stopped their tunneling after wood oil 35 was put on.

Bands treated with creosote oil and when placed on apple trees failed to control codling moth larva.

Conclusions

1. Base oil when applied during the dormant season injured both the buds and the wood tissue.
2. Base oil severely injured both the bark and buds of peach trees when sprayed while dormant.
3. Both 5 and 8 per cent creosote emulsions gave fairly good results when sprayed on aphid eggs during the dormant season.
4. Lime sulphur 1-8 combined with nicotine 1-800 produced the best results of the standard materials used.
5. Only 12 per cent creosote gave anywhere near satisfactory results in controlling oyster shell scale.
6. San Jose scale was effectively controlled with either 2 or 3 per cent.
7. Wood creosote was not effective against pear borer larva when applied to trunk of trees.
8. The creosote applied for Pear Borer did not injure the trunk tissue.
9. The creosote emulsion sprayed on apple foliage in greenhouse above 3 per cent severely burned the leaves.
10. TEC spray oil emulsion sprayed on apple foliage produced some burning.
11. TEC oil at 3 per cent strength caused a considerable amount of injury.
12. Any emulsion above 2 per cent burned the leaves too much to be used as a foliage spray material.

13. Three per cent creosote emulsion effectively controlled living aphis on foliage but severely burned the foliage.

14. Two per cent did not cause burning but only killed about 50 per cent of the living aphis.

15. All oil emulsions used at 1 per cent on potatoes failed to kill the insects and injured the foliage.

16. Oil emulsion sprayed on beans did not control the beetle. Strengths of 1 per cent severely injured the bean foliage.

17. Wood creosote emulsion did not control apple scab or frog eye.

18. Old house borers were effectively eradicated by creosote oil 35.

19. Neither wood oil nor base oil effectively controlled codling moth larva when used to treat bands.

20. Wood oil 35 gave excellent results when sprayed on burlap bands infested with codling moth larva.

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