TESTS TO DETERMINE THE COMMERCIAL VALUE OF WOOD PRESERVATIVES. A PROGRESS REPORT¹

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INTRODUCTION

A list of the various substances that have been used or suggested for preserving timber from decay would embrace many of those known to industrial chemistry. By-products for which no use could be found have generally taken their last stand as possible preservatives of wood. We have had sent to us for tests the condensed fumes of smelters, the waste liquors of pulp plants, the refuse of tanneries, the skimmed milk of creameries, and miscellaneous assortments of compounds under trade names. Many of these have been culled without any test whatever because the claims made for them were manifestly impracticable. Those, however, which appeared meritorious, or about which numerous inquiries from various consumers were received, were admitted to test.

The object of the tests here described is primarily to obtain information on the practical value as wood preservatives of those compounds or chemicals which fall within this latter classification, so that intelligent replies might be given to the various inquiries received. Further, it was thought that such an investigation would show clearly the deficiencies of present practice and pave the way for increasing its efficiency by suggesting lines for original research.

From 40 to 90 per cent., or an average of about 70 per cent., of the total cost of treating wood is in general due to the preservative alone. The most promising field for decreasing the cost, therefore, lies in decreasing the cost of the preservative used. In ordinary treatments with coal-tar creosote it is common practice to inject approximately ten pounds of the oil per cubic foot of wood, although about one-fifth of a pound will prevent fungous growth; in other words, a factor of safety of about fifty applied to the entire volume of wood is used. The safe reduction of this factor offers one of the many interesting problems.

Before undertaking investigations with new compounds, or improved methods of handling the old ones, it was thought best to first collect certain pertinent data which would be of most immediate value and which would broaden the investigator's viewpoint. The tests here described comprise what has

been accomplished thus far and should, therefore, be considered simply as preliminary to the more serious problems involved.

PROPERTIES INVESTIGATED

The practical value of a preservative depends very largely upon the conditions under which it is used, and, as these vary considerably, the investigations must necessarily be broad. With this in view, and with a study of the inquiries received as a basis, the following points were studied in these tests:

1. The important chemical and physical properties of the preservative.
2. The effect of the preservative on the strength of the wood treated with it.
3. The ability of the preservative to penetrate and diffuse through wood.
4. The permanency of the preservative after its injection into wood. This involves a study into its volatility and leachability.
5. The combustibility of the wood treated with the preservative.
6. The toxic efficiency of the preservative in inhibiting the growth of wood-destroying fungi.
7. The corrosive action of the preservative on steel.
8. The effect of the preservative on paint applied to the wood subsequent to treatment.

TABLE I

PIECE NO	SIZE	LATER CUT INTO	
		PIECE NO (MARK)	SIZE
1	1 1/2 x 1 1/2 x 13	1-1	1 1/2 x 1 1/2 x 5
2	"	2-1	"
3	"	3-1	"
4	"	4-1	"
5	"	5-1	"
6	"	6-1	"
7	1 1/2 x 2 x 13	7-1	"
8	"	8-1	"
9	"	9-1	"
10	"	10-1	"
11	1 1/2 x 1 1/2 x 13	11-1	1 1/2 x 1 1/2 x 4
12	"	12-1	"
13	"	13-1	"
14	"	14-1	1 1/2 x 1 1/2 x 6 1/2
		14-2	"

RECUT INTO	
PIECE NO (MARK)	SIZE
14-1-1	1 1/2 x 1 1/2 x 2
14-1-2	"
14-1-3	"
14-2-1	"
14-2-2	"
14-2-3	"

FIGURE I

Since the investigations were started two other groups of inquiries have become apparent; namely, the effect of the preservative as an *electrolyte* and in *contaminating drinking water*. No systematic tests on either have, however, been made, nor any tests which pertain to a special or limited use.

METHODS OF TEST

The methods by which the various tests were conducted will be only briefly described.

Thoroughly air-seasoned eastern hemlock (*Tsuga canadensis* L.) was selected as the wood best suited

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for the tests because of its low inherent resistance to attack, by fungi, its comparative uniformity of treatment, and its accessibility. Only perfectly clear, straight-grained, and uniform material, free from all mechanical and physical defects, was used—this being cut into test pieces $12" \times 13" \times 1\frac{1}{4}"$ and recut as shown in Fig. 1 and Table I.

Chemical and Physical Properties of the Preservatives.—Under this heading were tested, by standard methods, the chemical composition of the preservative, its specific gravity, viscosity, odor, flash, and burning points. In all distillations the apparatus described in *Forest Service Circular 112* was used.

The specific gravity was determined chiefly by a hydrometer or by a Westphal balance. Viscosities were obtained by using the Engler orifice viscosimeter at various temperatures. The flash and burning points were tested by heating the preservative at a rate of 2°C. per minute in an open flash-point tester, passing a small flame over the surface every minute.

Injection of the Preservative.—Pieces Nos. 4, 5, 6, 7, 11, 12, 13, and 14-2 were injected with the preservative. Before injection they were oven-dried at 100°C. , when they were weighed, and impregnated in the cylinder shown in Figure 2. The simplest procedure (Bethell process) was followed. For example: After the wood was placed in the cylinder the preservative was admitted, displacing the air, until the cylinder was completely filled; a hydrostatic pressure of about 50 pounds per square inch was then applied until the desired absorption was obtained, when the specimens were removed and weighed within 24 hours; when necessary higher pressures were used.

Strength Tests.—Pieces 1, 2, 3, 4, 5, and 6, the latter three treated with the preservative, were tested in bending to failure in an ordinary 30,000-pound testing machine, using a center load over a 12-inch span. Care was taken to have all specimens at approximately the same moisture content at the time of test (about 6 per cent).

Penetrance of the Preservative into Wood.—Sticks 4, 5, and 6, after the strength data had been obtained on them, were split and the depth and character of the penetration recorded. This could usually be done visually, but with those preservatives which in aqueous solution were colorless, an aniline dye was used or the specimens were chemically analyzed.¹

The results from these tests were used to supplement those secured from pieces 8, 9, and 10, which were tested in a specially constructed penetrance apparatus (see Fig. 3) operated as follows: A hole, one inch in diameter, was bored in the center of each stick, *E*, to a depth of three-fourths inch. The stick was then raised to a temperature of about 180°F. and clamped between two iron discs, *F* and *F'*, so that the preservative could be forced into the hole under a constant pressure and temperature. For oils, the length of the pressure period was 30 minutes, and for water-soluble salts, 3 minutes, with the exception of sodium silicate, for which the time was

¹ It was found by repeated tests that water and the dye had a tendency to penetrate in some cases slightly farther than the preservative, although the difference was of no practical significance.

prolonged to 30 minutes. The time it took to penetrate the wood longitudinally was noted, after which the specimen was sawed longitudinally and transversely through the center lines and the penetration radially, tangentially, and longitudinally was studied.

Volatilization Tests.—The volatility tests were made on oils only. Within three hours after stick 12 had been impregnated it was recut into three pieces, each $1\frac{1}{4}" \times 1\frac{1}{4}" \times 4"$ in size, weighed separately, and placed in the volatility apparatus (see Fig. 4) which consists of an air-tight, metal box, $15" \times 24" \times 30"$, through which was passed a constant current of air

FIG. 2—IMPREGNATION APPARATUS

previously dehydrated by passing through sulfuric acid. The box was heated to 30°C. by electric lamps, the temperature being automatically controlled within 1°C. The treated specimens were removed and weighed at weekly periods for three months. The loss in weight was taken as representing the amount of the preservative volatilized.

Leaching Tests.—Leaching tests were made on the water-soluble salts only. Within three hours after stick 13 had been impregnated it was recut into three pieces, each $1\frac{1}{4}" \times 1\frac{1}{4}" \times 4"$ in size, and weighed separately. Generally, within 48 hours of impregnation these pieces were submerged in a glass jar containing 300 cc. of distilled water at room temperature; this water was changed at stated intervals and analyzed for the presence of preservative. The total time of leaching was four weeks. To check the amount of the preservative remaining in the wood after the total

submersion, the specimens were shredded and chemically analyzed.

Inflammability Test.—The crib and shavings tests ordinarily used in examining the combustibility of wood were all discarded because of inability to get sufficiently concordant results. This made it necessary to develop original apparatus (see Fig. 5) which consisted of a silica tube, wrapped with nichrome ribbon. An iron tube fitted with a mica sight was cemented below the silica tube.

The specimen of wood, after being lowered in the silica tube, was heated at a uniform rate, by passing twenty-four amperes of electric current through the nichrome ribbon. Temperature readings were obtained from a thermocouple placed beside the specimen

specimens were first air-dried and then oven-dried before ignition. When the preservative was an oil, one inflammability test was made within twenty-four hours after impregnation and another after three months' seasoning in the volatility apparatus.

Toxicity Tests.—Because of the importance of toxicity tests and the inherent objections to various established methods of testing, three methods were followed:

1. Petri-dish method, in which the culture medium was made of juice from one pound of beef, 25 grams Löfflund's malt extract, 20 grams agar-agar, and 1000 cc. of distilled water.

2. The injection of the preservative into wood with a subsequent exposure to an isolated fungus (*Fomes annosus* Fr.) in sterilized jars.

3. The injection of the preservative into wood with subsequent exposure to various fungi in a fungus pit. Only those fungi which were known to attack wood substance were used.

At present, degrees of decay are determined visually. This method permits of too great error due to the personal equation. To overcome this the extent of attack in these tests was determined by noting the loss in weight of the wood after infection and by forcing a steel ball into it before and after decay, recording the force required to sink the ball to its semi-diameter.

Corrosion Tests.—To determine the corrosive action of the preservative on steel a strip of flange steel of the quality specified by the American Society for Testing Materials, August 16, 1909, was submerged in the preservative and heated to a constant temperature of about 98° C. The preservative was changed every week for four weeks in the case of oils; with aqueous solutions it was changed every day for one week. The difference in the weight of the steel before and after submersion was taken to indicate its corrosion. All depositions on the surface of the metal were removed as nearly as possible with a rubber policeman each time the preservative was changed. At the end of the test, where electrolytic deposition of metal had taken place, the deposited metal was removed by acid and its amount determined by an analysis of the acid solution. The deposited metal thus obtained was added to the loss of iron and this total represented the total corrosion.

Paint Tests.—The treated wood was first air-seasoned for about one month and then coated with white paint (30 pounds of lead oxide to one gallon of linseed oil), noting the color change which subsequently took place.

RESULTS

In the following brief summary of results already secured the author wishes to strongly emphasize that they are tentative only and may be changed in view of subsequent tests, as the field covered is new and errors in manipulation, not at present apparent, might exist. Every feasible precaution, however, was taken to avoid errors and when these were uncontrollable they are so mentioned.

Effect of the Preservative on the Strength of Wood (for details see Table III).—As a greater accuracy

FIG. 3—PENETRANCE APPARATUS

and reading direct from a Hoskins pyrometer. A pilot light was used to ignite the gases distilled from the wood. Compressed air partially dehydrated by expansion was passed through the apparatus, its intensity being indicated by a sensitive liquid manometer. Three untreated test specimens were burned as a check against the three treated specimens. When the preservative was a water-soluble salt, the test

TABLE II—CHEMICAL AND PHYSICAL PROPERTIES OF THE PRESERVATIVES

Preservative designated by co-operator as	Specific gravity	Degrees C.	Flash point ° C.	Burning point ° C.	Viscosity (Temperature ° C.)				ODOR	REMARKS
					10	50	30	95		
Coal-tar creosote.....	1.048	60	93	100	3.1	1.7	1.4	1.1	Strong creosote	Graded as "C"
Coal-tar creosote, Frac. 1....	0.934	60	62	69	...	1.1	1.0	0.95	Like toluene	Includes oils distilling between 0-205° C.
Coal-tar creosote, Frac. 2....	1.003	60	79	85	..	..	..	1.0	Strong like naphthalene	Includes oils distilling between 205-250° C. Solid at room temperature
Coal-tar creosote, Frac. 3....	1.045	60	103	110	2.45	1.4	1.2	1.1	Strong coal-tar creosote	Includes oils distilling between 250-295° C.
Coal-tar creosote, Frac. 4....	1.088	60	130	136	...	..	1.51	1.11	Mild coal-tar creosote	Includes oils distilling between 295-320° C. Would not flow at 30° C.
Coal-tar creosote, Frac. 5....	1.150	60	172	178	...	..	80.0	2.6	Mild coal-tar creosote	Includes residue above 320° C.
S. P. F. carbolineum.....	1.127	16	133	157	...	4.4	2.3	1.25	Tarry (mild)	These compounds are similar in many respects. Their exact composition was not determined
Avenarius carbolineum.....	1.126	16.5	139	166	...	7.5	2.4	1.25	Tarry	
C. A. Wood preserver	...	..	...	...	...	...	...	...		
Hardwood tar	1.195	60	90	*	...	17.5**	6.3**	1.4**	Disagreeable pyroligneous	* Water boiled off preventing burning
Wood creosote (Douglas fir)	1.052	60	45	85	...	15.2	4.9	1.4	Disagreeable pyroligneous	** Viscosity orifice viscosimeter
1.07 oil.....	1.058	60	48	65	16.0	3.7	2.0	1.2	Like kerosene	This resembled a tar more than a "creosote"
Timber-asphalt.....	1.063	60	240	260	...	..	99.2	5.2	Like crude oil	A water-gas-tar product
Copperized oil.....	0.937	25	125	164	...	18.0	5.1	1.5	Like crude oil (mild)	A residuum of petroleum
Fuel oil.....	0.87	60	72	101	2.8	1.57	1.3	1.1	Like crude oil (strong)	Contains 0.34% copper
Zinc chloride.....	1.028	20	...	...	Same as water				Odorless	A crude petroleum
Zinc sulfate.....	1.033	20	...	...	Same as water				Odorless	Contained 2.67% ZnCl ₂
Zinc sulfate (by-product)....	1.040	20	...	...	Same as water				Odorless	Contained 5.9% ZnSO ₄ ·7H ₂ O
Sapwood antiseptic.....	1.027	20	...	...	Same as water				Odorless	Contained 6.8% ZnSO ₄ ·7H ₂ O
B. M. preservative.....	1.025	20	...	...	Same as water				Odorless	Contained 2.92% NaCl
Sodium silicate.....	1.074	20	...	...	Same as water				Odorless	Contained 0.246% CaSO ₄
Sodium fluoride.....	1.009	20	...	...	Same as water				Odorless	Contained 0.246% ZnSO ₄ ·7H ₂ O
Cresol calcium.....	1.075	20	...	...	Same as water				Odorless	Contained 0.182% CuSO ₄ ·5H ₂ O
										Contained 0.06% FeSO ₄ ·4H ₂ O
										Contained 0.93% Al. sulfate
										Contained 1.8% ZnCl ₂
										Contained 8.9% sodium silicate
										Contained 1.2% sodium fluoride
										2.43% cresol calcium solution

than plus or minus ten per cent. could not be obtained in these tests, largely because of variables inherent in wood, the following conclusions should be interpreted liberally:

FIG. 4—VOLATILITY APPARATUS

1. All of the preserving oils, *viz.*, coal-tar creosote, hardwood tar, wood creosote, 1.07 oil, and copperized oil, produced, *per se*, no appreciable weakening in

the strength of the wood impregnated with them. The increases in strength noted in some cases were probably due to a lower moisture content in the treated specimens at the time of test. The amount of moisture which they contained could not be definitely determined although it is believed to be below six per cent.

2. In general, the water-soluble preservatives caused a slight weakening of the seasoned wood. This was most pronounced in the case of sodium silicate and by-product zinc sulfate. The values given for the effect of these preservatives are accentuated, due to the higher moisture content of the treated pieces. The application of a moisture correction factor would probably show that with the exception of sodium silicate and by-product zinc sulfate the weakening caused by these water-soluble preservatives is of no practical significance.

3. The following preservatives, so far as penetrance is concerned, can be considered satisfactory: coal-tar creosote, S. P. F. and Avenarius carbolineums, 1.07 oil, copperized oil, zinc chloride, zinc sulfate, cresol calcium, B. M. preservative, and sodium fluoride.

4. The "creosote" from Douglas fir was very difficult to force through hemlock, being about twice as resistant as coal-tar creosote.

5. Satisfactory penetrations with hardwood tar, timber-asphalt, and sodium silicate were not secured. The results indicated that they are from six to eighteen times as resistant to impregnation as the preservatives mentioned in conclusion (3).

Penetrance of the Preservative into Wood (for details see Table III).

TABLE III—PENETRANCE OF THE PRESERVATIVES AND THEIR EFFECT ON THE STRENGTH OF WOOD

Preservative designated by co-operator as	PENETRATION				Average absorption of preservative Lbs. per cu. ft.	Strength in per cent of modulus of rupture of untreated wood	Moisture at test	
	Rad. and Tang.		Long(a)				Untreated	Treated
	Max.	Min.	Max.	Min.				
	In.	In.	In.	In.				
Coal-tar creosote.....	0.28	0.23	6.0	5.3	8.76	93	6.2	..
S. P. F. carbolineum.....	0.37	0.23	6.0	5.7	8.83	...	..	..
Avenarius carbolineum.....	0.17	0.12	6.0	5.3	8.08	109	6.81	..
Hardwood tar.....	0.03	0.03	0.92	0.50	6.50	98	6.11	..
Creosote (Douglas fir).....	0.08	0.08	3.58	2.33	2.82	107	5.8	..
1.07 oil.....	0.10	0.10	6.0	3.33	9.58	108	4.52	..
Timber-asphalt.....	0.02	0.02	0.33	0.33	5.68	106	6.68	..
Copperized oil.....	0.22	0.22	6.0	4.08	8.58	101	5.49	..
Zinc chloride.....	0.10	0.083	6.0	5.3	0.43(b)	88	7.13	9.35
Zinc sulfate (by-product).....	0.25	0.17	6.0	4.66	1.11(c)	82	3.88	5.77
Zinc sulfate.....	0.10	0.08	6.0	4.66	0.96(c)	89	5.14	9.6
Cresol calcium.....	0.10	0.10	6.0	3.30	0.46	103	5.72	6.58
B. M. preservative....	0.13	0.10	6.0	4.6	0.50(c)	85	5.16	9.48
Sodium silicate.....	0.05	0.03	0.46	0.30	0.99	82	6.42	7.38
Sodium fluoride.....	0.10	0.10	6.0	5.00	0.20	85	5.82	8.7

(a) A penetration of 6 inches was the maximum that could be secured. The absorptions here given have no reference to the data on penetrance.

(b) Dry salt. (c) For composition, see Table II.

Permanence of the Preservative after Injection into Wood (for details see Table IV).

TABLE IV—PERMANENCE OF THE PRESERVATIVE AFTER INJECTION INTO WOOD

Preservative designated by co-operator as	LEACHING					VOLATILITY						
	Per cent dry salt leached after immersion in water for					Per cent volatilized after seasoning for						
	5 days	10 days	15 days	20 days	30 days	10 days	20 days	30 days	50 days	70 days	90 days	
Coal-tar ¹ creosote.....	..	..	..	..	..	13	20	24	28	30	32	
Coal-tar creosote, Frac. 1(a).....	..	..	..	..	..	13	21	26	32	36	..	
Coal-tar creosote, Frac. 2(a).....	..	..	..	..	..	8	12	16	20	22	..	
Coal-tar creosote, Frac. 3(a).....	..	..	..	..	..	7	10	12	15	17	..	
Coal-tar creosote, Frac. 4(a).....	..	..	..	..	..	3	4	4.5	5.0	..	..	
Coal-tar creosote, Frac. 5(a).....	..	..	..	..	..	1.8	2.5	3.0	4.0	..	..	
Hardwood tar.....	..	..	..	..	..	11	12	13	19	20	22	
Wood creosote (Douglas fir).....	..	..	..	..	..	11	11	17	19	20	28	
1.07 oil.....	..	..	..	..	..	11	8	11	12	14	18	
Copperized oil.....	..	..	..	..	..	1	2	4	6	9	11	
Zinc chloride.....	46	54	57	60	62	..	..	..	..	..	..	
Zinc sulfate.....	42	50	53	56	59	..	..	..	..	..	..	
Zinc sulfate (by-product).....	47	57	63	65	68	..	..	..	..	..	..	
Cresol calcium(b).....	21	26	28	31	33	..	..	..	..	..	..	
B. M. preservative(c).....	43	47	51	54	57	..	..	..	..	..	..	

(a) The volatility of these fractions are comparable only to each other. Their volatilization should not be compared with that of the other preservatives. For absorption of preservative, see Table III.

(b) Percentage of calcium; cresols not determined.

(c) Percentage of zinc chloride only.

6. After three months' exposure about one-third of the coal-tar creosote injected into the test specimens had volatilized. This was about 4 per cent more than for creosote from Douglas fir, 10 per cent more than for hardwood tar, 14 per cent more than for 1.07 oil, and 21 per cent more than for copperized oil, tested under similar conditions.

7. After one month's leaching, nearly two-thirds of the zinc chloride injected into the wood had leached. This loss was 38 per cent greater than the amount of coal-tar creosote which volatilized during the same period. It should be noted, however, that the test

for leaching was much more severe than the test for volatilization.

8. The volatility of coal-tar creosote fractions was proportional to their distillation. Fractions with low ranges, *ceteris paribus*, are less stable than those with high. At the end of one month the lowest had lost about eight times as much as the highest.

Effect of the Preservative on the Combustibility of Wood (for details see Table V).

TABLE V—INFLAMMABILITY OF TREATED WOOD

Preservative designated by co-operator as	Temperature of ignition C.		Loss in weight due to burning calculated in % of weight before ignition		CHARACTER OF COMBUSTION
	Days after impregnation		Days seasoned		
	2	90	2	90	
Untreated wood.....	320	...	29	..	Burned freely
Coal-tar creosote.....	173	216	40	27	Burned freely, black smoke, easily extinguished
S.P.F. carbolineum..	243	...	26	..	Burned like coal-tar creosote but not so freely
Avenarius carbolin- eum.....	213	...	32	..	Burned like coal-tar creosote but not so freely
Hardwood tar.....	190	241	29	30	Burned freely, dense black smoke
Wood creosote (Douglas fir).....	167	217	36	26	Burned like coal-tar creosote
1.07 oil.....	231	243	40	31	Burned like Avenarius carbolineum
Timber-asphalt.....	296	...	28	..	Did not burn freely
Copperized oil.....	200	228	43	33	Burned like coal-tar creosote
Zinc chloride.....		287(a)	..	19	Hard to ignite, burned poorly, easily extinguished
Zinc sulfate.....		304(a)	..	18	Hard to ignite, burned poorly, easily extinguished
Zinc sulfate (by-product).....		298(a)	..	15	Hard to ignite, burned poorly, easily extinguished
Cresol calcium.....		288(a)	..	29	Burned freely, white smoke, hard to extinguish
B. M. preservative.....		305(a)	..	18	More difficult to burn than zinc chloride
Sodium silicate.....		309(a)	..	10	More difficult to burn than B. M. preservative
Sodium fluoride.....		303(a)	..	25	Burned like zinc chloride

(a) Woods treated with salts were ignited as soon as their moisture content was reduced by air seasoning to 6%, usually about two weeks after impregnation. For absorption of preservative, see Table III.

NOTE.—All salts burned for less than three minutes. All oils burned for three minutes and were then extinguished.

9. Wood treated with the oils in every case ignited at lower temperatures than untreated wood. When permitted to air-season for three months the temperature of ignition was considerably raised, due probably to the evaporation of the more volatile constituents. The loss in weight from burning treated wood seasoned for three months was also less than in the specimens burned shortly after impregnation (exception—hardwood tar).

10. In general, wood treated with the water-soluble preservatives ignited at higher temperatures than wood treated with oils, although the temperature of ignition was lower than the untreated wood.¹ Furthermore, wood treated with the water-soluble salts showed in general a less loss in weight after combustion.

¹ Wood dipped in a 50 per cent. sodium silicate solution ignited at a temperature of 448° C. and its weight was reduced 17 per cent, although it immediately extinguished when dropped in the lower chamber of the inflammability apparatus.

tion than those treated with the oils. It should be noted, however, that the amount of wood actually burned may have been greater than in the case of oils.

11. Untreated wood and wood treated with oils (exception—timber-asphalt) burned freely and in gen-

FIG. 5—INFLAMMABILITY APPARATUS

eral had to be extinguished after a 3-minute period, while wood treated with water-soluble salts (exception—cresol calcium) burned slowly and became extinguished in less than three minutes.

Toxic Efficiency of the Preservative in Inhibiting Fungous Growth (for details see Table VI).

TABLE VI—TOXICITY OF PRESERVATIVES

(As determined by the Petri-dish method against *Fomes Annosus*, Fr.)
0 = no growth. 1 = slight growth. 2 = retarded growth. 3 = strong growth

PER CENT OF PRESERVATIVE	PRESERVATIVES DESIGNATED BY CO-OPERATOR AS													
	Coal-tar creosote, Fraction 1	Coal-tar creosote, Fraction 2	Coal-tar creosote, Fraction 3	Coal-tar creosote, Fraction 4	Coal-tar creosote, Fraction 5	P. F. carbolineum	Avenarius carbolineum	Hardwood tar	Wood creosote (Douglas fir)	1.07 oil	Timber-asphalt	Copperized oil	Fuel oil	Zinc chloride
0.2	1	2(a)	0	1	1	2	2	2	2	3	3	3	3	3
0.4	0	0	0	0	0	2	1	1	2	3	3	3	3	3
0.6	..	..	..	..	..	2	0	0	..	3	3	3	3	3
0.8	..	..	..	..	..	2	..	..	..	3	3	3	3	3
1.0	..	..	..	..	..	2	..	..	..	3	3	3	3	3
2.0	..	..	..	..	..	2	..	..	..	3	..	3	..	3
3.0	..	..	..	..	..	2	..	..	..	3	..	3	..	3
4.0	..	..	..	..	..	..	..	..	..	..	..	..	..	3
5.0	..	..	..	..	..	..	..	..	..	..	..	..	..	3(b)

(a) Creosote, Fraction 1, is so volatile that concordant results are difficult to obtain. At the close of the experiment it is probable that much of the preservative had evaporated from the medium—which may account for the low toxicity indicated.

(b) Slight growth at 75 per cent.

The following tentative conclusions on the toxicity of the various preservatives may be drawn, although the author wishes to emphasize that they should not as yet be considered final, due to errors peculiar to the Petri-dish method.

12. Zinc chloride and coal-tar creosote offered about the same resistance to the growth of a wood-destroying fungus.

13. The toxicities of the coal-tar creosote fractions distilling below 320° C. were quite similar to each other and to coal-tar creosote.

14. Those portions of coal-tar creosote distilling above 320° C. were but slightly toxic, being at least fifteen times less resistant than the creosote itself.

15. The toxicity of preservatives designated as S. P. F. and Avenarius carbolineums was quite similar, being somewhat less than that for the coal-tar creosote tested.

16. Preservatives designated as 1.07 oil, timber-asphalt, copperized oil, fuel oil, and sapwood antiseptic all had no effect in inhibiting fungous growth up to concentrations of at least one per cent.

The methods of determining toxicity by pure-culture-jar and fungus-pit tests have, up to this writing, not progressed sufficiently far to yield definite results.

Although too few determinations have been made to date to draw final conclusions, nevertheless those which have been made indicate that the ball test should prove highly valuable in determining mechanically the extent of decay in wood.

Corrosive Action of the Preservative on Flange Steel (for details see Table VII).

TABLE VII—CORROSIVE ACTION OF THE PRESERVATIVE

PRESERVATIVE DESIGNATED BY CO-OPERATOR AS	LOSS IN WEIGHT (GRAMS) OF FLANGE STEEL AFTER IMMERSION IN PRESERVATIVE AT 98° C. FOR	
	3 weeks	4 weeks
Coal-tar creosote.....	0.0064	
Coal-tar creosote, Frac. 1.....	0.0000	0.0008
Coal-tar creosote, Frac. 2.....	0.0389	0.0401
Coal-tar creosote, Frac. 3.....	0.0063	0.0467
Coal-tar creosote, Frac. 4.....	0.0313	0.0296
Coal-tar creosote, Frac. 5.....	0.0005	0.0015
Avenarius carbolineum.....	0.0807	0.0951
Hardwood tar.....	8.2629	11.2350
Wood creosote (Douglas fir).....	5.0989	
Spiritine.....	1.2938	1.5029
1.07 oil.....	0.0243	
Timber-asphalt.....	0.2222	
Copperized oil.....	0.0096	
Fuel oil.....	0.0012	0.0062
Zinc chloride.....	1.4636	
Zinc sulfate(a).....	0.6050	
Zinc sulfate(b) (by-product).....	1.3809	
B. M. preservative.....	3.1660	4.1746
Sodium fluoride.....	0.1256	0.1588
Cresol calcium.....	0.0139	0.0181

(a) Equivalent to 2.1% zinc chloride solution.

(b) Equivalent to 6.2% zinc chloride solution.

For concentration of salt solutions used, see Table II.

17. Of the various preservatives tested, coal-tar creosote and copperized oil had the least deleterious effect on steel and their action in practical operations can very probably be neglected.

18. All the metallic salts were much more pronounced in their action than coal-tar creosote, so that the

depreciation in plants using them would, unless precautionary measures were taken, be greater.

19. The very marked corrosion of hardwood tar and creosote from Douglas fir is probably due to the comparatively large amount of acetic acid which they contain.

Discoloration of Painted Wood (for details see Table VIII).

TABLE VIII—DISCOLORATION OF PAINTED WOOD	
PRESERVATIVE DESIGNATED BY CO-OPERATOR AS	CONDITION OF PAINTED SURFACE AFTER EXPOSURE FOR ONE MONTH
Coal-tar creosote	Very badly discolored and paint not dry
Hardwood tar	Very badly discolored and paint not dry
Wood creosote (Douglas fir)	Very badly discolored and paint not dry
1.07 oil	Very badly discolored and paint not dry
Copperized oil	Discolored, paint somewhat sticky
Zinc chloride	Appearance similar to the untreated specimen
Zinc sulfate (by-product)	Appearance similar to the untreated specimen
Zinc sulfate	Appearance similar to the untreated specimen
B. M. preservative	Appearance similar to the untreated specimen
Sodium fluoride	Appearance similar to the untreated specimen

20. All of the oils tested rendered the wood unfit for subsequent painting. Copperized oil was least objectionable in this respect. If thoroughly dried after treatment so that excess oil would not appear on the surface, it is possible that wood treated with some of these preservatives could be satisfactorily painted with dark pigments.

21. The water-soluble salts were all satisfactory in that they caused no discoloration of the painted surface. If used under conditions where the wood is subjected to moist air, none of these preservatives might prove commercially satisfactory.

CONCLUSIONS

The depth to which oils can be impregnated varies as some inverse function of the viscosity. As temperature strongly influences the viscosity of oils, and as the diffusion of the preservative through the wood is one of the most important factors in proper treatment, it is concluded that to secure best results both the wood and the preservative should be heated to the proper temperature during the pressure period. Because of the low thermal conductivity of wood, the treatments should not be made too rapidly. With water-soluble salts these precautions are not important.

With coal-tar creosote it appears that the fractions of greatest stability are the least toxic. Present practice rather favors the retention in treated wood of the more volatile fractions by an admixture of the more stable ones. If the toxic values here given are correct, there is in practice being forced into wood about two and one-half times as much zinc chloride and fifty times as much coal-tar creosote as is necessary to prevent decay. It is concluded therefore, that more economic results against decay, especially when it is accompanied by mechanical deterioration, can be secured by diffusing the preservative more thoroughly through the wood than by saturating the outer fibers and attempting to retain in the wood the volatile constituents through admixtures of non-volatile constituents.

In general, the flash or burning point of an oil affects the inflammability of wood treated with it.

Of greater importance, however, is the length of time the treated wood has seasoned, as a prolonged seasoning of such wood raises considerably its ignition temperature. It is concluded that it would be good practice to first season such treated timber before placing it in positions subject to fire. While wood treated with the water-soluble salts mentioned in these tests was in general less difficult to ignite than untreated wood, nevertheless the presence of such preservatives almost invariably renders the wood slow burning and easily extinguishable.

FOREST PRODUCTS LABORATORY
MADISON, WISCONSIN

THE MENHADEN INDUSTRY¹

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HISTORICAL

The fish scrap industry may be said to have had its inception even before the advent of white settlers on the American continent. While the industry as such did not exist at that early date, practices were in vogue which led directly to that industry. Reference is had here to the customs which existed among the American Indians of New England of fertilizing their crops by means of fish. It is stated that for fertilizing corn, one or two fish were placed in each corn hill. This practice was adopted by the colonists, and extended to the scattering of fish broadcast over the fields. In later years, where the latter was carried to an extreme, it was found that the practice resulted in serious detriment to the soil because of the accumulation therein of the undecomposed oil from the fish. Later, it was found that the oil could be easily removed from the fish without impairing their usefulness for fertilizer purposes. This was accomplished by placing the fish in hogsheads or barrels, covering with water, compressing with weighted boards, and allowing to stand for the putrefaction of the fish to release the oils. The oil rose to the surface and was skimmed off. The residue was spread upon the land. The oil thus obtained was put to various uses in the domestic enterprises of the farms. It was soon found that cooking the fish released the oil as effectually as disintegration through putrefaction, and very much more quickly and less offensively.

For the farmers living near the shore it became a part of the year's routine to prepare fish scrap and, incidentally, oil for the year's supply. As the spring was regarded as the best time for the application of this fertilizer, a few weeks of the spring were devoted to fishing and rendering. The apparatus necessary, seines and pots, were often owned and operated in common.

In time, pot-cooking was superseded by the adoption of steam cookers; the first factory for cooking by steam was a small one put up near Portsmouth, Rhode Island, in 1841.²

"In 1850 Daniel Wells built a factory on Shelter Island, New York. That was the first factory of con-

¹ Published by permission of the Secretary of Agriculture.

² Stevenson, "Aquatic Products in Arts and Industries," U. S. Fish Comm., Ann. Rept., 1902, 256.