A scheme has been devised for the approximate calculation of the percentage formation of hydrocarbons of the aromatic series, boiling below 150°. The assumption has been made that the average gravity of the mixed aromatics benzene, toluene and the three xylenes is 0.875. This figure is undoubtedly very near the true value and is justified by the results obtained through its use. By studying some results of a previous paper¹ it was learned that with the methods of distillation here employed the average specific gravities of 150° distillation cuts of uncracked oils are as follows:

Pennsylvania	Oklahoma	California	Mexican
0.721	0.734	0.742	0.759

Using these figures in connection with a value of 0.875 for the mixed aromatics a series of calculations was conducted and values obtained for the percentage formation of low-boiling aromatic hydrocarbons.

The following example is typical of one of the less favorable runs. For a California (Kern River) oil, cracked at 600° and 12 atmospheres the percentage recovery was 52.5 per cent and this oil gave below 150° a 22.5 per cent distillation cut of gravity 0.842. The last figure, according to the scheme indicated above represents a mixture containing 75 per cent of the aromatics. The total aromatic formation was therefore $75 \times 22.5 \times 52.5$ per cent or 8.3 per cent on the basis of the original oil.

Figures obtained in this way are shown in Table IV and again there appears an excellent agreement among the different original oils. The variations are moderate and are not characteristic. In consideration of the several approximations and the inherent experimental errors the agreement may be considered as striking. Again there is proof that the conditions of treatment are of such importance that any original tendencies on the parts of the oils used are rendered of negligible importance.

It will be noted from the average figures for low-boiling aromatics in Table IV, that most favorable conditions for the formation of benzene, toluene and xylenes seem to be 600° and above and at pressures greater than 4 atmospheres.

SUMMARY

Results of experiments here described have indicated the following conclusions:

I—Equilibrium products of the cracking reaction seem to be independent of the influence of chemical and physical properties of the original oils or at most are affected only in minor degree by such tendencies. The matter of carbon formation is the one clear-cut exception. Carbon is a residual product and its formation is proportional to the amount originally contained in the oil. Viscosities and specific gravities seem to show in slight degree the influence of properties of original oils but the differences are so slight that they may well be explained on the basis of failure to reach complete equilibrium.

II—The formation of aromatic hydrocarbons occurs best at moderate to high temperatures and under high pressure.

III—The formation of gasoline (low-boiling, low

gravity hydrocarbons) is favored by moderate to low temperatures and by high pressure.

IV—The results obtained by the series of laboratory experiments indicate striking commercial possibilities.

The experimental work connected with this paper was carried out in the laboratories of the Department of Industrial Chemistry of Columbia University, New York.

CHEMICAL SECTION OF PETROLEUM DIVISION
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A QUANTITATIVE METHOD FOR THE DETERMINATION OF THE ADULTERATION IN CHINESE WOOD OIL¹

By J. C. BRIER

Received October 5, 1915

Examination of a large number of shipments of Chinese wood oil extending over a period of several years, each shipment being checked against its behavior in the varnish kettle, has convinced the writer that the advocated methods of testing Chinese wood oil, while affording valuable indications in certain cases, can be used with any degree of accuracy only on grossly adulterated oils.

Hoffman² reports that the adulteration of wood oil with foreign oils was very common in China in former years and that the oils, pressed in China, hardly ever reached the market in a pure state. According to him, oil from the kernel of the vegetable tallow seed, especially, was employed for the fraudulent blending of wood oil. Boughton³ states that Chinese wood oil is frequently adulterated with soya bean oil. From numerous inquiries the writer believes that the larger amount of intentional adulteration is confined to the use of these two oils, but that frequent accidental adulteration happens with ground nut oil, sesame oil, and occasionally, with tea seed and perilla oils. Importers, who are familiar with the production of Chinese wood oil and the various stages and methods of its transportation until barreled ready for export, have informed the writer that adulteration, although not nearly as prevalent as at the time at which Hoffman wrote, is still exceedingly common.

It is well known that the oil is obtained from a large number of small producers by the middlemen or merchants, who transport it in baskets made of bamboo lined with oiled paper (the average capacity of these baskets being approximately 17 gallons). The native boats, which transport the oil to the export markets, frequently carry mixed cargoes of the oils occurring in that section of China where Chinese wood oil is produced. The frail baskets being piled on top of each other often become leaky, thus allowing the oils from the upper baskets to contaminate the contents in the others. Then, too, the oils that drip on the floor are collected and distributed among the various baskets throughout the cargo. Such cases as those just cited make it difficult for the Chinese wood oil importers to be sure as to the purity of the oil they are buying,

¹ This method was developed in collaboration with Dr. C. D. Holley in the Research Laboratory of the Acme White Lead and Color Works.

² *Seifensieder-Zeit.*, **35** (1908), 169.

³ *Drugs, Oils and Paints*, **29**, 252-256.

¹ Rittman and Egloff, *THIS JOURNAL*, **7** (1915), 578.

since the methods of detecting adulteration are so unsatisfactory.

The demand for Chinese wood oil for the manufacture of varnishes has increased very rapidly during recent years owing to the fact that with certain gums, as well as rosin, this oil, when properly manipulated, gives a very high-grade product for certain uses. Since slight variations in the purity of the oil affect the finished product it is necessary that the varnish maker have a uniform grade of oil, otherwise every shipment will mean an experimental batch.

METHODS OF EXAMINATION

The oldest method for testing Chinese wood oil is the practical kettle test. This, however, is hardly feasible when one considers that large plants use from 100 to 300 or more barrels per month.

The methods of Bacon, Worstall, Potsdammer, Browne and others,¹ are based on the well-known characteristic that Chinese wood oil has of polymerizing when heated to 280° C.

Other methods of testing Chinese wood oil are the McIlhiney,² the iodine jelly³ and the Ware Schumann.⁴

The urgent need for standardizing the methods of testing Chinese wood oil, led Sub-committee D1 of the American Society for Testing Materials to take up the problem. Their work has covered a period of several years and the various methods have been tried out. However, specifications for raw Chinese wood oil were not proposed until the report of the committee was given at the meeting of the society held June 22, 1915. These specifications were based on the analytical constants which had been determined in previous years along with the modified Browne's method and the modified iodine jelly test, which were reported on at this time. The work for this year was done on the following five samples:

OILS	PER CENT PRESENT IN SAMPLE NO.				
	1	2	3	4	5
Pure China wood oil....	100	95	90	95	90
Soya bean oil.....	..	5	10	..	..
Linseed oil.....	..	..	..	5	10

From the results obtained by the various operators on these samples the time limit at or under which pure oil should polymerize was specified as 12 minutes when using the Browne test, while a time limit of four minutes was specified for the setting period in the iodine jelly test.

The wide variations in the results obtained by the different members of the committee indicate the necessity of working both the tests against standards, and not to a time limit as proposed in the specifications. A brief résumé of the results obtained show the large personal equation involved:

(a)—Accepting the 12-minute time limit in the case of the Browne test, at or under which the oil is to be considered acceptable, and above which it is to be rejected, the pure sample should be rejected by one operator, the sample adulterated with 5 per cent

soya bean oil should be accepted by 5 operators and the sample adulterated with 10 per cent soya bean oil should be accepted by one operator. The sample adulterated with 5 per cent linseed oil is acceptable by the reports of 3 operators.

(b)—Accepting the time limit of 4 minutes, as is specified in the case of the iodine jelly test, 6 out of the 9 operators reporting gave figures below the time limit on sample No. 2. With sample No. 4, the same 6 operators gave in their reports figures which were below the accepted time limit for pure Chinese wood oil.

The contention that all tests on shipments of wood oil should be made against standards is further supported by the supplementary report of Boughton (meeting held June 22, 1915), which shows that variations in temperature of the bath, the weight of oil used, the amount of chloroform taken, and the strength of the iodine solution, cause large differences in the results obtained.

The index of refraction has been reported as giving valuable information as to the purity of Chinese wood oil by Wise,¹ Chapman,² Hoepfner and Burmeister,³ and Boughton.⁴ Dr. Holton⁵ noticed, while working with the Abbey instrument on the index of refraction, that it was necessary to set the compensator at an abnormal point when taking readings on Chinese wood oil.

Shook,⁶ while working on the dispersion of various oils with the Pulfrich refractometer, noticed that Chinese wood oil showed anomalous dispersion; *i. e.*, while the spectrum of all the other oils appeared with the red on the upper side and the green and blue on the lower side (Fig. 1), Chinese wood oil com-

pletely reversed this condition, showing the blue and green on top with the red on the lower side of the spectrum (Fig. 2). This phenomena probably accounts for the observations made by Holton.

APPARATUS

The principle used is that of the Pulfrich refractometer. The essential features of the apparatus are as follows: Referring to Fig. 4, *X* is the source of light and in this work was a tungsten light. *L* is a condensing lens. The prism *P*, the most essential part of the apparatus, is a 90° prism having an index of refraction of 1.62. The cell *C*, in which the oils were placed, is so mounted on the prism that the upper surface of the prism is above the joining of the cell and prism. The telescope *T*, which picks up

¹ Boughton, "Testing of Chinese Wood Oil," *Proc. Am. Soc. Test. Materials*, **13** (1913), 923.

² *THIS JOURNAL*, **4** (1913), 496-497.

³ *Proc. Am. Soc. Testing Materials*, **1914**, 242.

⁴ *THIS JOURNAL*, **6** (1914), 806.

⁵ *J. Soc. Chem. Ind.*, **4** (1912), 497.

⁶ *Analyst*, **37** (1912), 543.

⁷ *Chem. Zeit.* (1913), No. 2, 18.

⁸ *Drugs, Oils and Paints*, **29**, 252-256.

⁹ Private communication to Dr. C. D. Holley, Chief of this Laboratory.

¹⁰ *Met. and Chem. Eng.*, Oct., 1915, and also private communication.

the spectrum, is bent at a right angle of 90° between the objective *O* and the eyepiece *e* for convenience in observing the spectrum.

EFFECT OF DIFFERENT OILS ON THE SPECTRUM OF CHINESE WOOD OIL

Additions of linseed oil to Chinese wood oil up to about 8 per cent show very little change in the spec-

FIG. 4

OUTLINE OF APPARATUS

trum. Beginning with 9 per cent adulteration, the yellow becomes more pronounced while the red begins to disappear. However, when the adulteration

gradually develop until finally the spectrum has been completely and distinctly reversed.

All other oils used as adulterants of Chinese wood oil affected its spectrum in the same manner, the changing point varying over a range of 2.5 per cent depending on the particular oil used. To illustrate: light tallow seed oil and perilla oil begin to affect the spectrum of Chinese wood oil at about 9 per cent, while the "turning point" is at 17 per cent adulteration. On the other hand, with ground nut, cotton seed, sesame and rape oils this effect is first noticed at a little below 7 per cent and the "turning point" takes place with 14.5 per cent adulteration. Candle nut, linseed, poppy seed, dark tallow seed, and soya bean oils affect the spectrum of Chinese wood oil at a point about midway between the cases just cited, the "turning point" taking place with 15.5 per cent adulteration in the case of poppy seed, linseed, and candle nut oils, with 16 per cent of dark tallow seed, and with 15 per cent adulteration of soya bean oil.

TABLE I—APPEARANCE OF THE SPECTRA OF ADULTERATED CHINESE WOOD OIL AT 25°C .

ADULTERANT PRESENT Per cent by weight	TALLOW SEED OIL (Light)	SEED OIL (Dark)	PERILLA OIL	CANDLE NUT OIL	LINSEED OIL (Raw)	(Refined)	POPPY SEED OIL	SOYA BEAN OIL	SESAME OIL	GROUND NUT OIL	COTTON-SEED OIL	RAPE OIL
13.5	.....	.....	.....	.....	.....	.....	.....	Green Yellow	Green Yellow	Green Yellow	Green Yellow	Green Yellow
14.0	.....	.....	.....	Green Yellow	Green Yellow	Green Yellow	Green Yellow	Green Yellow	Yellow	Yellow	Yellow	Yellow
14.5	.....	.....	.....	Green Yellow	Green Yellow	Green Yellow	Green Yellow	Yellow	Red Yellow	Red Yellow	Red Yellow	Red Yellow
15.0	.....	Green Yellow	.....	Yellow	Yellow	Yellow	Yellow	Red Yellow	.....	.....	.....	.....
15.5	Green Yellow	Green Yellow	Green Yellow	Red Yellow	Red Yellow	Red Yellow	Red Yellow	.....	.....	.....	.....	.....
16.0	Green Yellow	.....	Green Yellow	.....	.....	.....	.....	.....	.....	.....	.....	.....
16.5	.....	Red Yellow	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
17.0	Red Yellow	.....	Red Yellow	.....	.....	.....	.....	.....	.....	.....	.....	.....

reaches 10 per cent, the green takes the form of a more distinct band with the red slowly decreasing in intensity. With 11 per cent adulteration, the green band becomes more marked and the line of demarcation from the yellow is much sharper than with 10 per cent adulteration. The red shows now only to a very limited degree. The addition of 12 per cent linseed oil to the Chinese wood oil shows a spectrum consisting of only two colors, green and yellow, which appear as very distinct bands of about the same width, the green still remaining upon the upper side. The appearance of the bands with 13 per cent adulteration is very little different from that with 12 per cent, the green, however, being a trifle less distinct. With 13.5 per cent the conditions remain practically the same, while with 14 per cent and 14.5 per cent the green shows very indistinctly, and when 15 per cent linseed oil has been added, only a distinct yellow band can be seen. The next change noted, occurring with 15.5 per cent adulteration, is the red beginning to appear in a distinct narrow band on the upper side of the spectrum. This is the most noticeable change and the one most readily observed, and in the work which follows this point is called the "turning point" (Fig. 3). Further additions of linseed oil increase first the distinctness of the red, and when about 16 to 16.5 per cent has been added, the green begins to appear. From this point on the colors

Table I shows the effect of the individual adulterants on the spectrum of Chinese wood oil at varying percentages just below and at the "turning point."

Reading from top to bottom, it will be noticed that at 0.5 per cent below the "turning point" the spectrum showed, in each case, only a yellow band, while, with an adulteration of one per cent less than this, the spectrum showed two bands, namely, green and yellow. In all cases these bands were very definitely divided and not blended one with the other.

TABLE II—APPEARANCE OF SPECTRA OF ADULTERATED CHINESE WOOD OIL

ADULTERANT	TALLOW SEED OIL	LINSEED OIL	SOYA BEAN OIL	COTTON-SEED OIL	GROUND NUT OIL	SESAME OIL
Percent by weight 20° C.	Percent by weight 30° C.	(Dark)	(Raw)			
13.75	12.25	.....	.....	Green Yellow	Green Yellow	Green Yellow
14.25	12.75	.....	.....	Green Yellow	Green Yellow	Green Yellow
14.75	13.25	Green Yellow	Green Yellow	Yellow	Yellow	Yellow
15.25	13.75	Green Yellow	Yellow	Red Yellow	Red Yellow	Red Yellow
15.75	14.25	Green Yellow	Yellow	Red Yellow	.....	.....
16.25	14.75	Green Yellow	Red Yellow	.....	.....	.....
16.75	15.25	Yellow	.....	.....	.....	.....
17.25	15.75	Red Yellow	.....	.....	.....	.....

Temperature influences the effect of the adulteration on the spectrum of Chinese wood oil to a very marked degree. However, this factor seems to be the same for each of the oils used. For example:

the "turning point" with soya bean oil at 25° C. takes place with 15 per cent adulteration, at 20° C. with 15.75 per cent adulteration, and at 30° with 14.25 per cent adulteration. With linseed oil the "turning point" at 25° C. takes place with 15.5 per cent, at 20° C. with 16.25 per cent, and at 30° C. with 14.75 per cent adulteration. A comparison of Tables I and II clearly shows the influence of temperature on the spectrum at the different adulterations.

It is obvious from these results that either a correction for temperature should be made when making a determination, or, better, all readings should be made at one temperature. In the remainder of the work this latter plan has been adopted.

Up to this point in the investigation the work has been carried on using only one sample of Chinese wood oil. This oil is No. 1 in Table III, which shows the effect on the spectra of different Chinese wood oils when the same soya bean oil is used as an adulterant. It will be noticed that the "turning point"

TABLE III

SOYA BEAN OIL Per cent by weight	Appearance of the Spectra of different Chinese Wood Oils Adulterated with Soya Bean Oils						
	1	2	3	4	5	6	7
13.0	.....	.....	.....	Green	.....	Green	Green
.....	.....	.....	.....	Yellow	.....	Yellow	Yellow
13.5	Green	Green	Green	Green	Red	Green	Green
.....	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
14.0	Green	Green	Green	.....	.....	.....	.....
.....	Yellow	Yellow	Yellow	Yellow	.....	Yellow	Yellow
14.5	.....	.....	.....	Red	.....	Red	Red
.....	Yellow	Yellow	Yellow	Yellow	.....	Yellow	Yellow
15.0	Red	Red	Red	.....	.....	.....	.....
.....	Yellow	Yellow	Yellow	.....	.....	.....	.....

in the cases of oils 1, 2 and 3 takes place at the same point, that is, with an adulteration of 15.0 per cent, in the cases of oils 4, 6 and 7 with 14.5 per cent, and with oil 5, the poorest one given in the table, with 13.5 per cent.

Samples 1, 2, 3, 5, 6 and 7 were taken from shipments covering a period of two years and from different importers. Sample No. 4 was furnished to Dr. C. D. Holley by Mr. E. W. Boughton and is the *Aleurites fordii* used by him in his investigations on the various oils from the Orient. In actual use, oil No. 5 proved to be inferior to oils 1, 2, 3, 6 and 7.

Of the oils mentioned above, the ones generally supposed to be used as adulterants are soya bean, tallow seed, sesame, and occasionally ground nut and candle nut oils. It has been pointed out that the effect on the spectrum of Chinese wood oil when adulterated with these oils is to cause the "turning point" to take place at adulterations varying between the limits of 14.5 to 17.0 per cent. As a working basis for an analytical method, the writer assumes an arbitrary adulteration of 15.5 per cent, at which the "turning point" will take place, *i. e.*, when the red first appears on the upper side of the spectrum.

ANALYTICAL METHOD

Since 15.5 per cent of linseed oil in Chinese wood oil causes the "turning point" to take place, it is used as the oil to be added when necessary to bring about the "turning point."

The author's procedure is as follows: First a sam-

ple of the oil in question is placed in the cell and its spectrum examined. If the oil is pure, or contains less than 8 per cent of adulteration, the spectrum will be inverted and appear practically the same in all cases. If the percentage of adulteration is over 8 per cent and under the "turning point" (15.5 per cent), the spectrum will appear as previously described for the various adulterations within these limits. By this means one may get a clue as to about what the adulteration is. If the first observation indicates that the oil is pure, or contains less than 8 per cent adulteration, 15 per cent of linseed oil is added. Then, if the oil in question is pure, only the yellow band will be visible in the spectrum, and as a check, the writer at this point then makes another observation on a sample of the oil adulterated with 15.5 per cent of linseed oil, and if the red now appears on the upper side of the spectrum, the sample of Chinese wood oil may be considered pure beyond question. If, on the other hand, the spectrum has reversed to the normal it is evident that the oil is adulterated, since more than 15 per cent of foreign oil is required to bring this reversal about. The amount of adulteration will, however, not exceed 8 per cent, as shown by the preliminary examination. The depth of the colors of the spectrum will give some idea as to whether or not the adulteration is very small or quite large. If the green is very indistinct the adulteration will probably not be over two per cent. However, if more than two per cent of adulteration is present, the colors will be more intense, since the intensity of both the green and the red vary directly with the adulteration when over 15.5 per cent foreign oil is present. In order to determine the percentage it is necessary to find out how much adulterant must be added before the "turning point" is reached, then, by subtracting the amount added from 15.5, the amount present in the oil may be obtained.

If the preliminary examination shows the adulteration to be between the limits of 8 per cent and 15.5 per cent, successive additions of the adulterating oil are added to the sample in question until the "turning point" has been reached. Then by subtracting the amount added from the arbitrary figure, 15.5 per cent, the amount of adulteration in the Chinese wood oil is obtained, as in the case when the foreign oil present is less than 8 per cent. This procedure is best illustrated by concrete examples.

1—A sample of oil which was rejected on the kettle test during the past year, was examined as follows: the oil when placed in the cell for preliminary examination showed the characteristic spectrum of pure Chinese wood oil, or of an oil not adulterated over 8 per cent. Upon adding 15 per cent of linseed oil the spectrum was observed to have been completely reversed, showing the colors red, yellow and green comparatively strong, thus indicating that the oil contained about 5 to 8 per cent adulteration. Seven per cent of linseed oil was then added to the original sample. The spectrum of the oil thus adulterated showed a distinct green band on top with a yellow band on the bottom, indicating that sufficient adulterant had not

been added. When a sample of the original oil to which 8 per cent of linseed oil had been added was examined, its spectrum showed only a yellow band; 8.5 per cent of linseed oil was then added to the original sample and the observation made; the "turning point" was now reached, shown by the characteristic red band appearing on the upper side of the spectrum. Subtracting the amount added, 8.5 per cent, from the arbitrary figure 15.5 per cent, it is evident that the sample in question contained 7 per cent adulteration.

2—Another sample taken from a rejected shipment, when first observed in the cell, showed a spectrum which was deficient in the red. It was therefore thought to contain about 10 per cent adulteration. When 6 per cent of linseed oil was added to this sample, the spectrum appeared only as a yellow band, and when 6.5 per cent of adulterant was added to the sample in question the red appeared on the upper side of the spectrum. Subtracting 6.5 from 15.5 the adulteration was shown to be 9 per cent.

3—Another sample, taken from a rejected shipment, when examined by this method, showed an adulteration of 7.5 per cent, and a sample marked questionable by the chemist of a large varnish works, showed an adulteration of 4.5 per cent.

The sample of pure Chinese wood oil used by the American Society for Testing Materials, and reported on as an exceptional oil, required an addition of 17.0 per cent linseed oil before the "turning point" occurred; hence in examining the four adulterated samples of this oil, which were used by the society in the work for 1915, it was deemed advisable, for sake of comparison, to use the figure 17.0 as well as the arbitrary figure of 15.5. Table IV gives the results in both cases:

TABLE IV
Per cent adulteration found by using as
"turning point"

SAMPLE NO.	17.0 per cent	15.5 per cent
2.....	5.25	3.75
3.....	10.50	9.00
4.....	5.0	3.5
5.....	10.0	8.5

If these samples had been examined without having the pure oil the last column would have been considered as the percentage to which the Chinese wood oil had been adulterated.

SUMMARY OF RESULTS

If the adulterating oil is known, very accurate results can be obtained by this method, otherwise the accuracy is limited to 1.25 per cent either way from the true value, owing to the fact that the turning point varies between the limits of 14.5 to 17.0 per cent and the arbitrary value of 15.5 is not correct.

If, however, the oil with which the Chinese wood oil is adulterated can be determined, the accuracy is thereby increased. Lewkowitsch,¹ in commenting on tallow seed oil, says: "The most characteristic property of this oil is that it rotates the plane of polarized light to the left, *viz.*, 6° 45' in a 200 mm. tube in a Laurent polarimeter, corresponding to -29.9 saccharimeter degrees. The optical activity is confirmed by Nash." This is being investigated as a means

¹ "Chemical Technology and Analysis of Oils, Fats and Waxes," Vol. II, p. 70.

of detection in Chinese wood oil at the present time in this laboratory. If the attempt is successful the accuracy for adulterations with other oils will be increased, since the only other oil which causes the "turning point" to take place as high as 17.0 per cent adulteration is perilla oil, which is used only occasionally as an adulterant of wood oil.

The detection of sesame by the Baudouin test and the detection of cottonseed oil by the various methods as described in Lewkowitsch, would eliminate most of the oils which affect the turning point as low as 14.5 per cent. The remaining oils affect the turning point within such a close range of each other that the arbitrary figure assumed as the turning point would be very close to the true value.

The writer believes that concentration of the adulterating oils by the light break method described by Ware and Schumann¹ may facilitate the detection of those oils readily identified.

Another factor which must be taken into consideration is the fact that the prism itself has a dispersive power and if its dispersion is too large the anomalous dispersion of Chinese wood oil will be counteracted. Also, prisms, though having a dispersion low enough to be used in this method, may vary from each other, so that in using an instrument of this type one must first calibrate his prism before making determinations. This is readily done by finding the "turning points" brought about by the addition of different oils to Chinese wood oil.

The fatty acids of Chinese wood oil also show anomalous dispersion. This fact gives promise of interesting information when studied in connection with other fatty acids.

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COMPOSITION OF WOOD TURPENTINE²

By MAXWELL ADAMS

Received June 14, 1915

Because of the shortage in the supply of "gum" turpentine, and the enormous wood waste of our lumber mills during the past ten years, many methods for the extraction of turpentine from wood have been proposed. The economics of steam, solvent, alkali digestion, oil bath, destructive distillation, under both increased and diminished pressure processes have been given thorough consideration, but very little attention has been accorded the composition of the turpentine obtained by these different procedures. Although the products obtained by these various methods differ widely as to color, odor and physical constants, without any attempt at standardization, they have all been classed together. The result has been that a strong prejudice has arisen against any product sold under the name of wood turpentine.

The physical properties of wood turpentine obtained, presumably, from long leaf or Cuban pine, have been

¹ This JOURNAL, 6 (1914), 806.

² This work was in part done in Prof. Wallack's laboratory at Göttingen, Germany, and supported by the Adams Fund of the Nevada Agricultural Experiment Station.