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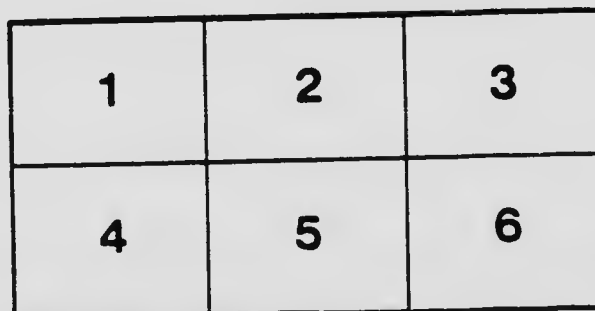
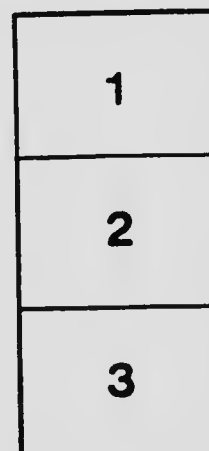
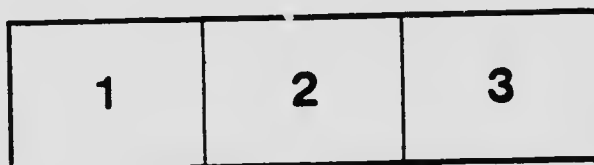
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LABORATORY
OF THE
INLAND REVENUE DEPARTMENT

OTTAWA, CANADA

1901

BULLETIN No. 79

OIL OF TURPENTINE

LABORATORY
OF THE
INLAND REVENUE DEPARTMENT

BULLETIN No. 79.

OIL OF TURPENTINE.

OTTAWA, October 29, 1901.

W. J. GERALD, Esq.,
Deputy Minister of Inland Revenue.

SIR,—In January last, application was made to the department by certain dealers in the article to have this branch examine samples of oil of turpentine in order to determine whether or not they were genuine. It was alleged that impure oil of turpentine was being imported into Canada, that the impurity was foreign matter of the nature of petroleum, and that sometimes the article contained an excessive percentage of resinous matter. Samples were offered for analysis by parties engaged in the trade, but their origin being unknown it was not deemed wise to undertake their examination. At the same time, oil of turpentine being a standard article and a drug distinctly defined in the British Pharmacopœia, it was thought advisable to recommend that a collection of samples should be made in the manner prescribed by the Adulteration Act, and that they should be submitted to the district analysts for examination as to their purity. This proposal was approved by the Hon. the Minister of Inland Revenue in February, but it was not found possible to make the collection until June of the present year. The source of the samples is stated in table No. 1. of this report together with the results obtained by the analysts in testing them and the opinions which they express concerning them. The duplicate samples were submitted to Mr. A. McGill, B.A., of this laboratory, who subjected them to a very detailed and thorough examination, the results of which are given in his report hereto appended. In all fifty samples were collected, of which only two were pronounced adulterated by the district analysts. Mr. McGill, however, points out six other cases, the genuine character of which is very doubtful. This would indicate that sixteen per cent of the oil of turpentine sold in the open market is adulterated, and justifies the suspicions entertained by the parties who brought the subject to the attention of the department.

I have to recommend the publication of this and Mr. McGill's report.

I have the honour to be, sir,
Your obedient servant,
THOMAS MACFARLANE,
Chief Analyst.

TABLE

RESULTS of the Examination of 48

Date of Collection.	No. of Sample.	Quantity purchased.	Cost.	Name and Address of Vendor.	RESULTS			
					Sp. gr. at 15.5°C.	Colour.	Boiling Point. Centigrade.	Dissilate from 100cc. under.
1901.			\$ cts.	<i>Official Analyst, Mr. Bowman, Halifax, N.S.</i>				
				<i>Halifax, N.S.</i>				
June 6	20049	1 quart.	0 40	T. M. Power & Sons, druggists, Gottingen street.	0.8600	.....	156°	180°C.
" 7	20050	" ..	0 18	W. B. Arthur & Co., hardware merchants.	0.8666	.....	158°	95 p.c. 180°C.
" 7	20051	" ..	0 25	A. A. Thompson, druggist, Agricola street.	0.8680	.....	157°	95 p.c. 180°C.
				<i>St. John, N.B.</i>				94 p.c.
" 4	17785	1 lb. ...	0 75	The McDiarmid Drug Co., Ltd., Market Square.	.....	.....	.....	.....
" 4	17787	2 lbs. ...	1 00	T. B. Barker & Son, druggist, 37 King street.	.....	.....	.....	.....
				<i>Official Analyst, Dr. M. Finet, Quebec.</i>				
				<i>Montreal.</i>				
" 3	19830	1 quart	0 20	J. Denis, hardware merchant, 236 St. Lawrence street.	0.864	White, but turbid.	160°	.....
				<i>Quebec.</i>				
" 6	19833	" ..	0 20	Lagennese et Frere, hardware merchant, 773 St. Valier street.	0.8670	White, but not quite clear.	159°	.....
				<i>Richmond, P.Q.</i>				
" 7	19835	" ..	0 20	J. Sullivan, painter, Main street.	0.8708	White and clear.	159.5°	.....
				<i>St. Hyacinthe, P.Q.</i>				
" 11	19837	" ..	0 35	E. St. Jacques, druggist, Cascade street.	0.8928	Yellowish, but clear.	162.5°	.....
" 11	19838	" ..	0 20	U. Beaunoyer, paint and oil merchant, Cascade street.	0.8690	" ..	160°	.....
				<i>Official Analyst, A. L. Tourchot, St. Hyacinthe.</i>				
				<i>Granby, P.Q.</i>				
June 18	19839	" ..	0 20	Montly Bros., general store.	0.866	.....	156°	180°C.
" 18	19840	" ..	0 20	N. Mitchell, general store.	0.867	.....	156°	96 p.c.
" 18	19841	" ..	0 30	Dy. St. Onge, druggist.	0.892	.....	150°	96 p.c.
" 18	19842	" ..	0 30	J. E. Dozors, Druggist.	0.870	.....	154°	87 p.c. 95 p.c.

TABLE

of 48

I.

Samples of Oil of Turpentine.

RESULTS

Distillate from
100cc. under.

180°C.
95 p.c.
180°C.
95 p.c.
180°C.
94 p.c.

80°C.
6 p.c.
6 p.c.
7 p.c.
5 p.c.

OF ANALYSIS.							No. of Sample.	Remarks by Analyst.	Serial Number.
Residue from 100cc. gram-mes.	Solubility in Glacial Acetic Acid.	Specific Rotation.	Flash Point.	Residue in Asbestos at 100°C.	Residue in Asbestos at 180°C.	Loss between 100°C. and 180°C. in Asbestos.			
p. c.					p. c.	p. c.			
.....	Soluble.....						20049	Genuine.....	33
.....	".....						20050	".....	34
.....	".....						20051	".....	35
.....							17785		5
.....							17787		6
1.060	Not quite homogeneous.		46°-48°c.				19830	Genuine.....	12
0.915	"		46°-48°c.				19833	".....	13
1.913	"		41°-43°c.				19835	".....	14
5.76	Homogeneous.		42°-45°c.				19837	Adulterated with rosin oil.	15
0.968	Not quite homogeneous.		42°-44°c.				19838	Genuine.....	16
3.10	Soluble.			24.45	15.38	9.07	19839		17
2.0	".....			22.58	13.54	9.04	19840		18
14.0	Incomplete.....			33.33	19.90	13.34	19841	Impure containing resin....	19
4.0	Soluble and limpid.....			24.27	15.58	8.69	19842		20

RESULTS of the Examination of 48

Date of Collection.	No. of Sample.	Quantity purchased.	Cost.	Name and Address of Vendor.	RESULTS		
					Sps. Gr. at 15.5°C.	Colour.	Boiling Point - Centigrade. Distillate from 100cc. under.
1901.			\$ cts.	<i>Official Analyst, A. L. Tourchot, St. Hyacinthe.</i>			
				<i>Magoy, P.Q.</i>			
June 20	19843	1 quart.	0 25	Gilbert Morrier, paints.....	0 871	134°..	95 p.c.
" 20	19844	" ..	0 25	A. D. Martin, paints.....	0 870	152°to 153°..	93 p.c.
				<i>Sherbrooke, P.Q.</i>			
" 20	19845	" ..	0 25	J. R. McBain, druggist.....	0 868	154°..	96 p.c.
" 20	19846	" ..	0 20	Kerr & Foss, hardware.....	0 867	154°..	98 p.c.
" 20	19847	" ..	0 19	Coderre Bros. & Co., hardware	0 866	153°to 154°..	98 p.c.
" 20	19848	" ..	0 22	G. N. Bourque, paints.....	0 869	151°..	96 p.c.
" 20	19849	" ..	0 30	G. Richard, Druggist.....	0 869	155°..	98 p.c.
				<i>St. John, P.Q.</i>			
" 25	19850	" ..	0 20	Côté et Frère, hardware.....	0 868	153°to 154°..	97 p.c.
" 25	19851	" ..	0 30	Dr. Savarin, druggist.....	0 863	148°..	85 p.c.
" 25	19852	" ..	0 20	Gervais et Frère, general store	0 860	153°to 154°..	97 p.c.
				<i>Cowansville, P.O.</i>			
" 25	19853	" ..	0 20	McClatchie Bros., hardware.	0 862	153°..	96 p.c.
				<i>Sweetsburg, P.Q.</i>			
" 25	19854	" ..	0 23	C. H. Boright, general store.	0 875	153°to 154°..	92 p.c.
				<i>Official Analyst, Dr. F. X. Valade, Ottawa.</i>			
				<i>Ottawa.</i>			
May 30	20848	" ..	0 30	J. Skinner & Co., druggist...	0 8698	150°..	162°C. 80 p.c.
" 30	20849	3 pinta..	0 30	Josh. Archambault, oil and colour merchant, Dalhousie St.	0 8659	148°..	165°C. 80 p.c.
" 30	20850	1 quart.	0 23	J. B. Duford, oil and colour merchant, Rideau St.	0 8662	156°..	163°C. 80 p.c.
				<i>Peterboro', Ont.</i>			
June 5	20851	" ..	0 23	A. F. Micks & Co., oil and colour merchants.	0 8669	159°..	162°C. 80 p.c.
" 5	20852	" ..	0 20	Peterboro' Hardware Co.	0 8637	158°..	165°C. 80 p.c.
				<i>Official Analyst, Dr. W. H. Ellis, Toronto.</i>			
				<i>Peterboro', Ont.</i>			
" 5	20862	" ..	0 25	Peterboro' Hardware Co.	0 8654	155°..	185°C.

Samples of oil of Turpentine.—Continued.

OF ANALYSIS.									
Residue from 100cc. Grains	Solubility in Glacial Acetic Acid.	Specific Rotation.	Flash Point.	Residue in	Residue in	Loss between	No. of Sample.	Remarks by Analyst	Serial Number.
				Asbestos at 100°C.	Asbestos at 150°C.	100° and 150° in Asbestos.			
				p. c.	p. c.	p. c.			
4.0	Sol. and limp			20.45	15.77	10.68	19843		
6.0				25.04	15.54	10.50	19844	Doubtful	
3.0	"			21.15	14.49	6.66	19845		23
2.0	"			18.39	10.20	8.19	19846		24
2.0	"			16.71	9.87	6.84	19847		25
3.0	"			21.28	13.59	7.69	19848		26
3.0	"			22.13	13.48	8.65	19849		27
2.50	"			20.48	11.80	8.68	19850		28
16.0	Incomplete			30.28	15.45	14.83	19851	A bad product—contains resin	29
3.0	Soluble			22.33	12.06	9.37	19852		30
3.0	"			17.93	9.58	8.36	19853		31
6.0	Soluble and limpid			26.39	16.33	10.36		Doubtful	32
2cc. of red oil.	1 in 1.						20848	Genuine	36
7cc. of red oil.	1 in 1.						20849	"	37
"	1 in 1.						20850	"	38
3cc. of yellow oil.	1 in 1.						20851	"	39
6cc. of yellow oil.	1 in 1.						20852	"	40
.....	Incomplete	15.2					20862	"	41

RESULTS of the Examination of 48

Date of Collection.	No. of Sample.	Quantity purchased.	Cost.	Name and Address of Vendor.	RESULTS		
					Sp. gr. at 15.5°C.	Colour.	Boiling Point. Centigrade. Distillate from 100cc. under.
1901.			8 cts.	<i>Official Analyst, Dr. W. H. Ellis, Toronto. Toronto.</i>			
June 6	20863	1 quart.	0 15	Elliott & Co., wholesale druggist, Front St.	0.8692		160°.. 165°C.
" 6	20864	" ..	0 20	Thos. Meredith & Co., hardware merchants, King St.	0.8680		155°.. 165°C.
" 6	20865	" ..	0 20	The Harris Co., Ltd., oil and colour merchants, King St.	0.8683		158°.. 163°C.
" 6	20866	" ..	0 20	Lynan Bros. & Co., wholesale druggist.	0.8688		160°.. 165°C.
" 6	20867	" ..	0 20	Russill & Co., hardware merchants, King St. <i>Official Analyst, F. T. Harrison, London, Ont. Stratford, Ont.</i>	0.8555		158°.. 185°C.
June 3	19492	" ..	0 25	W. H. Thomson, druggist... <i>Windsor, Ont.</i>	0.8692		154°.. 170°C. 99.11 p.c
" 4	19495	" ..	0 25	H. O. Fleming, druggist.... <i>London, Ont.</i>	0.8676		155°.. 170°C. 99.59 p.c
" 5	19497	" ..	0 25	C. McCallum, druggist	0.8620		155°.. 180°C. 99.68 p.c
" 5	19499	" ..	0 25	James Wright, hardware merchant.	0.8664		156°.. 174°C. 97.71 p.c
" 5	19500	" ..	0 25	A. Westman, hardware merchant. <i>Official Analyst, E. B. Kenrick, Winnipeg. Winnipeg, Man.</i>	0.8681		154°.. 172°C. 99.38 p.c
" 4	17330	" ..	0 25	Graham & Rolston, hardware merchants.	0.8666	Yellow, with a strongly marked blue fluorescence.	156.5°.. 167.5°C. 95.5 p.c.
" 4	17331	" ..	0 25	R. Wyatt, hardware merchant.	0.8680	"	156.5°.. 165.5°C. 95.2 p.c
" 4	17332	" ..	0 25	J. H. Ashdown, hardware merchant.	0.8674	"	156°.. 166°C. 94.4 p.c
" 4	17333	" ..	0 20	G. F. Stephens & Co., oil and colour merchant. <i>Official Analyst, Dr. C. J. Fagan, Vancouver, B.C. Vancouver, B.C.</i>	0.8680	"	156.5°.. 167.5°C. 96.1 p.c
" 4	21579	" ..	0 50	J. K. Patton, druggist....	0.8715	Limpid colourless.	155°.. 161°C.

Samples of Oil of Turpentine—Continued.

OF ANALYSIS.							No. of Sample.	Remarks by Analyst.	Serial Number.
Residue from 100cc. grammes.	Solubility in Glacial Acetic Acid.	Specific Rotation.	Flash Point.	Residue in Asbestos at 100°c. p. c.	Residue in Asbestos at 180°c. p. c.	Loss between 100°c. and 180°c. in Asbestos. p. c.			
.....	Complete.	13·03	.....	.....	.....	.....	20863	Genuine	42
.....	"	15·54	.....	.....	.....	.....	20864	"	43
.....	Incomplete....	14·39	.....	.....	.....	.....	20865	"	44
.....	"	15·14	.....	.....	.....	.....	20866	"	45
.....	Complete.....	15·35	.....	.....	.....	.....	20867	Specific gravity too low, of doubtful composition.	46
0·89	Soluble in own volume.	.....	.....	.....	.....	.....	19492	Character and tests correspond to B.P. except residue is high. Genuine.	7
0·41	" .....	.....	.....	.....	.....	.....	19495	Corresponds to B.P. tests and character. Genuine.	8
0·32	" .....	.....	.....	.....	.....	.....	19497	"	9
0·29	" .....	.....	.....	.....	.....	.....	19499	"	10
0·62	" .....	.....	.....	.....	.....	.....	19500	"	11
.....	.....	.....	.....	.....	.....	.....	17330	Genuine.	1
.....	.....	.....	.....	.....	.....	.....	17331	"	2
.....	.....	.....	.....	.....	.....	.....	17332	"	3
.....	.....	.....	.....	.....	.....	.....	17333	"	4
A small quantity.	In an equal volume.	.....	.....	.....	.....	.....	21579	"	47

RESULTS of the Examination of 48

Date of Collection.	No. of Sample.	Quantity Purchased.	Cost.	Name and Address of Vendor.	RESULTS			
					Sp. gr. at 15.5°C.	Colour.	Boiling Point. Centigrade.	Distillate from 100cc. under.
1901.			8 cts.	<i>Official Analyst, Dr. C. J. Fagan, Vancouver, B.C.</i>				
				<i>Vancouver, B.C.</i>				
June 4	21582	1 quart.	0 20	McLennan & McFeely, hardware merchants. <i>Victoria, B.C.</i>	0 869	Limpid greenish yellow.	154°	158°C. 99 p.c.
" 5	21585	1 " "	0 30	J. W. Mellor.	0 869	Limpid colourless.	154°	160°C. 98.8 p.c.
" 5	21586	1 " "	0 35	R. Lettier.		Limpid yellowish.	154°	158°C. 98.5 p.c.

Samples of Oil of Turpentine—*Concluded.*

OF ANALYSIS.							No. of Sample.	Remarks by Analyst.	Serial Number.
Residue from 100cc. grammes.	Solubility in Glacial Acetic Acid.	Specific Rotation.	Flash Point.	Residue in asbestos at 100°c.	Residue in Asbestos at 180°c.	Loss between 100°c. and 180°c. in Asbestos.			
				p. c.	p. c.	p. c.			
1cc.	In an equal volume.	.....	.....	.....	.....	.....	21582	Genuine.	48
1.20cc.	"	.....	.....	.....	.....	.....	21585	"	49
1.5cc.	"	.....	.....	.....	.....	.....	21586	"	50

LABORATORY OF THE INLAND REVENUE DEPARTMENT,
OTTAWA, October 24, 1901.

THOS. MACFARLANE, Esq., F.R.S.C., &c.,
Chief Analyst.

SIR,—I have the honour to submit herewith the results of my investigation of oil of turpentine. This matter was placed in my hands in June last, and would have been reported upon some time ago but for illness. Other demands upon me, since returning to the laboratory, have delayed its completion, and must also account for any deficiencies in it.

Owing to the fact that most of the tests applicable to turpentine are physical rather than chemical in the strict sense, and require larger quantities of material, I should recommend that at least two pints of each sample be furnished to the analysts, where practicable.

I have the honour to be, sir,
Your obedient servant

A. MCGILL.

Oil of Turpentine,

Oil of turpentine, or Terebinthinae Oleum of the British Pharmacopœia, is thus described by that authority: 'The oil distilled, usually by the aid of steam, from the oleoresins obtained from *Pinus sylvestris* and other species of *Pinus*; rectified if necessary.'

Squire's Companion to the Pharmacopœia gives the following additional information as to the sources of oil of turpentine. 'The oil of turpentine sold in Britain is almost wholly imported from America, and is the product (mainly) of *Pinus australis* and *P. tæda*. German and Russian oil is chiefly distilled from *P. sylvestris*, French oil from *P. maritima*, Hungarian turpentine is distilled from the cones of *P. pumilis*, and Carpathian turpentine from *P. cembra* or *P. pumilio*.'

According to Long (1) American turpentine is distilled from gum which is collected from notches cut in the trees, or from that (technically known as *Serote*) which hardens on the bark and surface of the tree. After four or five years the yield is too small to be profitable, collected. This gum was formerly distilled dry, but it is now usually distilled with water, from copper stills holding from eight to fifty barrels. The yield of oil is about one-fifth the weight of the gum. The Virgin dip and scrape yield more oil than the later produce of the trees.

The specific characters of oil of turpentine, are given as follows by the British Pharmacopœia—'Limpid, colourless, with a strong peculiar odour which varies in the different kinds of oil, and a pungent and bitter taste. It is soluble in its own weight of glacial acetic acid. It commences to boil at about 160° C., and almost entirely distils below 180° C.—little or no residue remaining.'

Squire's Companion adds the following:—'The specific gravity varies from .860 to .880. French oil is strongly levorotatory. Oil of turpentine, especially Russian, when exposed to the continuous action of air, in presence of water, develops a large quantity of hydrogen-peroxide, camphoric acid, and other oxygenated products. It dissolves beeswax, iodine, sulphur, phosphorus, fixed oils and resins, with the latter forming varnish. It is soluble in 6.5 volumes of 90 per cent alcohol; in all proportions in absolute alcohol, carbon-bisulphide, chloroform, ether (0.720) and glacial acetic acid.'

The opinions expressed by the public analysts regarding the genuineness of the forty-eight samples of oil of turpentine reported upon in Table 1, of this Bulletin, are based upon a study of the characters enumerated above. The analysts have reported all of the samples as genuine, with exception of two; and in these cases the genuineness is called in question on the ground of want of conformity to B.P. requirements, as follows:—

- No. 19837—High gravity, dark colour, high boiling point and large (15) residue on drying, indicate rosin oil.
 No. 20867—Low gravity, probable presence of some ingredient having (46) a less density than turpentine.

In addition to corroborating this finding, I have given reason in the sequel for calling in question the genuineness of Nos. 9, 19, 22, 29, 31, 40, and 51.

Commercial oil of turpentine is not a definite chemical substance. When carefully distilled it consists chiefly of *pinene*, $C_{10}H_{16}$; but other terpenes, and products of the oxidation of these are always present. Owing to the readiness with which oil of turpentine undergoes oxidation, in the presence of air and moisture, its composition is continually changing, and for this reason it is not easy to fix numerical constants by means of which the genuineness of a given sample may be judged.

The adulteration of turpentine spirit is no new thing. Materials for effecting this have been made the subject of patents in England and in Germany. (See English patent 12249 granted October 14, 1885,) P. H. Conradson (1) described a so-called 'wood turpentine,' having a specific gravity 0.845 and a flash point below 80° Fah. The most usual adulterant of our time is probably certain fractions of petroleum obtained in the refining of burning oils. In order to disguise their presence, resin oil may be added, or suitable resins (Kaori) dissolved.

In addition to the examination of the samples recorded in Table I, I have done some work on certain petroleum products similar to those which are employed in the sophistication of oil of turpentine, a so-called 'spiritine', a by-product of the refining of wood naphtha, and a sample of resin oil. Since these substances are themselves of very indeterminate composition, it is evident that their presence in a sample of oil of turpentine must be ascertained rather by attention to physical than to chemical properties.

The following list comprises the chief characters which are available for this purpose.

Physical characters:—

1. Colour,
2. Clearness,
3. Odour,
4. Taste.
5. Density,
6. Boiling point,
7. Volatility—presence of a fixed residu,
8. Vapour Density,
9. Flash point,
10. Viscosity,
11. Solubility,
12. Solvent power,
13. Rotatory power for polarised light,
14. Refraction,
15. Fluorescence.

Chemical Characters.—

16. Oxidisability,
17. Bromine Absorption,
18. Rise of temperature with sulphuric acid.

1. *Colour*.—Although recently distilled oil of turpentine is colourless, in thin layers, it has a distinctly yellowish-red tint when viewed through a column of from 20—60cm. After settling quite clear, I find the colour in a 60cm. column to be equivalent to yellow, 5 units + red, 1 unit of the Lovibond scale; and I have not been able to obtain any sample with less colour than this. Samples, as purchased, are always

much darker. The following numbers are stated for columns of 16 cm., viewed against a strongly illuminated, white wall.

	Yellow.	Red.
No. 7. First 75cc. distilled from 100cc.	0·8	0·1
" 44. The sample.	1·0	0·1
" 46. "	1·0	0·1
" 48. "	6·0	1·0
" 51. "	2·0	0·5
" 59. Gasol.	1·0	0·3
" 54. Spiritine.	5·0	0·2
Redistilled turpentine + 5 per cent resin oil.	20·0	29·0

So far as I know the colour of pure turpentine does not undergo change, if kept in the dark and in air-tight vessels. My experience only covers a period of two months. A sample exposed to sunlight (diffused) has not darkened perceptibly, during a period of one month.

Among the adulterants of turpentine, gasoline is indistinguishable, in this regard, from oil of turpentine, and appears to undergo no change of colour by keeping either in darkness or in sunlight. Spiritine, recently distilled, is nearly as free from colour, but rapidly becomes yellow on exposure to sunlight. The sample quoted above had been exposed to sunlight for two weeks since distillation. Rosin oil gives to turpentine a decided coloration in which red predominates.

Many of the samples which I have examined have been coloured by traces of linseed oil or varnish, due to their having been poured through the same funnels, or stored in the same containers which had been used for these substances. It would perhaps be too much to expect perfect freedom from traces of oil and varnish in the case of oil of turpentine which is avowedly sold for the use of painters. It is evident, however, that such impurity must prevent the colour test from having any value. As applied to the redistilled turpentine sold by druggists, the colour test has a decided value.

2. *Clearness.*—Oil of turpentine is perfectly clear and transparent. A very minute trace of water, if mixed with the turpentine by shaking, suffices to give a distinct turbidity.—Upon standing for some time, most of the water separates, and may be identified by giving a blue colour to anhydrous sulphate of copper. The clear supernatant oil of turpentine is not, however, absolutely anhydrous, and if subjected to distillation, the first portions of the distillate will be found quite turbid—only after 20 or 30 per cent by volume has come over will the distillate become clear. Samples of turpentine distilled from recently fused chloride of calcium come over turbid, and on settling clear the liquid at the bottom of the cylinder gives a blue colour to anhydrous sulphate of copper. It would therefore seem impossible, by any ordinary care, to obtain oil of turpentine perfectly anhydrous. This difficulty may be due to the fact that turpentine in presence of air and sunlight is continually producing hydrogen peroxide, which, by decomposition into oxygen and water, accounts for the traces of water always found in oil of turpentine.

Light petroleum products such as are used to adulterate turpentine, are rendered momentarily turbid by being shaken up with a trace of water, but the water separates in minute droplets almost instantly, so that the difference between oil of turpentine and petroleum is very marked in this respect.

When oil of turpentine containing 10 per cent of gasoline is submitted to distillation, the first fraction comes over quite clear, behaving

in this respect quite differently from genuine samples. A faint turbidity appears when about 15 to 20 p. c. volume has passed over, in cases where the amount of the adulterant is not large. No doubt this clearness of the first portions of the distillate is connected with the lowered boiling point of the sample, which causes the water to come over with a fraction very rich in petroleum.

Although the opacity to which I have referred is largely due to presence of water, I am not convinced that it is altogether due to this cause. The indefinite character of oil of turpentine, and the great number of oxidation products being constantly formed in it when in contact with air and sunlight, make it not unlikely that some of the less soluble products, passing into the distillate, or mechanically carried over with it, may partly explain the opacity referred to.

Another cause of opacity in oil of turpentine is the difference in refractive power possessed by its different components, and by the same component under different conditions of temperature. — Unless very great care be taken to have the whole sample at uniform temperature and thoroughly mixed — it is usually impossible to fill the (20 cm.) tube of the polarimeter so that an immediate reading can be made. A peculiar 'troubled' appearance is seen which makes the clear definition of the polariscope field impossible. On allowing the tube to lie at rest for some time, this troubled effect disappears, and very often a peculiar blackness is seen at a point in the top of the field (which as it is inverted, corresponds with the bottom of the tube) caused by the optical disturbance of droplets of water, (or other liquid) which has separated from the sample.

3. *Odour.*—The odour of such of these samples of turpentine as I have reason to believe genuine, is very characteristic and uniform. It is sufficiently strong to disguise effectively the presence of 10 to 20 per cent of gasoline (B. P. 90° C). Higher percentages of gasoline can be detected by its characteristic odour; and, in the first fraction, of one-tenth volume, from a turpentine containing 5 per cent of gasoline, this can be recognized.

Spiritine has a distinct acetone smell, but this is very effectively hidden, up to 20 per cent, by the odour of turpentine.

Rosin oil has a very persistent and characteristic odour of rosin. This is fairly well disguised, up to 10 per cent by that of oil of turpentine, but becomes distinct in the later fractions, and rosin oil constitutes a large part, if not the whole of the residue which is left after the B. P. has reached 210° C.

4. *Taste.*—This property has not been examined.

5. *Density.*—As was to be expected from its indefinite composition, the Density of oil of turpentine is very variable. Pinene, $C_{10}H_{16}$, which is the principal component, has a density 0.858 at 20° C. The oxidation products of turpentine possess a higher gravity than this, H. E. Armstrong¹ is of opinion that pinol hydrate, (which he proposes to name *Sobrerol*, after *Sobreró*, who first described it in 1851) is the initial product of the oxidation of turpentine. Pinol hydrate, $C_{10}H_{16}(OH)_2$ is a crystalline substance M.P.—150° isomeric with pinene glycol, another oxidation product of turpentine. Resinous bodies are also among the products of oxidation, and their presence in solution, raises the density of oil of turpentine. Allen² quotes the following densities for pine resin :

Yellow, transparent = 1.083—1.084.

Whitish, opaque = 1.044—1.047.

Dark, colophony = 1.100.

and for *rosin oil*, 0.980—1.100.

¹Proc. Chem. Soc. 1890, 99; abstracted in the Jour. Soc. Chem. Indus. 1890, 819

²Commercial Org. Anal. II, 453 and 461.

TABLE II.
 SPECIFIC GRAVITY of Oil of Turpentine, and fraction of 10 p. c. volume.
 Temp. 15.5° C.

Serial Number.	Description.	JUNE, 1901.		SEPTEMBER, 1901.		OCTOBER, 1901.	
		Sample.	Fraction.	Sample.	Fraction.	Sample.	Fraction.
1		17330	8672				
2		17331	8691	9472			
3		17332	8687	9418			
4		17333	8694	9560			
5		17785	8673				
6		17787	8674				
7		19492	8704				
8		19495	8656	8991		9007	8688
9		19497	8622	9013			8719
10		19499	8670				
11		19500	8685	8958		8978	
12		19830	8673	9561			
13		19833	8678	8879			
14		19835	8712	8965		8891	8698
15		19837	8927			8980	8669
16		19838	8693				
17		19839	8720	8811		8825	8689
18		19840	8700				
19		19841	8938				
20		19842	8720				
21		19843	8714				
22		19844	8744				
23		19845	8682	8821		8890	8647
24		19846	8644	8819	8641		
25		19847	8672	8717	8641		
26		19848	8678	8839			
27		19849	8703	8745			
28		19850	8691		8694		
29		19851	8832	8931	8630	8944	8684
30		19852	8696	9030			
31		19853	8622	8747	8605		
32		19854	8746	8696	8624		
33		20049	8694	8789	8672		
34		20050	8670				
35		20051	8675	8616			
36		20848	8709	8597	8797		
37		20849	8685			8821	8686
38		20850	8685	8716			
39		20851	8664				
40		20852	8646	9162			
41		20862	8650	9364			
42		20863	8675				
43		20864	8672	8985	8700		
44		20865	8683	9003			
45		20866	8693	8794		9004	8669
46		20867	8600	9216		8798	8650
47		21579	8692	8671	8590	9251	8716
48		21582	8658			8714	8566
49		21585	8691	8969			
50		21586	8675	8849		8859	8666
51	M			9037		9060	8684
52	Resin oil	8548	8041	8762		8771	8654
53	Coal oil	9893		8611	8170	8666	8122
54	Spiritine	7830	7539			9896	
55	V	8600	8540	7852			
56	W	8619		8663		9679	8592
		8202		8831			
				8268	8169	8288	

M. A suspected sample of turpentine sent in for examination.
 V. Mixed fractions of turpentine boiling at 155° to 156°.
 W. A mixture of equal volumes of No. 53 and No. 55.

TABLE II *Concluded.*

SPECIFIC Gravity of Oil of Turpentine, and fraction of 10 p. c. volume.

Temp. 15.5° C.

Serial Number.	Description.	JUNE, 1901.		SEPTEMBER, 1901.		OCTOBER, 1901.	
		Sample.	Fraction.	Sample.	Fraction.	Sample.	Fraction.
		57	X	8698	.....	8726	.....
58	Y	.....	.....	8873	8646	.....	.....
59	Gasoline	.....	.....	7289	7185	7290	.....
60	T	.....	.....	8007	7412	8007	7473
61	S	.....	.....	.....	.....	.....	8598
62	R	.....	.....	.....	.....	8808	.....
63	P	.....	.....	.....	.....	7462	.....

X. and Y. Turpentine samples believed to be genuine.

T. A mixture of equal volumes of No. 57 and No. 59.

S. A mixture of turpentines, probably genuine.

R. A mixture of turpentines, probably genuine.

P. A substance sold for the purpose of adulterating turpentine.

In the accompanying table (II) I have arranged the observed specific gravities of a number of samples of turpentine oil. The specific gravity was determined in June, immediately after collection of the samples. These were contained in glass bottles of about 12 to 20 ounces capacity. After work upon them had been completed as far as was possible at that time, the samples were placed in a dark cupboard, the bottles being corked, and approximately half full of the sample. After three months it was found that the specific gravity had increased as shown in the columns headed 'September 1901.'

A third determination of the density, about a month later showed a further increase, in every sample examined, although in this case, the increase is less considerable.

The mean density found in June for 47 samples, is 0.8687. The highest density among these samples is 0.8832 and the lowest is 0.8622. From independent comparisons the genuineness of these two samples is questioned.

Thirty-two of these samples were examined after a period of three months, and their mean density was found to be 0.8982, an average increase of 0.0295, or 3.4 per cent. This increase is, however, very different in different samples. The most noted increases are as follows:—

No. 3—10.05 per cent,

" 11—10.08 "

" 40— 8.30 "

In certain samples the increase is slight; such samples are:—

No. 12— 2.37 per cent.

" 16— 1.35 "

" 22—0.88 "

" 24—0.61 "

" 26—0.79 "

" 32—0.48 "

" 37—0.36 "

There is, however, no exception to the fact of increase in weight. The volume of the sample left in each bottle was about 8 ounces. An increase of weight of 3 per cent upon this would mean the absorption of nearly 7 grammes (or 4.9 litres) of oxygen. Since no special precautions were taken in the closing of the bottles, and most of the corks had been perforated by a cork-screw, there can be no difficulty in accounting for access of oxygen; but it may be that some of the corks were too closely fitting to permit ready passage of air, so that no certain inferences can be drawn from those cases in which little increase in weight occurred.

If this study had been pre-arranged, I would have taken pains to expose the samples to atmospheric oxygen under defined conditions. The results above tabulated are only of value as showing the very large increase in density which results from oxidation. The maximum specific gravity quoted by Squire (1) 0.880, may be exceeded by a genuine sample as a result of exposure to air for a few months, so that, unless certain conditions of storage are fulfilled, a determination of specific gravity is of limited value in fixing the genuineness of oil of turpentine.

The only sample of Rosin oil (See No. 52) which I examined, had a specific gravity 0.9893 in June, and 0.9896 in October, so that during 4 months, the increase in density was insignificant. It was stored during this interval, in a loosely corked bottle.

Petroleum products likely to be used in turpentine adulteration have a lower density than any of the genuine samples examined. (See No. 53 and 59.) They show but a trifling increase of density, due probably to evaporation of the lighter constituents.

Spiritine shows an increase of density amounting to 0.92 per cent for 4 months. Whether a free exposure to air would elicit a greater increase is not known.

It is evident that admixture of petroleum with oil of turpentine would be indicated by a lower density as well as by a lower rate of increase in density through absorption of oxygen. No. 56, a mixture of coal oil and rectified turpentine in equal volumes, illustrates this. During three months the turpentine increased 2.46 p.c.

coal oil	"	0.28	"
mixture	"	0.80	"

Long (2) found 13 samples of oil of turpentine, distilled in his own laboratory, to vary from 0.8622 to 0.8655. With *pure* commercial samples he found the gravity from 0.8656 to 0.8748.

In order to eliminate as far as possible the influence of oxidation upon the samples, I distilled these, and collected apart the first 10 per cent by volume. The mean density of this fraction for 10 samples, presumably genuine, was found to be 0.8600 in June, 1901. (see Table II.) The highest gravity found among these was 0.8639 and the lowest 0.8560. The specific gravity of pinene is 0.858 at 20 C.(3).

In September, I fractionated in the same way, 8 samples, and obtained a mean density of 0.8651 for the first fraction of one-tenth volume.

In October, 5 samples were examined and a mean density of 0.8693 obtained.

1. Companion to B. P., 1899, 625.
2. Jour. Analyt. and App. Chem. VI., 2.
3. Richter. Org. Chem., Trans. II, 322.

The results may be summarized as follows:—

JUNE.		SEPTEMBER.		OCTOBER.	
Samples.	Fraction.	Samples.	Fraction.	Samples.	Fraction.
8671	8600	8811	8651	9035	8693

TABLE III.

DENSITIES OF RESIDUAL FRACTIONS OF ONE-TENTH VOLUME.

Serial Number.	Description.	June.	September.	Remarks.
9	19497	8639	.....
14	19835	8665	.....
15	19837	1 0142	.....	Adulterated with resin oil.
18	19840	8950	.....
21	19843	8758	.....
24	19846	.....	9125	
28	19850	8918	.....
32	19854	.....	9524	
34	20050	9502	.....
36	20848	9265	.....
38	20850	8891	.....
40	20852	8849	.....
41	20862	8724	.....
46	20867	.....	8973	Probably adulterated.
51	M	8949	9416	
54	Spiritine	8618	.....
60	T	.....	8532	Mixture turpentine and gasoline.
44	20865	.....	9600	
59	Gasoline	.....	7526	

Thus it is seen that although the first fraction of one-tenth volume increases in density, its rate of increase is very much less than that of the whole sample; and a fraction falling well within the limits for turpentine may be obtained from a sample of oil of turpentine which much exceeds these limits.

When a sample is adulterated with gasoline, or other adulterant of low density and boiling point, this constitutes the main part of the first fraction, and the sophistication is clearly indicated by the reduced gravity. See samples 51, 56 and 60.

When the distillation is carried on until 90 per cent of the sample comes over, there is usually left a residue of more or less well-defined brown colour. This contains the resins formed by oxidation, and any resin oil added as an adulterant. It sometimes happens that the temperature rises considerably above 180° C., before 90 per cent comes over. I have not as a rule carried the distillation beyond 200, and in a few cases a residue of more than 10 per cent of volume has then remained. In table III. I have given the densities of some of these residues. They are usually characterised by a high index of refraction and a well-marked odour of resin.

6. *Boiling Point.*—The boiling point of pinene is 155° C. Long (1) found the initial B. P. for pure commercial turpentines to be uniformly

(1) Jour. Analyt. and App. Chem. VI. 2.

155° to 156° C, and 85 per cent distilled over between this temperature and 163° C. He states that the distillation is practically complete below 185° C.

I have read the B. P. when 2 or 3 cc. from 100 cc. had distilled over, and I find this point, in presumably genuine turpentine, to vary from 153° C to 158°, (See Table VII). In most cases the B. P. is 155° to 156°; and it always rises to 155° before 5 per cent of the sample has come over.

The initial temperature of distillation appears to be but little affected by oxidation of the sample.

Rosin oil has an initial B. P. above 200° C.

Spiritine begins to distil at 151° C. The various fractions of petroleum which may be used to adulterate oil of turpentine, usually have lower boiling points than 150° C. Gasoline (No. 59) begins to distil at 90° C, and 90 per cent of its volume comes over below 114° C.

The effect of oxidation is to raise the B. P. of the last fraction. No general conclusions can, however, be drawn as to the rate of this increase, since these samples have not been oxidized under similar or definite conditions. The results, as observed, are summarized below.

Samples.		Initial Boiling Point for last fraction of 10 per cent volume.	
Serial Number.	Description.	June.	September.
7	19492	167°	198°
8	19495	169°	210°
12	19830	164°	179°
13	19833	163°	200°
16	19838	168°	170°
28	19850	167°	195°
35	20051	163°	186°
43	20864	164°	201°
44	20865	164°	174°
45	20866	167°	200°
48	21582	163°	196°
49	21585	175°	200°
51	M	164°	169°
54	Spiritine...	175°	175°
56	W	200°	250°
60	T	155°	159°
Mean for first 12 samples.		166°	192°

7. *Volatility*.—When the distillation of a sample of oil of turpentine is pushed to its furthest, there is always found a residuum which cannot be volatilized without decomposition. I find this to be true even in the case of a rectified oil of turpentine. The residue is usually very small, but sometimes amounts to nearly 10 per cent of the sample. This residue is resinous, and an attempt to volatilize it results in a decomposition which is probably analogous to the *cracking* of petroleum. An oil (resin oil) comes over, and a carbonised mass is left in the retort. Decomposition begins soon after a temperature of 210° C. is reached. It would be interesting to carry the distillation of a series of samples to this point, and to ascertain the weight of the residue. This would be a measure of the degree to which resinification had been carried, and might lead to the fixing of a number above which the addition of rosin or rosin oil should be indicated.

Vulpins (1) suggests the evaporation of 1 gramme of a suspected sample side by side with 1 gramme of a pure oil of turpentine, on watch glasses, floated on water kept at 80° C. This test assumes that pure turpentine so treated leaves a fairly constant amount of residue, an assumption which does not agree with my experience. Oxidation proceeds *pari passu* with evaporation, and since different turpentines have very different capacity for taking up oxygen (2) the residual resin must vary in amount. Even with a recently distilled oil of turpentine a decided residue is left on evaporating in an open dish. (See No. 55.) I have found that the conditions under which evaporation is conducted produce so large variation in the result, that unless the process is carried out with strict attention to detail the estimation has little value. If too small a quantity be operated on, the unavoidable variation due to error of experiment becomes relatively great.

The numbers given in the third column of Table IV, were obtained by evaporation of 25 grammes of the sample in a porcelain dish of 4 inch diameter and hemispherical shape. The dish was placed on a water bath, in contact with the water, (which was kept in vigorous ebullition), and was weighed from time to time until the residue ceased to lose more than a few milligrammes in 30 minutes. Even under these conditions duplicates were not always satisfactory, and in a few cases showed differences of 0.5 per cent when the total residue was less than 2 per cent.

The numbers in the fourth column of Table IV, were obtained by heating 10 grams of the sample, (spread over fibrous asbestos in a large sized Macfarlane tube (3) to 100° C. during 24 hours. I hoped in this way to secure a maximum oxidation and maintained a rapid current of hot air through the oven during the whole time of the experiment. The duplicates were very unsatisfactory, and I was led to conclude that the shape of the tube prevented access of air to the centre of the mass. On using a shallow tube, the numbers in column 5 were obtained, and duplicates were much closer. These percentages, bear no consistent relation to the residue obtained by drying in an open dish; and if they are functions of the capacity of absorbing oxygen from hot air, this fact has not been made clear by a study of other characters.

The numbers given in the next three columns were obtained by treating 10cc. of the sample, absorbed by 3 grammes of loosely packed fibrous asbestos contained in a shallow and wide Macfarlane tube, with a current of air at the ordinary temperature for 48 hours and for a second period of 24 hours. This was followed by exposure in a current of air at 100° C. for 24 hours. The object sought was to obtain a maximum oxidation of the sample under given conditions. The duplicates finally obtained are good. This may indicate that a method of working could be devised which should give some idea of the oxidizability of oil of turpentine, and thus afford a means of ascertaining whether the resinous residue has been produced by oxidation of the sample through long keeping, or has been added as an adulterant in the form of rosin oil. It has not been possible for me to further investigate this subject.

(1) Apoth. Zeit., 1891, 6, 289. Abstracted in Jour. Soc. Ch. Indus. 1891, 800.

(2) Kingzett, Jour. Soc. Ch. Indus, 1886, 7.

(3) Analyst, Vol. xvii, 79.

TABLE IV.

Serial Number.	Description.	Residue		Residue using Short tubes.	10cc. in Short tubes with 3 grms. Asbestos for successive periods of			Duplicates.
		evapora- tion in open dish.	Mac- farlane tubes - large		48 hrs. Cold.	24 hrs. Cold.	24 hrs. Hot.	
1	17330	2 864	21 14					
2	17331	1 064	21 21	17 30	32 02	23 66	6 30	(4 30
3	17332	1 348	26 64					16 31
4	17333	1 388	22 08					
5	17785	0 816	17 60					
6	17787		11 73					
7	19492	1 490	18 06	12 50	18 09	11 78	4 60	(4 53
8	19495	1 360						14 68
9	19497		23 60					
10	19499	1 196		9 40	18 80	10 25	3 63	(3 45
11	19500	1 436	22 20					13 81
12	19830	1 896		6 65	11 10	4 84	2 00	(2 14
13	19833	1 016						11 87
14	19835	1 932						
15	19837	5 988	31 70	22 22	40 37	32 71	12 16	(12 01
16	19838	1 324						112 30
17	19839	1 654						
18	19840	0 948						
19	19841	2 584	22 25					
20	19842	1 680						
21	19843	1 920						
22	19844	3 032						
23	19845	1 304						
24	19846	0 572						
25	19847	0 636						
26	19848	1 488						
27	19849	1 320						
28	19850	0 764						
29	19851	5 024		13 25	32 81	23 50	7 46	(7 46
30	19852	1 456						17 46
31	19853	0 732						
32	19854	3 340						
33	20049	1 272						
34	20050	0 816						
35	20051	0 872		6 58	16 52	7 64	2 78	(2 60
36	20848	1 564	21 00					12 97
37	20849	1 962	21 40					
38	20850	1 168						
39	20851	1 036						
40	20852	2 352						
41	20862	1 280						
42	20863	1 140						
43	20864	0 928						
44	20865	1 220						
45	20866	1 508		12 56	26 87	13 50	4 64	(4 48
46	20867	1 250		6 56	14 77	7 67	1 83	14 80
47	21579	1 296						(2 01
48	21582	0 468						11 65
49	21585	0 980						
50	21586	1 542	12 32					
51	M (1)	1 280	8 51	18 88	8 74	2 78		(2 69
52	Resin oil.	95 980						12 87
53	Coal oil.	10 272						
54	Spiritine.	1 400	7 42					
55	V (1)	2 400						
56	W (1)	7 268						
57	X (1)							
58	Y (1)							
59	Gasoline.	0 004						
60	T (1)							
61	S (1)							
62	R (1)	3 912						
63	P (1)	0 296						

(1). See explanatory note to Table II.

Petroleum products of low boiling point volatilize completely without oxidation. When the B.P. of the petroleum adulterant is high, a large residue is left (see No. 53) but this is of an oily character, not resinous; and when obtained in asbestos, is easily washed out with petroleum ether.

I think that determinations of vapour tension, made with an instrument on the same principle as Geissler's well known vaporimeter, might give useful indications, but I have not found time to investigate this point.

8. *Vapour Density.*—The molecular weight of pinene, $C_{10}H_{16} = 136$ corresponds to a vapour density of 68 (Hydrogen = 1), or 4.72 (air = 1). That of the paraffins which are generally used to adulterate oil of turpentine corresponds to a V.D. of about 57 (or 3.96). For a petroleum benzine distilling between 80° and 150°, Long (1) obtained a V.D. = 4.09. For a fraction of oil of turpentine distilled at 156° he obtained V.D. = 4.67; while fifteen commercial samples gave V.D. from 4.80 to 5.11.

I have repeatedly attempted the determination of the vapour density of oil of turpentine with Victor Meyer's apparatus, using methyl salicylate as a bath, but without satisfactory result. The temperature of boiling methyl salicylate (224° C.) is not high enough to secure the complete vaporisation of oil of turpentine. I have also tried a bath of Rose's metal kept as nearly as possible at 300° C. The results are better, but are not such as to justify expectation of the method proving available in assay work; at least until the glass vessel shall have been replaced by something less fragile. I am now experimenting in this direction, but results are yet too incomplete to justify publication.

9. *Flash Point.*—The usual flash point for oil of turpentine, according to Long, is 32° C. He used a Stoddard apparatus. (2).

Most of the petroleum products used to adulterate turpentine have a lower flashing point. Conradson (3) describes a so-called 'wood turpentine' having a flash point below 27° C. The following numbers have been obtained with Abel's well-known apparatus.

Serial Number.	Description.	Flash Point.
—	Turpentine spirit	32°
62	" " R	32°
57	" " X	28°
53	Coal oil	35°
59	Gasoline	20°
60	Mix turpentine and gasoline	23°
51	Sample M.	26°

The flash point is apparently a valuable indication of the presence of low boiling petroleum adulterants. It would, however, fail to detect mineral oils of flash test above 32° C.—such as the ordinary burning oils (kerosene).

(1) Jour. Analyt. and App. Chem. VI.

(2) American Chem. Jour.—4, 287

(3) Jour. Soc., Chem. Indus. 1897, 519.

10. *Viscosity*.—The viscosity of a sample of oil of turpentine having a sp. grav. 0.8710 at 12° C. was found by E. J. Mills to be 177.48 (water = 100 (1)).

The following determinations of viscosity were made with a viscosimeter which I designed in 1894. (2). A cylindrical nozzle of $\frac{1}{32}$ inch diameter was used.

Sample.	Temp. 20° C.	
	Seconds for 50 cc.	Ratio.
Water.....		
(S. g. 785) Coal Oil (No. 53).....	128.5	1.000
(S. g. 729) Gasoline (No. 59).....	181.0	1.408
T (No. 60).....	114.0	0.887
Turpentine.....	126.5	0.984
" + 5% Resin oil.....	157.5	1.226
" + 10% ".....	166.0	1.291
M. (No. 51).....	172.0	1.338
	153.0	1.191

No. 60 is a mixture of equal volumes of genuine turpentine with gasoline. It is evident from the above results that the admixture of a low gravity petroleum with turpentine could be detected by the change in viscosity. Also, that a mixture of petroleums could easily be prepared having the same viscosity as oil of turpentine. Since mineral oil is not chemically affected by contact with air, it is probable that a study of the change in viscosity produced by aspirating a current of air through turpentine (under conditions which should prevent loss by volatilization) might be made a simple and reliable means of detecting adulteration with petroleum products.

11. *Solubility*.—The solubility of oil of turpentine in glacial acetic acid is usually regarded as demonstrating the absence of petroleums. Care must be taken in using the test, for the following reasons:—(1) The presence of a very small amount of water suffices to determine the separation of the liquids. Hence, many commercial samples of glacial acetic acid fail to mix with oil of turpentine. (2) Petroleums of B. P. 150° to 200° C. may be present to the extent of nearly 50 per cent without affecting the solubility of oil of turpentine in glacial acetic acid. Light petroleums are easily separated by fractioning, and the test may be applied to the fraction boiling below 150° C.

Resin oil and spiritine are both quite miscible with glacial acetic acid.

12. *Solvent Power*.—I have examined the relative solvent power of spirit of turpentine and of certain adulterants for asphaltum in the following way: 10cc. of the sample is poured upon 1 gram of powdered asphaltum in a test tube and shaken at intervals for an hour. 1cc. of the resulting solution is filtered into a second tube, and the filtrate is diluted with 10 to 15cc. of the sample until a transparent solution is obtained. When genuine turpentine is treated in this way, it is found that a much darker solution is obtained than when petroleum is pre-

(1) Journal of the Society of Chem. Indus. 1886, 149.

(2) Canadian Record of Science, 1894, 153 and transactions Roy. Soc. of Can. 1895, p. 97.

sent, owing to the greater solvent power of turpentine. An approximate estimation of the quantity of mineral oil adulterant may be made by noting the relative depth of colour.

The process has been tested upon the following samples with the results given.

Serial No.	Description.	Intensity of colour.	Remarks.
46	20867	Very black	Doubtful sample.
	Genuine	" "	Pure.
51	M	Much lighter	Doubtful sample.
63	P	" "	Surrogate.
59	Gasoline	" "	Petroleum.
53	Coal Oil	" "	"

13. *Rotatory power for polarised light.*—Kingzett (1) asserts that the oxidisability of oil of turpentine and its capability of producing hydrogen peroxide varies much in different samples. Those having a high rotatory power are most marked in this regard, next coming those of very low rotation. He claims that American oil of turpentine is not readily oxidisable, and is not a prolific source of peroxide of hydrogen. H. E. Armstrong holds (2) that there are two terpenes (dextro and levoterebenthenes) represented by the essential components of French and Burmese oil of turpentine respectively, and that American and other turpentines are mixtures of these.

J. H. Long (3) finds American oil of turpentine to vary through wide limits in its rotatory power. He is of opinion that the presence of small quantities of the resin from *Pinus palustris*, which is strongly levorotatory

$$([\alpha]_D = -34.83)$$

may account for the left-handed rotation of many American samples. He notes the following peculiarities: 'After carefully fractionating distilled turpentine, the first portions possess a higher, both + and - rotation than the last portions. The lower rotation of the last fractions is probably not due to the presence of oxygenated bodies. Exposure to light appears to increase the specific rotation. In one case it did so from 16.15° to 17.08° in 50 days. Combination with oxygen during exposure to air increases the rotation. In one sample, air at 90° C. passed through for 55 hours, changed the rotation from 9.79 to 13.56.'

My results with these samples are stated in Table V. The readings made in June were made in a 20 cm. tube, using sodium light. The polarimeter was graduated in circular degrees, and the specific rotation is calculated by the usual formula—

$$[\alpha]_D = \frac{100 a}{2 \times sp. grav.}$$

(1) Jour. Soc. Ch. Indus., 1886-7.

(2) Proc. Chem. Soc., 1890, 99.

(3) Jour. Analyst and App. Ch., VI, 1.

The later readings were made with a triple field instrument of Schmidt & Haensch new pattern. I find that the solution of bi-chromate of potash recommended as a light filter (the white light of a small incandescent electric lamp is employed) is less satisfactory with turpentine than a solution of fuchsin red, (0.2 gramme per 100cc. water) which gives a very evenly lighted field. The scale is graduated in sugar degrees, and the specific rotation for this light is calculated by the formula—

$$[\alpha]_R = \frac{.352 \times a}{2 \times \text{sp. grav.}} = \frac{.176a}{\text{sp. grav.}}$$

The factor .352 was determined by reading a series of samples in both instruments, using the sodium flame for the circular polarimeter. The numbers obtained are therefore comparable with each other.

Of 51 samples of oil of turpentine examined, 5 proved to be levorotatory. The effect of keeping these samples in loosely corked bottles for three months has been to reduce the specific rotation in the three levorotatory samples which were examined at both dates.

Of the samples exhibiting dextro-rotation, only 9 show any marked reduction of rotatory power by keeping; 5 show a decided increase, and 11 are but little changed in this regard.

The specific rotation of the first distillate of $\frac{1}{10}$ volume is always higher than that of the sample; and this agrees with Long's observation.

TABLE V.
SPECIFIC ROTATION [S]_D for Oil of Turpentine.
20°

Serial No.	Description.	THE SAMPLE		FIRST FRACTION OF 1/6 VOLUME.		LAST FRACTION OF 1/6 VOLUME.	
		June.	Sept.	June.	Sept.	June.	Sept.
1	17330	-16.95	- 8.06				
2	17331	+15.53	+12.33				
3	17332	+16.46	+11.04				
4	17333	+ 5.00					
5	17785	+ 9.40					
6	17787	+ 9.07					
7	19492	+12.06	+12.13		+16.11		
8	19495	+ 4.23	+ 5.47		+ 7.47		
9	19497	+14.78					
10	19499	+11.96	+12.18				
11	19500	+14.01	+10.41				
12	19830	-16.43	-14.19		-15.26		
13	19833	+13.68	+14.29		+18.68		
14	19835	+13.67					
15	19837	+14.16					
16	19838	+ 4.17	+ 4.95		+ 7.74		
17	19839	- 4.87					
18	19840	-11.21					
19	19841	+11.35					
20	19842	+ 1.15					
21	19843	+15.63					
22	19844	+14.5	+13.95		+18.65		
23	19845	+14.22	+14.07				
24	19846	+14.41					
25	19847	+ 5.94	+ 6.85				
26	19848	+15.55	+15.51				
27	19849	+ 4.30			+ 7.09		
28	19850	+11.72	+12.77		+16.88		
29	19851	+12.45					
30	19852	+16.09	+14.97				
31	19853	-13.77	-12.92				
32	19854	+13.95	+14.22				
33	20049	+13.79					
34	20050	+17.12					
35	20051	+14.12	+13.12		+16.92		+ 1.37
36	20848	+14.06					
37	20849	+ 2.44	+ 1.68				
38	20850	+ 0.92					
39	20851	+ 3.31					
40	20852	+ 1.01	+ 2.97				
41	20862	+13.15					
42	20863	+12.10			+15.18		
43	20864	+13.83	+13.87		+18.37		
44	20865	+12.98	+12.87		+15.91		
45	20866	+12.59	+12.03		+17.60		
46	20867	+13.57	+12.46		+15.94		
47	21579	+16.87	+16.52				
48	21582	+17.03	+16.80		+20.92		
49	21585	+12.99	+12.93		+17.35		
50	21586	+15.37	+15.54		+19.44		+ 7.67
51	M (1)	+10.55	+ 8.79		+ 9.19		
52	Resin oil.						
53	Coal oil.	+ 0.00	+ 0.06				
54	Spiritine.	+11.45	+11.74		+14.54		+ 3.95
55	V (1)		+12.04				
56	W (1)		+ 4.77		+ 7.89		
57	X (1)		+11.49				
58	Y (1)		+ 1.33		+ 3.32		
59	Gasoline.		+ 0.12				+ 0.28
60	T (1)		+ 6.55		+ 3.70		+ 6.98
61	S (1)						
62	R (1)		+11.69		+13.61		
63	P (1)		- 0.35				

(1). See explanatory note at foot of Table II.

The rotation of the last fraction of one-tenth volume has only been read in the cases of two presumably genuine samples (Nos. 35 and 50). In these, as well as in the residual tenths from 54, 59 and 60, the specific rotation is very low. This also agrees with the results found by Long. Owing to the brown colour of this residue it is difficult to read the rotation even in a 1 dm. tube.

It is usually assumed that a low specific rotation indicates the presence of a petroleum or other not optically active adulterant. From the fact, however, that levorotatory samples are by no means infrequent (such samples make up 10 per cent of those herein reported) it is evident that a mixture of these with the dextrorotatory kind would lower the observed rotation, and might even produce a non-optically active mixture.

Spiritine has the same dextrorotation as an ordinary turpentine oil.

Aignan (1) states that the presence of resin-oil in turpentine is easily detected by the change in rotatory power, especially when a residual fraction is used in the experiment. This is doubtless true of French oil of turpentine, which is levorotatory—but it altogether fails with American turpentine.

The determination of optical activity does not appear to have any value for analytical purposes. Except in so far as a high rotation either + or — is an indication of genuineness.

14.—INDEX OF REFRACTION.

This has been determined by the use of the Abbe-Zeiss Refractometer of the older form, and not furnished with prism casings. Since changes of temperature greatly affect the readings, and the instrument is not easily maintained at any other temperature than that of the room, I have found it advisable to determine a correction factor, and have adopted $\pm .0005$ for 1° C. (See Table VI.) The readings have all been made within a few degrees of 20° C., and have been corrected to this temperature by the above factor. The correction is additive for temperatures above and subtractive for temperatures below 20° C.

The instrument was adjusted to read 1.3330 for water at 20° C.

(1) *Comp. Reud.* 124, 1367.

TABLE VI.

CORRECTION of Refractive Index for Temperature.

(Abbe's Refractometer.—The scale readings give three decimal figures; the fourth decimal is estimated by the observer.)

	No.	Temperature of Observation.	Observed Index of Refraction.	Differences for each 1° C.	Remarks.
Whole samples of turpentine.	17	31°	1.4687	} .00051	} The mean value for a difference of 1° C. is 0.000547.
		18°	1.4753		
	21	28°	1.4680	} .00051	
		18°	1.4731		
	58	32½°	1.4658	} .00062	
	18°	1.4745			
First fraction of one-tenth volume.	29	15°	1.4715	} .00050	} The mean value for a difference of 1° C. is 0.000437.
		18°	1.4700		
	31	16°	1.4703	} .00033	
		19°	1.4693		
	42	21°	1.4684	} .00048	
	17°	1.4703			
Last fraction of one-tenth volume.	29	18°	1.504	} .00050	} The mean value for a difference of 1° C. is 0.000477.
		15°	1.5222		
	31	20°	1.4845	} .00033	
		16°	1.4858		
	42	20°	1.5055	} .00050	
	17°	1.5070			

The average value for a difference of one degree centigrade is therefore 0.00049. A slightly higher value is observed in whole turpentines, and a somewhat lower value in the fractions obtained on distillations. I have adopted the uniform correction, $1^\circ = \pm .0005$, and when the reading is made at a temperature but a few degrees removed from 20° C., only a negligible error can result by using this constant.

TABLE VII.

REFRACTIVE Indices of Oil of Turpentine, at 20° C.

A. Observed in June, 1901.

B. Observed in September, 1901.

Serial No.	Description.	Letter of Reference.	REFRACTIVE INDEX.			Difference.	Boiling Point.
			The Sample.	First Fraction of $\frac{r_1}{r_2}$ Volume.	Residue of $\frac{r_1}{r_2}$ Volume.		
1	17330	A	1.4684	1.4677	1.4790	0.0113	155°-164°
		B	1.4797	1.4797	1.5111		157°
2	17331	A	1.4681	1.4622	1.4757	0.0095	153°-162°
3	17332	A	1.4682	1.4672	1.4806	0.0134	153°-164°
4	17333	A	1.4688	1.4675	1.4783	0.0103	154°-166°
5	17785	A	1.4678	1.4660	1.4816	0.0156	156°-164°
		B	1.4818				
6	17787	A	1.4682	1.4660	1.4837	0.0168	156°-164°
7	19492	A	1.4684	1.4660	1.4851	0.0191	155°-167°
8	19495	A	1.4685	1.4663	1.4859	0.0193	155°-169°
		B	1.4692				156°-210°
9	19497	A	1.4667	1.4648	1.4670	0.0022	154°-180°
		B	1.4830				
10	19499	A	1.4678	1.4656	1.4751	0.0095	153°-165°
11	19500	A	1.4679	1.4668	1.4852	0.0184	155°-164°
12	19830	A	1.4697	1.4676	1.4779	0.0103	155°-164°
		B	1.4754	1.4706	1.5153	0.0447	156°-179°
13	19833	A	1.4681	1.4662	1.4777	0.0115	156°-163°
		B	1.4695	1.4695	1.5164	0.0469	156°-200°
14	19835	A	1.4686	1.4665	1.4942	0.0277	155°-170°
15	19837	A	1.4726	1.4674	1.5049	0.0375	158°-200°
16	19838	A	1.4688	1.4664	1.4793	0.0129	156°-168°
17	19839	A	1.4722	1.4689	1.4832	0.0143	156°-167°
		B	1.4741				
18	19840	A	1.4721	1.4689	1.4810	0.0121	156°-165°
		B	1.4749				
19	19841	A	1.4751	1.4674	1.5138	0.0464	154°-200°
20	19842	A	1.4716	1.4684	1.4842	0.0158	157°-172°
		B	1.4729				
21	19843	A	1.4706	1.4668	1.4808	0.0135	155°-164°
		B	1.4712				
22	19844	A	1.4729	1.4673	1.4939	0.0266	114°
		B	1.4730	1.4692	1.5080	0.0388	154°-175°
23	19845	A	1.4705	1.4666	1.4842	0.0176	155°-170°
		B	1.4720	1.4697	1.5025	0.0326	155°
24	19846	A	1.4703	1.4669	1.4726	0.0057	156°-166°
		B	1.4707	1.4694	1.4833	0.0159	
25	19847	A	1.4702	1.4668	1.4756	0.0088	157°-165°
		B	1.4724				
26	19848	A	1.4705	1.4663	1.4790	0.0127	156°-166°
		B	1.4716	1.4693	1.4912	0.0219	
27	19849	A	1.4714	1.4670	1.4795	0.0125	155°-167°
		B	1.4740	1.4695	1.5119	0.0424	
28	19850	A	1.4707	1.4670	1.4787	0.0117	155°-167°
		B	1.4733	1.4698	1.4980	0.0282	155°-195°
29	19851	A	1.4725	1.4668	1.5322	0.0354	154°-179°
		B	1.4755	1.4690	1.5195	0.0505	
30	19852	A	1.4704	1.4670	1.4785	0.0115	156°-170°
		B	1.4719	1.4687	1.4900	0.0213	157°
31	19853	A	1.4682	1.4650	1.4676	0.0017	158°-185°
		B	1.4700	1.4683	1.4840	0.0155	
32	19854	A	1.4707	1.4660	1.4867	0.0227	155°-168°
		B	1.4716	1.4697	1.4943	0.0246	156°-168°
33	20049	A	1.4713	1.4661	1.4825	0.0164	155°-165°
34	20050	A	1.4673	1.4660	1.4780	0.0120	156°-162°
35	20051	A	1.4694	1.4667	1.4817	0.0150	155°-163°
		B	1.4683	1.4685	1.5085	0.0402	155°-186°
36	20848	A	1.4685	1.4661	1.4898	0.0232	155°-170°
		B	1.4708	1.4649	1.4900	0.0291	155°

TABLE VII—Continued.

REFRACTIVE INDICES of Oil of Turpentine, at 20° C.—Concluded.

Serial No.	Description.	Letter of Reference.	REFRACTIVE INDEX.			Difference.	Boiling Point.	
			The Sample.	First Fraction of $\frac{1}{10}$ Volume.	Residue of $\frac{1}{10}$ Volume.			
37	20849	A	1.4688	1.4650	1.4871	0.0223	155°-165°	
38	20850	A	1.4701	1.4673	1.4787	0.0114	155°-165°	
39	20851	A	1.4701	1.4679	1.4800	0.0130	155°-165°	
		B		1.4717			155°	
40	20852	A	1.4672	1.4659	1.4758	0.0089	157°-174°	
41	20862	A	1.4696	1.4657	1.4712	0.0055	155°-175°	
		B		1.4665				
42	20863	A	1.4706	1.4667	1.4843	0.0175	154°-166°	
		B		1.4755	1.4688	1.5055	0.0367	156°
43	20864	A	1.4697	1.4660	1.4764	0.0104	155°-164°	
		B		1.4763	1.4717	1.5148	0.0437	155°-201°
44	20865	A	1.4696	1.4663	1.4805	0.0142	155°-164°	
		B		1.4694	1.4985	0.0291	156°-174°	
45	20866	A	1.4706	1.4659	1.4819	0.0160	155°-167°	
		B		1.4816	1.4701	1.5196	0.0495	156°-200°
46	20867	A	1.4651	1.4625	1.4626	0.0001	155°-186°	
		B		1.4685	1.4658	1.4780	0.0122	
47	21579	A	1.4710	1.4662	1.4787	0.0125	156°-167°	
48	21582	A	1.4688	1.4666	1.4743	0.0078	156°-163°	
		B		1.4749	1.4696	1.5091	0.0395	156°-196°
49	21585	A	1.4700	1.4661	1.4857	0.0196	155°-175°	
		B		1.4689	1.5150	0.0461	155°-200°	
50	21586	A	1.4692	1.4670	1.4796	0.0126	155°-170°	
		B		1.4723	1.4691	1.4919	0.0228	
51	* M	A	1.4627	1.4437	1.4759	0.0322	131°-164°	
		B		1.4679	1.4466	1.4951	0.0485	
52	Resin oil	A	1.5398				200°+	
53	Coal oil	A	1.4341				171°-200°+	
54	Spiritine	A	1.4701	1.4654	1.4788	0.0134	151°-175°	
		B		1.4722	1.4698	1.4891	0.0193	154°-175°
55	* V	A	1.4763				155°-156°	
56	* W	A	1.4507	1.4506	1.4562	0.0056	154°-200°+	
		B		1.4538	1.4494	1.4565	0.0071	154°-250°+
57	* X	A	1.4700	1.4660	1.4733	0.0073		
58	* Y	A	1.4737	1.4696	1.4985	0.0289	157°-172°	
59	Gasoline	A	1.4668	1.4633	1.4231	0.0198	96°-114°	
60	* T	A	1.4398	1.4178	1.4770	0.0592	93°-155°	
62	* R	A	1.4733	1.4647			155°-174°	
63	* P	A	1.4175					
	Water	A	1.3336					

* See explanatory note at foot of Table II.

The mean index of refraction for 42 samples of oil of turpentine is 1.4694 at 20° C. The extremes among these samples are 1.4667 and 1.4722. It is matter of observation that wherever these numbers have been exceeded, the sample has been found to be suspicious upon other grounds.

The refractive index of rosin oil is so much higher than that of oil of turpentine, that the admixture of a few per cent causes a notable rise. At the same time, it is evident that the resinous bodies which result from atmospheric oxidation of the turpentine act like rosin oil in this respect. These are for the most excluded from the first fraction of one-tenth volume, and the refractive index of this fraction shows a remarkable uniformity. It may be taken as averaging 1.4670 when distilled from a newly opened barrel of turpentine; and when distilled from a sample long exposed to the air, it rarely exceeds 1.4700.

I had hoped to be able to make use of the difference between the refractive indices of the first fraction, and the residual tenth, but this number varies so much in consequence of the ageing of the sample, that it does not appear to be available for analytical purposes. The absolute magnitude of the refractive index for the residual tenth is a good indication of the extent to which the sample has undergone oxidation, or to which rosin oil, or similar adulterant of high specific refraction, has been added. In genuine samples, which have not been unduly exposed to air, it should apparently not exceed 1.4850. The difference between the refractive indices of the first and last fractions of normal samples is therefore about 0.0180. There are, however, several notable exceptions among the samples tabulated (see Nos. 9, 31 and 46) and it is worthy of remark that, although two of these samples are passed as probably genuine upon the whole results of analysis, their specific gravity is exceptionally low. The indications of the difference column must evidently be interpreted in conformity with the reading of the first fraction. Where this is abnormally low, (see No. 59) the number in the difference column considered by itself, may be misleading.

Spiritine (No. 54) behaves very like turpentine in regard to refraction. Other adulterants are characterised by much higher (rosin oil) or much lower refraction numbers. (See 53, 59, 63.)

15. *Fluorescence*.—I have not been able to make the fluorescence of petroleum serviceable for its detection or estimation in presence of oil of turpentine. Mr. Kenrick has recorded a blue fluorescence in samples 17330, 17331, 17332, 17333. These samples he considers genuine.

16. *Oxidizability*.—The property of taking up atmospheric oxygen with the formation of resinous products of higher gravity and boiling point than oil of turpentine itself, naturally affects the sample in these two particulars, as has already been mentioned under Sections 5, 6 and 7. Engler (2) states that half of the oxygen at first absorbed is in the active condition, and subsequently performs intramolecular oxidation.

The ready polymerization and conversion of oil of turpentine into soluble compounds under the influence of strong sulphuric and nitric acids has been proposed for the quantitative separation and estimation of petroleum adulterants which are but little influenced by these oxidants.

The use of sulphuric for this purpose seems to have been suggested by H. E. Armstrong (1.) The sample is treated with sulphuric acid and the portion unacted upon is distilled off in a current of steam. This is treated a second time, and, if necessary, a third and fourth time, till the acid has no further effect upon the material. I have found the process fairly satisfactory, but very tedious, and not suited for the practical examination of commercial samples, where time is a consideration.

Oxidation by fuming nitric acid has been proposed by Burton (1.) In my hands it has not proved a success. If the temperature be allowed to rise, there is certainty of loss of material, and if it be kept down, as recommended, by immersion of the decomposing flask in water, the reaction does not occur with regularity or certainty, and the addition of turpentine cannot be regulated so as to prevent violent and dangerous explosions. It may be that further experience would over-

(1.) Jour. Chem. Soc., 1890, 99.

(2.) Abst. in Jour. Soc. Chem. Indus. 1900, 682.

(1.) Amer. Chem. Jour., 12, 102.

come these difficulties. The method has been approved by Long and others.

My attempts to bring about atmospheric oxidation under fixed and constant conditions are described in Section 7.

17. *Bromine Absorption*.—F. Evers (1) proposes the decolorization of bromine water by oil of turpentine as a way of distinguishing it from mineral adulterants.

Schreiber and Zetzche (2) improve upon this suggestion by modifying the details of the process, as follows:—

The sample is prepared by dissolving 1cc. in 49cc. alcohol (90–95 per cent.)

Solution (1).—Bromide of potassium 50 grammes and bromate of potassium 15 grammes, in 1 litre of water.

Solution (2). Dilute sulphuric acid, 1:3.

20cc. of the prepared sample is treated with 20cc. of each solution, and the mixture shaken for half a minute, the temperature being kept as near 20° C. as possible.

Genuine spirit of turpentine decolorizes this solution.

I have found this to work fairly satisfactorily with four samples of genuine turpentine spirit. The decoloration was complete in one case, and nearly so in the others. Coal oil, gasoline and rosin oil, failed to decolorize the bromine solution. Oil of turpentine with 20 per cent of coal oil was easily distinguished from the unadulterated article, but 10 per cent coal oil gave only a doubtful indication.

18. If oil of turpentine be mixed with about 4 volumes of a mineral oil (coal oil) the addition of strong sulphuric acid produces little or no charring, and the rise of temperature is gradual. In the following experiments, 10cc. of strong sulphuric acid was added with constant stirring, to a mixture of 10cc. turpentine with 40cc. of ordinary kerosene (coal oil). The beaker containing the turpentine mixture was placed in a larger beaker, the intervening space being filled with fibrous asbestos.

The coal oil used to dilute the turpentine was found to produce a rise of 3.4° C. on mixing 50cc. with 10cc. sulphuric acid. Two samples of turpentine gave (a) 57° (b) 57° mean=57° C. and (a) 54.8 (b) 52.9 mean=53.9°—while the sample, No. 63 of the tables, gave (a) 10.9 (b) 10.4, mean=10.7° C.

The initial temperature was, in each experiment, nearly that of the room. Further investigation of this test will be made.

(1.) Chem. Centralb., 1898, 865.

(2.) Chem. Zeit., 1899, 696. Abstracted in Jour. Soc. Chem. Indus., 1899, 949.

SYNOPSIS of results pointing to adulteration.

Character.	Serial Number of Sample.																			
	1	9	12	13	14	15	16	19	22	29	31	32	34	36	40	41	44	46	51	
Colour abnormal.....						x					x									
Clearness of first fraction.....		x									x									x
Odour abnormal.....																				x
Density abnormally low in sample.....																				x
Density abnormally high in sample.....						x					x									x
Density abnormally low in fraction.....		x						x		x										
Density abnormally high in residue.....		x									x									x
Boiling point abnormally low.....							x							x	x	x				
" " " high.....								x												x
Residue abnormally high.....		x										x								
Flash point abnormally low.....						x			x	x	x					x				
Viscosity ratio low.....																				x
Solubility in acetic acid incomplete.....																				x
Index of refraction high.....			x	x	x			x	x		x								x	x
" " " low.....																				x
Summary.....	1	3	1	1	1	6	1	4	2	6	4	1	1	1	3	1	1	1	4	8

In the accompanying synopsis I have arranged the results of my tests as applied to the samples collected. It will be seen that 9 samples give abnormal indications in regard to two or more characters. The identifying numbers are as follows:—

Serial Numbers.	Description.	Remarks.
9	19,497	Probably contains petroleum.
15	19,837	Contains rosin oil.
19	19,841	Probably contains rosin oil.
22	19,844	May contain rosin oil.
29	19,851	Probably contains rosin oil.
31	19,853	May contain petroleum.
40	20,852	" " "
46	20,867	Contains mineral oil.
51	M	" "

It occurred to me that the determination of the heat of combustion might furnish numbers which would have value in discriminating between genuine and adulterated turpentines. My friend Dr. H. C. Sherman of Columbia College, New York, was good enough to determine (with the bomb calorimeter) the calorific values for three samples, viz:—

No. 53—(Coal oil).....(a) 11168
 (b) 11176
 (c) 11198

Mean = 11184 calories per gram at constant volume.

No. 54—(Spiritine)..... (a) 10568
 (b) 10546

Mean = 10557 calories per gram at constant volume.

No. 55—(Genuine turpentine).. (a) 10813
 (b) 10788

Mean = 10801 calories per gram at constant volume.

The comparatively small differences shown make it very doubtful whether useful indications could be obtained. It may be possible at some future time to further investigate this subject.

The following is an attempt to define oil of turpentine on the basis of the work just recorded. The definition must be regarded as provisional, and subject to correction and amplification.

Oil of turpentine is a liquid, *colourless* in thin layers, and having a *yellow-red* tint, equivalent to about 1 unit of yellow and 0.1 unit of red (Lovibond scale) when viewed in a column 2 dm. long. *Clear*, but made decidedly opaque by shaking with 0.1 per cent water, and giving an *opaque distillate* of one-tenth volume, which settles clear in a few hours. *Odour* peculiar and characteristic, quite distinct from that of gasoline, rosin oil or acetone, and capable of disguising these odours to the extent of 10 per cent admixture. *Density* between 0.860 and 0.880, (usually about 0.870)—but samples which have been long exposed to air may have a higher density. The *first fraction* of one-tenth volume, has a density between 0.856 and 0.870 (usually about 0.860). The *residual tenth* should not exceed 0.900. The *Boiling point* should lie between 154° and 158° C., and nine-tenths should distil below 180° C. The *fixed residue*, on evaporating over boiling water in a 4 inch, hemispherical dish, should not exceed 2 per cent. The *viscosity*, at 20° C., should be nearly 1.230 (water = 1.000)—McGill viscosimeter. *Flash point* should be about 32° C.—(Abel instrument.)—Should *dissolve* completely in an equal volume of glacial acetic acid, and the first fraction should similarly dissolve. A *saturated solution* of asphaltum should not be rendered translucent by dilution to ten volumes. (This test is best made by comparison with a sample of known purity.) The *optical activity* of the first fraction should increase in a + direction by oxidation. The *refractive index* at 20° C. should lie between 1.4667 and 1.4722. That of the first fraction should not exceed 1.4700. Moistened iodide of starch paper should become blue when suspended over turpentine exposed to air. *Free Bromine* in solution (*see* Section 17) should be decolorized. *Strong sulphuric acid* should polymerize and char the sample at a boiling temperature. A *rise of temperature* (*see* Sec. 18), should result on mixing with sulphuric acid.

NOTE.—I may mention that an investigation is now being carried on with a view to utilizing the specific heat of oil of turpentine as a means of determining its purity. There is a sufficient difference between the specific heat of oil of turpentine and that of hydrocarbons of the paraffin series, to make this determination available, if a sufficiently simple and yet accurate apparatus could be devised for carrying it out.

A. MCGILL

