

## WEST AUSTRALIAN "SANDALWOOD OIL."

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### INTRODUCTION.

The oil commonly called West Australian sandalwood oil, like the West Indian oil, is not a true sandalwood oil, as it is obtained from a species of wood quite different from the *Santalum album* Linn., from which the East Indian oil is manufactured and belongs to a different genus. It is the essential oil obtained by the steam distillation of the wood of *Fusanus spicatus*, R. Br., a tree originally known as *Santalum cygnorum*, Miq. The Western Australian Year Book issued in 1902 has the following note about this tree.

'The sandalwood, although only a tree or shrub, is an important factor in the timber industry of Western Australia. The species is somewhat peculiar in its appearance and certainly has more of the character of a large bush than of a tree proper. It has a low, depressed habit and is consequently decidedly branchy and heavily topped. It is seldom more than eight inches in diameter and 12 to 18 feet high, with stems 8-10 feet long.'

It grows over an area more than twice as large as that of Great Britain and is quite different from *Fusanus acuminatus*, R. Br., formerly known as *Santalum Preissianum*, Miq., which grows wild to a certain extent in South Australia, and from which Berkenheim has isolated a solid sesquiterpene alcohol,  $C_{15}H_{24}O$  melting at 101-103.<sup>1</sup>

The value of the wood exported from Australia is given as £96,050 in 1882 when the price was £10 per ton and £117,072 in 1918-19 when the price of wood was £13 per ton.<sup>2</sup> Most of the wood finds its way to China and to a small extent to other eastern countries. Within recent years increasing quantities of wood have been imported into India as shown by the following figures:—

Year	...	.... 1914-15	1916-17	1917-18	1918-19	1920-21 (10 months.)
Value of imported wood	...	£8,372	£11,080	£16,080	£29,860	£30,370.

<sup>1</sup> J. Russ. Phys. Chem. Soc., 1892, 24, 688.

<sup>2</sup> Perf. and Essent. Oil Rec., 1920, 11, 88.

The yield of oil from the wood is 2 to 3 per cent. as compared with a yield of 5-6 per cent. for the genuine East Indian sandalwood (*Santalum album*). The oil was first distilled in 1875 by Messrs. Schimmel & Co., of Leipzig, and subsequently the distillation was undertaken in Freemantle. In 1918-19 3,720 lbs. of oil were distilled in Australia and found a market in Australia and Java, as a substitute for East Indian sandalwood oil in both perfumery and medicine. For perfumery purposes it does not appear to rank as an equivalent for East Indian oil as indicated by the following quotation from the *Perf. Essent. Oil Rec.*<sup>1</sup> 'It may be well to state the experiences of the users of West Australian oil for years that they have never found it equal in quality to the East Indian oil and have consequently confined its employment to second quality soaps and perfumes.' According to statements in the *Perf. Essent. Oil Rec.*<sup>2</sup> medical practitioners in Australia claim that medicinally its effects are as good as those obtained with East Indian oil, and in the same communication it is stated that the oil does not contain santalols but a closely related alcohol.

Although this essential oil has been known for some time it is noteworthy that up to the present very little of a definite character has been ascertained respecting the nature of its constituents.

Parry<sup>3</sup> gives analytical values for four samples of oil and also states that the distillation water of the oil contains traces of methyl alcohol, diacetyl and furfurol. Two samples of the oil have been analyzed at the Imperial Institute.<sup>4</sup> A sample of oil was distilled in these laboratories in 1919 from a parcel of wood obtained from Australia and its analytical constants determined; later a sample of oil supplied by Faulding & Co., of Adelaide, Perth and London, was analysed. All the analytical data are given in Table I.

It is clear from these data that the alcohol content calculated as santalol,  $C_{15}H_{24}O$ , falls below that required for the different pharmacopœias for genuine sandalwood oil, viz. 90 per cent., but as the oil contains low boiling constituents it is comparatively easy to fractionate the oil and so obtain a product with an alcohol content of more than 90 per cent. The oil as distilled from the wood does not pass the B.P., Am. P or J.P. IV. solubility tests but by eliminating some of the lower boiling constituents it is possible to obtain an oil passing the B.P. and Am. P. solubility tests. The chief difficulty met with in introducing the West Australian oil as a substitute for East Indian oil is the difference in optical rotation between the two oils.

<sup>1</sup> 1919, 10, 52.

<sup>2</sup> 1920, 11, 88, 292.

<sup>3</sup> *The Chemistry of Essential Oils*, 1918, vol. i, p. 183.

<sup>4</sup> *Bull. Imp. Inst.*, 1920, 18, 163.

The official requirements of the different pharmacopœia are—

	Rotation.
B.P., 1914	.... - 13 to - 21° at 20°.
Am. P., 1914	.... - 15 to - 20° at 25°.
J.P. IV., 1920	.... - 15 to - 20°.

The values of  $[\alpha]_D$  for the various samples of West Australian oil given in Table I show that none of the samples possesses an optical rotation approximating to these requirements. And experiments made in these laboratories (p. 167-169) prove that no method of fractional distillation yields products with rotations required by the pharmacopœia.

Experiments on fractional distillation have been made in the laboratories of the Imperial Institute and it is claimed<sup>1</sup> that when 30 per cent. of the oil is removed by fractional distillation under a pressure of 7-11 mm., the total alcohol content of the two fractions is less than that of the original oil, in other words in all probability a decomposition of alcohols into sesquiterpenes occurs during distillation. We have repeated these experiments but have not been able to confirm the results. The Imperial Institute authorities state that when the alcohols of the West Australian oil are oxidised by Chapman and Burgess' method<sup>2</sup> using 5 per cent. permanganate the same santalenic acid,  $C_{13}H_{20}O_2$  (m.p. 76°), as is obtained by oxidising santalol, is formed only in smaller quantity, viz. 8 per cent. as compared with 24 per cent., and hence conclude that a santalol is present but only in small quantities.

Somerville<sup>3</sup> has carried out an investigation on the solubility of the West Australian oil in alcohol-water mixtures of different strengths.

The work described in this paper comprises the following :—

(1) Determination of the analytical constants of two samples of West Australian oil.

(2) The distillation of the oil under reduced pressure and determination of the total alcohol content of the undistilled oil and of the fractions.

(3) Isolation of the alcohols by conversion into the hydrogen phthalates and careful fractionation of the recovered alcohols in order to ascertain whether any fractions corresponding in properties with either  $\alpha$  or  $\beta$  santalol could be isolated.

<sup>1</sup> *Bull. Imp. Inst.*, 1920, 18, 164.

<sup>2</sup> *J. Chem. Soc.*, 1901, 79, 134.

<sup>3</sup> *Perf. and Essent. Oil. Rec.*, 1922, 13, 261.

## EXPERIMENTAL.

1. *Analytical Constants.*

In Table I are given the values for two different samples of oil, the one a sample obtained by the steam distillation of wood received from Australia and the other a sample of oil obtained from Messrs. Faulding & Co. The yield of oil from the wood was 2.97 per cent. Side by side with the values found are given the values obtained by other authorities and also the requirements of the B. P. for genuine Sandalwood oil.

TABLE I.

*Analytical constants of West Australian sandalwood oil.*

	A	B	C	D	B. P. limits for East Indian oil.
Sp. gr. at 15/15° ...	0.957	0.970	0.958	0.972	0.973 to 0.985
Refractive index at 25° ...	1.5019	1.5040	1.5030	1.510	1.498 to 1.508
Optical rotation at 25° ...	- 7.7°	- 0.7°	- 0.25°	- 0.87°	- 13 to - 21°
Solubility in six parts of 70 per cent. (by volume) alcohol at 20° ...	Insoluble	Insoluble	Insoluble	Insoluble	Clear at 20°
Total alcohols calculated as santalol, C <sub>15</sub> H <sub>24</sub> O ...	80.0	69.3	76.3	78.5	Over 90 per cent.
Esters calculated as santal- yl acetate ...	2.4	6.5	2.3	3.8	...
Acid value ...	...	5.0	2.9	4.2	...

A = Sample of oil distilled in these laboratories.

B = Sample of oil from Messrs. Faulding & Co.

C and D are samples examined at the Imperial Institute.

The values given by Parry are :—

Sp. gr. 15/15° ....	0.9643 to 0.9650.
Alcohols ....	65 to 75 per cent.
Esters ....	1.3 to 1.6 ,,
Rotation ....	+ 5 to + 8°.

*Distillation of West Australian oil under atmospheric and under reduced pressure.*

A sample of oil B was distilled under atmospheric pressure and three fractions collected and examined: the following values were obtained.

TABLE II.

II. *Distillation of West Australian oil under atmospheric pressure (683 mm.).*

No. of fraction	B. P.	Weight in grams	Percentage weight	$n_D^{25}$	Optical rotation at 25°
1	258-280	3.2	21.3	1.4994	- 2.0
2	280-285	3.1	20.0	1.5014	- 1.1
3	285-309	7.0	46.6	1.5079	+ 1.2

During the distillation fumes and an empyreumatic odour were observed, indicating partial decomposition.

The oil was saponified and then distilled under reduced pressure (7 mm.) and three fractions collected and examined, more particularly with reference to alcohol content. The results of two separate experiments are given in Table III-A and B.

TABLE III.

*Distillation of saponified West Australian oil under 7 mm. pressure.*

	No. of fraction	Temperature in degrees C.	Weight in grams	Percentage	Alcohol Content per cent.	Weight of Alcohol in grams	Optical rotation	Refractive index at 25°
A 162 grams	1	120-140	21	13	37.0	7.9	- 4.36°	1.4955
	2	140-157	26	16	52.3	13.1	- 3.56°	1.4976
	Residue	...	115	71	77.9	89.2	...	1.5096
B 94 grams	1	109-126/5 mm.	9	9.6	31.2	2.9	- 4.6°	1.4947
	2	126-140/5 mm.	19	20.2	53.0	10.0	- 3.43°	1.4982
	Residue	...	66	70.2	79.0	52.0	...	...

In Experiment A 162 grams of saponified oil were taken with an alcohol content of 69.3 per cent. calculated as santalol,  $C_{15}H_{24}O$ , and hence corresponding with 112 grams of alcohol. The total alcohol content of the three fractions was 110.2 grams.

In Experiment B 94 grams of oil containing 65.1 grams of alcohol ( $C_{15}H_{24}O$ ) were used and the three fractions contained 64.9 grams of alcohol ( $C_{15}H_{24}O$ ).

These results indicate that there is no appreciable destruction or loss of alcohol calculated as  $C_{15}H_{24}O$  during distillation under pressures of 5 or 7 mm.

A 50 grams sample of the oil was subjected to steam distillation, 44 per cent. passed over with the steam and 56 per cent. remained in the flask. The analytical data for the two portions are given in Table IV.

TABLE IV.

*Steam distillation of West Australian oil.*

	Distillate 44 per cent.	Residue 56 per cent.
Ref. Index at 25°	1.5035	1.5062
Opt. rotation at 25°	-2.0°	-0.2°
Solubility in 6 volumes of 70 (by vol.) per cent. alcohol at 20°	Insoluble	Clear at 18.5°
Alcohol content as $C_{15}H_{24}O$	44.5 per cent.	89.4 per cent.

The 50 grams of original oil contained 34.65 grams of alcohol ( $C_{15}H_{24}O$ ) and the combined distillates contained 34.7 grams of alcohol, proving that no destruction of alcohol had occurred during the distillation.

### 3. ISOLATION OF ALCOHOLS FROM THE SAPONIFIED OIL.

#### A. *Fractional distillation of the saponified oil.*

200 grams of the original oil were saponified with alcoholic potash, washed, dried with anhydrous potassium carbonate and subjected to fractional distillation under a pressure of 9-10 mm. using a pear-shaped fractionating column with five pears.

From 180 grams of saponified oil 17 fractions and a residue were obtained and the analytical data for these fractions are given in Table V.

TABLE V.

*Fractional distillation of saponified West Australian oil.*

No. of fraction	Pressure in mm.	Temp. in degrees C.	Weight in grams	Optical rotation at 25°	Refractive index at 25°	Soluble in 6 vols. of 70 per cent. alcohol	Alcohol C <sub>15</sub> H <sub>24</sub> O per cent.
1	13	135-150	6.4	-4.8	1.4942	Insoluble	...
2	Do.	150-153	9.4	-4.6	1.4963	do.	...
3	Do.	153-158	10.5	-4.2	1.5001	do.	...
4	Do.	do.	8.6	-3.6	1.5000	do.	...
5	Do.	158-160	6.5	-3.5	1.5006	do.	...
6	Do.	160-164	5.1	-2.6	1.5004	do.	...
7	Do.	do.	12.1	-1.6	1.5022	Clear at 60°	...
8	9-10	164-166	8.9	-1.3	1.5034	do. 45°	73.3
9	Do.	do.	6.4	-1.1	1.5041	do. 35°	...
10	Do.	do.	10.3	-1.0	1.5048	do. 26°	...
11	Do.	166-168	8.4	-0.9	1.5059	do. 20°	...
12	Do.	do.	7.1	-0.6	1.5065	do. 14°	...
13	Do.	do.	8.2	-0.3	1.5067	do. 13°	87.9
14	Do.	do.	6.5	+0.3	1.5092	do. 6°	...
15	Do.	168-172	6.6	+1.5	1.5101	do. 2°	95.1
16	Do.	do.	7.0	+1.6	1.5103	do. 3°	...
17	Do.	do.	22.2	+1.4	1.5096	do. 28°	87.9
Residue	...	...	25.2	...	...	...	...

15 grams from Fraction 17 was redistilled under a pressure of 18 mm. and two fractions collected, and these gave the following analytical values:—

No. of fraction	Boiling point	Weight in grams	Optical rotation at 25°	Refractive index at 25°	Soluble in 6 vols. of 70 per cent. alcohol	Alcohol per cent.
17-1	168-178	4.0	+1.3	1.5062	Insoluble	78.9
17-2	178-180	7.0	+2.5	1.5096	Below 0°	99.8

Fraction 17-2, which constitutes 6.1 per cent. of the original oil and which has a specific gravity of 0.9783 at 15°, corresponds in properties with one of the alcohols ( $\beta$ -fusanol) isolated by the phthalate process.

For purposes of comparison the fractions obtained by distilling East Indian sandalwood oil under a pressure of 13 mm. are given in Table VI together with the more important constants for the fractions.

TABLE VI.

*Distillation of East Indian Sandalwood oil under a pressure of 13 mm. (230 grams.)*

No. of fraction	Weight in grams	Temperature in degrees C.	Optical rotation at 25°	Refractive index at 25°
1	7	to 165	-17°	1.5008
2	108	165-172	-13°	1.5059
3	45	172-176	-21°	1.5067
4	30	176-180	-30°	1.5085

It is clear that, after the removal of the lower boiling sesquiterpene fraction, the remaining fractions give rotations which tend to become more and more negative, owing to the presence of  $\beta$ -santalol (which has  $(\alpha)_D = -42^\circ$ ) in the East Indian oil. The West Australian oil, on the other hand, yields fractions which become less negative as regards rotation as the temperature rises and which finally give positive values. The properties of the fractions obtained from the West Australian oil preclude the possibility of the existence of  $\beta$ -santalol in the oil.

B. *By conversion into the hydrogen phthalate esters, and subsequent hydrolysis.*

The method adopted was that first introduced by Haller for the separation of terpene alcohols<sup>1</sup> and subsequently used by Guerbet<sup>2</sup> by von Soden and Muller<sup>3</sup> and by Semmler.<sup>4</sup>

<sup>1</sup> *Compt. rend.*, 1889, **108**, 1308; 1896, **122**, 865.

<sup>2</sup> *Bull. Soc. Chim.*, 1900, **23**, 542.

<sup>3</sup> *Pharm. Zeit.*, 1899, **44**, 258.

<sup>4</sup> *Ber.*, 1910, **43**, 1893.



To prepare the hydrogen phthalate 50 grams of the saponified oil were mixed with 50 grams of freshly sublimed phthalic anhydride and 25 grams of thoroughly dry benzene and the whole heated at 110-120° during ten hours in a flask fitted with a reflux condenser. The product was cooled, mixed with an equal volume of water, and sodium hydroxide solution added gradually until the mass was just alkaline to phenolphthalein. To remove all oil not converted into the hydrogen phthalate the mass was shaken several times with ether, in fact until the ethereal layer was colourless. The clear alkaline liquid was acidified with concentrated hydrochloric acid and the oily phthalate which separated removed, washed with water and dried and then weighed 25 grams. As there was still an appreciable amount of alcohols in the oil which had been washed out with ether, this was again treated with phthalic anhydride and benzene and the total yield of acid phthalate was 48 grams.

Another portion of saponified oil (60 grams) was treated in the same manner and gave 62 grams of the acid phthalate.

To recover the alcohols from the acid phthalates, the latter were heated with excess of alcoholic potash on the water bath using a reflux condenser. The precipitated potassium salt was removed by filtration and the solution again heated to ensure complete saponification. The ethyl alcohol was then removed by distillation and the residual oil washed with water until neutral and then dried with anhydrous potassium carbonate.

From 110 grams of the acid phthalate 60 grams of alcohols were obtained in place of the theoretical yield of 68 grams assuming the alcohols to have the composition represented by the formula  $C_{15}H_{24}O$ .

The acetyl value of the alcohols was found to be 214.3 corresponding with 100.3 per cent. of an acetyl derivative of the alcohol  $C_{15}H_{24}O$ . The sp. gr. at 15° was 0.977, the refractive index at 25° 1.5086 and the optical rotation at 25° + 5.0.

Forty grams of the alcohols were fractionally distilled under a pressure of 7 mm. from a 100 cc. flask provided with a five pear fractionating column and six fractions were collected, the constants of which are given in Table VII.

TABLE VII.

*Fractionation of the alcohols from West Australian oil under a pressure of 7 mm.*

No. of fraction	Temperature in degrees Centigrade	Weight in grams	Refractive index at 25°	Rotation at 25°	Sp. gr. at 15°
1	148—151	4.0	1.5058	+5.7	0.9773
2	151—152	4.6	1.5062	+5.6	0.9770
3	152—153	6.0	1.5069	+5.4	0.9770
4	152—153	6.5	1.5075	+5.0	0.9772
5	152—153	6.0	1.5082	+4.5	0.9765
6	153—154	4.0	1.5094	+4.2	0.9762
Residue	...	5.5	1.5123	...	...

The results indicate the presence of two distinct alcohols the boiling points of which lie very close to one another, but which differ as regards their refractive indices and to a less extent their specific gravities. In order to obtain somewhat purer samples of these two alcohols the earlier and last fractions were further examined.

#### *a*-FUSANOL.

Fractions 1 and 2 were redistilled under a pressure of 5 mm. and 5 grams of an oil boiling at 146–149° were collected. This oil had the following values:—

$$n_D^{25} = 1.5060$$

$$[\alpha]_D^{25} = +5.7^\circ$$

$$\text{and } D_{15} = 0.9775.$$

This oil was soluble in 5.5 parts of 60 per cent. (by weight) alcohol at 5.6° and gave the following numbers on combustion.—

(1) 0.2020 gram gave 0.1974 gram of water and 0.6038 gram of carbon dioxide.

(2) 0.2107 gram gave 0.2039 gram of water and 0.6203 gram of carbon dioxide.

	Found		Calculated for C <sub>15</sub> H <sub>24</sub> O.
	1	2	
C	81.50	81.38	81.82
H	10.85	10.80	10.91.

*Molecular weight determination.*

(1) 0.398 gram in 26.38 grams of pure ethylene dibromide gave a depression of 0.750° and 0.665 gram in the same weight of solvent gave a depression of 1.173°.

	Found		Calculated for C <sub>15</sub> H <sub>24</sub> O.
M.	1	2	
	213	213.2	220.

The values were obtained by application of the formula.<sup>1</sup>

$$\text{Mol. wt.} = \frac{K \times 100 \times w}{\Delta(W + bw)}$$

where K = molecular depression for ethylene dibromide = 118<sup>2</sup>

w = Weight of solute.

W = Weight of solvent.

Δ = Depression in freezing point.

b = Arbitrarily introduced constant depending on solute and solvent.

$$b = \frac{W \left( \frac{\Delta_1}{w_1} - \frac{\Delta_2}{w_2} \right)}{\Delta_2 - \Delta_1}$$

where w<sub>1</sub> and w<sub>2</sub> are two different weights of a solute giving Δ<sub>1</sub> and Δ<sub>2</sub> respectively with the solvent.

Substituting the values obtained in the above experiments

$$b = \frac{26.38 \left( \frac{0.750}{0.398} - \frac{1.173}{0.665} \right)}{1.173 - 0.750} = 7.48.$$

*Molecular refraction.*

The value of  $\frac{M(n^2-1)}{d(n^2+2)}$  the molecular refraction according to the Lorentz-Lorenz formula, has been calculated from the refractive index ( $n_D^{15}$ ) 1.5100 and the density ( $d_4^{15}$ ) 0.9766, as 67.39 whereas the value for C<sub>15</sub>H<sub>24</sub>O with two olefine linkings is 67.66 and for C<sub>15</sub>H<sub>24</sub>O with one olefine linking is 65.92 using Eisenlohr's atomic refractions.<sup>3</sup>

$$C = 2.418$$

$$H = 1.100$$

$$O = 1.525$$

$$\text{olefine linking} = 1.733$$

<sup>1</sup> Fawsitt, *J. Chem. Soc.*, 1919, 114, 795.

<sup>2</sup> *Freezing Point, Boiling Point, and Conductivity Methods*, by Harry C. Jones, p. 9.

<sup>3</sup> *Spectrochemie organischer Verbindungen* 1922 Edition p. 46.

Repeated fractionation of fractions Nos. 3 + 4 + 5 (p. 172) under a pressure of 7 mm. gave an additional 3 grams of oil with  $[\alpha]_D = +5.7$  and in other respects identical with  $\alpha$ -fusanol.

### $\beta$ -FUSANOL.

The residue obtained in the fractional distillation of the alcohols (p. 172) viz. 5.5 grams was distilled from a 20 cc. distillation flask under a pressure of 5 mm. and 3.5 grams of oil were obtained with the following properties.—

B. P. = 153–155° under 5 mm.

$$n_D^{25} = 1.5100$$

$$D_{15}^{15} = 0.9753$$

$$[\alpha]_D^{25} = +2.6^\circ$$

and soluble in 5.5 parts of 60 per cent. (by weight) alcohol at 4°.

The physical constants agree quite well with those given by the alcohol obtained by fractional distillation of the saponified oil (p. 169).

#### *Analysis.*—

(1) 0.171 gram gave 0.1917 gram water and 0.5593 gram carbon dioxide.

(2) 0.399 gram gave 0.2208 gram water and 0.6756 gram carbon dioxide.

	Found		Calculated for $C_{15}H_{24}O$ .
	1	2	
C ...	81.50	81.10	81.82
H ...	10.80	10.79	10.91

#### *Molecular weight.*—

(1) 0.171 gram in 28.65 grams ethylene dibromide gave a depression of 0.317°.

(2) 0.399 gram in the same weight of solvent gave a depression of 0.685°.

	Found		Calculated for $C_{15}H_{24}O$ .
	1	2	
M ...	217.3	217.0	220

$$\text{The value of } (b) \text{ obtained in these experiments} = \frac{28.65 \left( \frac{.317}{.171} - \frac{.685}{.399} \right)}{0.685 - 0.399} = 7.55.$$

*Molecular refraction.*—

$$\frac{M(n^2-1)}{d(n^2+2)} = 67.91 \text{ (from the } n_D^{15} = 1.5140 \text{ and } d_4^{15} = 0.9744)$$

$C_{15}H_{24}O$  with two olefine linkings = 67.66.

It would thus appear that both  $\alpha$ - and  $\beta$ -fusanol are bicyclic sesquiterpene alcohols with two olefine linkings and thus resemble  $\beta$ -santalol.

In Table VIII the properties of  $\alpha$ - and  $\beta$ -santalols are given side by side with those for the two alcohols obtained from West Australian oil.

TABLE VIII

*Constants of Santalols and Fusanols*

—	$\alpha$ -Fusanol	$\beta$ -Fusanol	$\alpha$ -Santalol	$\beta$ -Santalol
B. P. 5 mm.	146—148°	153—155°	148°	158°
$d_{15}^{15}$	0.9775	0.9753	0.979	0.973
$n_D^{25}$	1.5060.	1.5100	1.4968	1.5067
$\alpha_D^{25}$	+5.7°	+2.6°	+1.1°	—42°
Mol. wt. found.	213	217	215	—
Mol. refraction.	67.39	67.91	65.88	67.48
Temperature at which mixture of 5.5 parts by volume of 60 per cent. (by weight) alcohol and one part by volume of oil becomes clear.	5—6°	4°	12°	9°

## SUMMARY.

1. The so-called West Australian sandalwood oil is derived from a species of tree quite different from the *Santalum album*, Linn., the species from which the East Indian oil is obtained. It differs in general properties from the East Indian oil and in order to avoid confusion it should be given a name other than sandalwood oil.

2. The oil, as distilled direct from the wood, differs in most of its analytical data from the genuine sandalwood oil. It does not fall within the limits allowed by the British pharmacopœia as regards specific gravity, optical rotation, alcohol content or solubility in 70 per cent. (by volume) alcohol at 20°.

3. By fractional distillation and removal of the lower boiling sesquiterpene fraction it is possible to obtain an oil which passes the B. P. tests for genuine sandalwood oil, with the exception of the optical rotation which is always well below the standard required by the B. P.

4. Although it is easy by fractional distillation to obtain an oil containing more than 90 per cent. of alcohols (calculated as  $C_{15}H_{24}O$ ), nevertheless the alcohols present are not identical with either of the two santalols present in East Indian oil but are isomeric with them.

5. There appear to be at least two alcohols present in the West Australian oil. They are probably to be represented as  $C_{15}H_{24}O$ , and, in order to distinguish them from the isomeric santalols, they have been termed  $\alpha$ - and  $\beta$ -fusanols.

6. These fusanols yield hydrogen phthalates and phenylurethanes. The fact that they react much more slowly than the santalols with phthalic anhydride indicates that they are probably secondary and not primary alcohols.

7. From their molecular refractions it is probable that both fusanols are bicyclic compounds containing two olefine linkings.

8. The statement that during distillation of the oil under reduced pressure there is a loss of alcohols has not been confirmed; neither steam distillation nor distillation under reduced pressure appears to change the alcohol content.

9. It is generally agreed that for perfumery purposes the West Australian oil is inferior to genuine sandalwood oil.

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Indian Institute of Science,  
Bangalore.*