Therefore, in conclusion, with the aid of the ultraviolet absorption and amine salt techniques[2] it has been shown that Kraft's proabietic acid is a mixture of levopimaric, neoabietic, abietic and isodextropimaric acids. In addition to these there are other acids present such as dextropimaric and a dihydroabietic acid, found in oleoresin acids, to account for the large fraction of acids that do not demonstrate absorption in the ultraviolet region as shown by the low log K_{molar} of the absorption curve of Kraft's preparation. Proabietic acid is, then, another example of what Duffour[7] described as isomorphous-mixed crystals that were obtained by the recrystallization of mixtures with virtually no separation to pure constituents.

Experimental[8,9]

Isolation of Proabietic Acid from *Pinus palustris*.—Many kilograms of gum oleoresin were suspended, in small batches, in 80% acetone and stirred to obtain a homogeneous suspension which was centrifuged. This operation was repeated at least twice to obtain colorless crystals which were dissolved in acetone, freed of foreign material by filtration, and crystallized by the addition of water to the acetone solution at 60°. The crystals which melted at 140–145° and had a specific rotation, $[\alpha]^{24}D$ −95°, were dissolved at 60° in 1% ammonia. After standing overnight at 0–3° the whole mass formed a paste of fine needles which was removed by centrifuging. The acids were regenerated from the mother liquor with carbon dioxide and redissolved in 1% ammonia. The regenerated acids with rotation $[\alpha]^{24}D$ −18°, were again dissolved in the minimum amount of 1% ammonia and the salts centrifuged. The regenerated acids from the filtrate had a rotation $[\alpha]^{22}D$ +10°, and were crystallized from aqueous alcohol with the same rotation and melting point, 159–162°.

Determination of Levopimaric Acid Content.—A solution of 20.0 g. of acids in 20 g. of *n*-pentane was treated with 3.2 g. of triply distilled maleic anhydride in 3 g. of acetone. The reaction was exothermic. At the end of two hours of agitation, the solution was poured slowly into a 3% solution of aqueous alkali containing a sufficient amount of alkali (4.0 g.) to neutralize the acids. The solution was diluted to a total volume of 3 liters and solid boric acid was added during rapid agitation to a *p*H of 6.2.

Sodium sulfate, 60 g., was added to coagulate the precipitated acids that were filtered and washed well with water. The rotation of these acids was $[\alpha]^{24}D$ +39°. Using the Biot principle the per cent. of levopimaric acid was calculated to be 9–10%.

Investigation of the Levopimaric Acid-Free Acids.—The acids (18 g.) were dissolved in 40 g. of acetone and treated with 4.5 g. of butanolamine (2-amino-2-methyl-1-propanol) in 5 g. of acetone. The salts were filtered and fractionally crystallized to obtain (1) the more insoluble fraction with rotation $[\alpha]^{24}D$ 0°, from which isodextropimaric acid was isolated and (2) the more soluble fraction with rotation $[\alpha]^{24}D$ +103°, from which neoabietic acid was isolated, both in small yield.

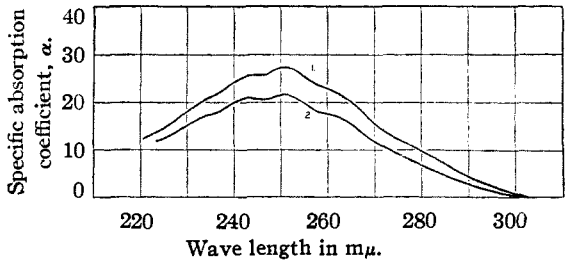


Fig. 1.—Ultraviolet absorption spectra: 1, Kraft's acid; 2, levopimaric acid-free Kraft's acid.

Summary

Kraft's proabietic acid was found to be a mixture of the following primary resin acids: levopimaric, abietic, neoabietic, isodextropimaric and others that do not demonstrate characteristic absorption maxima in the ultraviolet region and were not separated by the amine salt method.

WILMINGTON, DELAWARE RECEIVED[10] MARCH 10, 1948

(7) M. A. Duffour, *Compt. rend.*, **175**, 109 (1922).

(8) All melting points are corrected.

(9) All rotations are of 1% solutions in absolute ethanol.

(10) Original manuscript received August 9, 1946.

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, COLUMBIA UNIVERSITY]

Cashew Nut Shell Liquid. III. The Cardol Component of Indian Cashew Nut Shell Liquid with Reference to the Liquid's Vesicant Activity[1]

BY DAVID WASSERMAN[2] AND CHARLES R. DAWSON

India and Brazil are the chief sources of supply of raw cashew nut shell liquid which has found important commercial usage in this country as a phenolic raw material for the manufacture of certain resins and plastics possessing unusual electrical and frictional properties. The raw cashew nut shell liquid has the objectionable property, however, of causing a severe irritation or poison-ivy like dermatitis after coming in contact with the skin.[3]

Working with a solvent extracted oil from the shell of the cashew nut (*Anacardium occidentale*) grown in Java and Surinam, Backer and Haack[4] found, as had Städeler[5] many years earlier, that the oil is almost completely phenolic in character, being made up of two major components, anacardic acid and cardol. By means of quantitative hydrogenation and oxidative degradation experiments, the structures of anacardic acid and cardol, except for the positions of the olefinic linkages in the side chains, were deduced as 2-carboxy-3-pentadecadienylphenol and 5-pentadecadienylresor-

(1) For the second article in this series, see Sletzinger and Dawson, THIS JOURNAL, **68**, 345 (1946).

(2) Present address: Irvington Varnish and Insulator Co., Irvington, N. J.

(3) Keil, Wasserman and Dawson, *Ind. Med.*, **14**:11, 825 (1945).

(4) Backer and Haack, *Rec. trav. chim.*, **60**, 661 (1941).

(5) Städeler, *Ann. Chem. Pharmacie*, **63** 137 (1847).

cinol, respectively. These structures were not confirmed by synthesis of the saturated homologs. Backer and Haack found, as had earlier workers, that anacardic acid was subject to easy decarboxylation, and the carbon skeleton of the resulting monophenol[6] was established as that of a 3-pentadecadienylphenol by synthesis of the corresponding tetrahydro derivative.

The raw commercial cashew nut shell liquid is not obtained by a low temperature solvent extraction such as used by Backer and Haack and earlier workers, but rather by a hot oil extraction process.[11] During this process most of the anacardic acid is decarboxylated, and consequently the two major components of the commercial shell liquid are the monophenol, cardanol[6] and the resorcinol derivative, cardol. Direct and rapid vacuum distillation of the raw commercial shell liquid yields, as the main component of the shell liquid, a cardanol specimen having an olefinic unsaturation equivalent to about two double bonds. However, further heat or acid treatment reduces the degree of unsaturation of the distillable monophenol[12] without altering the length or position of the alkenyl side chain.[10]

Most of the vesicant activity of the shell liquid is associated, however, with the higher boiling dihydric phenol fraction which undergoes marked polymerization during the vacuum distillation of the monophenol. For this reason, the dihydric phenol component, cardol, can more easily be obtained from a solvent extracted oil which contains practically all of its monophenol in the form of anacardic acid. The latter is readily separated from the cardol by precipitation with lead. Using this procedure on a solvent extracted oil from the Indian cashew nut shell it has been found that the carbon skeletons of the anacardic acid and cardol components are identical with those of the oil from the Java and Surinam cashew nut shells used by Backer and Haack. Furthermore, the structure of tetrahydrocardol has been verified by synthesis.

When the commercial shell liquid is catalytically hydrogenated after a preliminary mild acid treatment, the reduced monophenol and dihydric phenol components can be separated by direct vacuum distillation. A recrystallized sample of hydrogenated cardol obtained in this way from the commercial liquid was found to be identical by mixed melting point analysis with a sample of tetrahydrocardol derived from the solvent extracted oil. In other words, just as in the case of the monophenol,[10] the carbon skeleton of the dihydric phenol, cardol, is not altered during the rather drastic heat treatment employed for extracting the commercial shell liquid.

The nature of the vesicant action of raw commercial cashew nut shell liquid has led to the speculation that the toxic effects might be due to contaminating nitrogen compounds, possibly protein in character. Previous investigations have revealed that the liquid and certain commercial fractions of the liquid do contain nitrogen in small amounts.[11] However, recent patch test studies employing the various phenolic components of the shell liquid have revealed that the dihydric phenol, cardol, is by far the most toxic component of the raw liquid.[3] Likewise it was found that tetrahydrocardol prepared by hydrogenating the cardol fraction of the extracted oil is also a strong vesicant. Both of these phenolic compounds as obtained from the oil, however, contained traces of nitrogen. In order to eliminate the possibility that the vesicant action of these isolated fractions might be due to their nitrogen containing impurities, it was decided to synthesize a nitrogen-free tetrahydrocardol, and to compare its vesicant action with that of the tetrahydrocardol obtained from the natural source. The method employed for synthesizing the tetrahydrocardol is an adaption of the general method used by Backer and Haack,[4] for the synthesis of compounds of this type and is outlined by the sequence of reactions shown in Chart I.

The synthetic tetrahydrocardol (IV) was contaminated with a small amount of the dimethyl ether precursor (III) as evidenced by the fact that it melted about four degrees lower than tetrahydrocardol prepared from solvent-extracted cashew nut shell liquid as described in the experimental section. However, a mixed melting point of the synthetic product and that derived from the solvent extracted cashew nut shell liquid showed no depression but melted within the 4° temperature range separating the melting points of the two samples.

(6) Backer and Haack called this monophenol, anacardol, presumably following the nomenclature used by Pillay,[7] who had previously worked on the structure of the monophenol resulting from the decarboxylation of anacardic acid obtained from the shell liquid of the cashew nut, *Anacardium occidentale*. However Pillay apparently overlooked the fact that Naidu[8] had earlier used the term, anacardol, to identify a different monophenol, of empirical formula $C_{15}H_{22}O$, which he isolated from the kernel oil of the marking nut, *Semecarpus anacardium*. In view of this confusion in naming the monophenolic constituent of cashew nut shell liquid, it seems advisable to use the term, cardanol, as proposed by Harvey[9] to identify decarboxylated anacardic acid. A previous investigation in this Laboratory[10] has revealed that the monophenol resulting from the decarboxylation of anacardic acid has the same carbon skeleton whether derived through the solvent extraction method, such as used by Backer and Haack or the hot oil extraction method such as used commercially in obtaining cashew nut shell liquid.

(7) Pillay, *J. Indian Chem. Soc.*, **12**, 226 (1935).

(8) Naidu, *J. Indian Inst. Sci.*, **8A**, 129 (1925).

(9) Harvey, U. S. Patent 2,098,824 (Nov. 9, 1937).

(10) Wasserman and Dawson, *Ind. Eng. Chem.*, **37**, 396 (1945).

(11) Harvey and Caplan, *Ind. Eng. Chem.*, **32**, 1306 (1940).

(12) Backer and Haack believed that anacardic acid, cardol and the monophenol (anacardol) were in each case single entities possessing a fifteen-carbon side chain with two olefinic double bonds. Recent studies in this laboratory have revealed that anacardic acid[13] and the monophenol which results on decarboxylation[14] are actually mixtures made up of saturated, mono-, di- and probably polyolefinic components giving under certain conditions an average unsaturation equivalent to two double bonds. Loss of unsaturation on heat or acid treatment occurs presumably as the result of selective polymerization of the more highly unsaturated components.

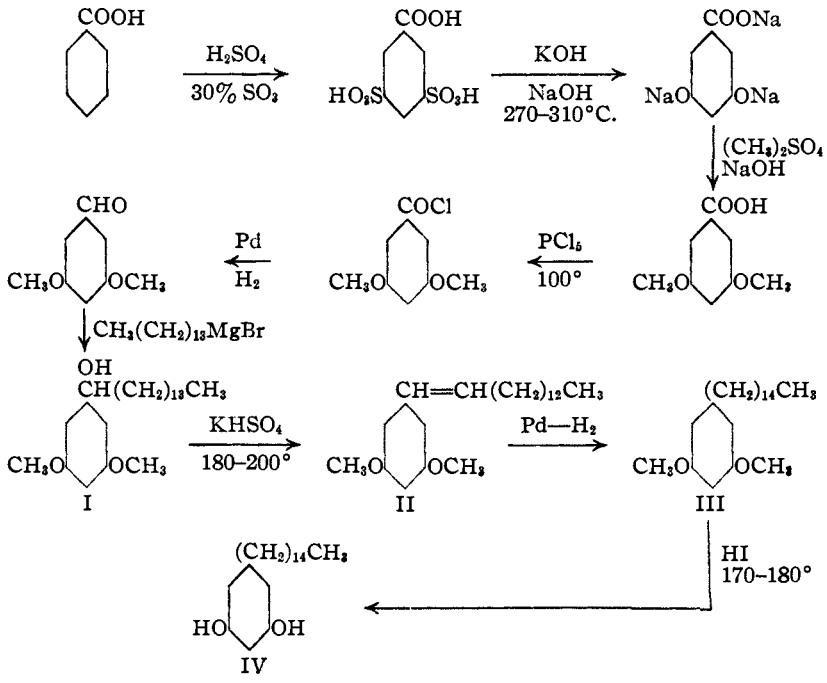
(13) Izzo and Dawson, to be published.

(14) Sletzinger and Dawson, THIS JOURNAL, **68**, 345 (1946).

The identity of the synthetic tetrahydrocardol and its counterpart from the solvent extracted shell liquid was further confirmed by mixed melting point data using the synthetic dimethyl ether (III) and the dimethyl ether obtained by hydrogenating and then methylating the cardol obtained from the solvent extracted shell liquid. Although the completely synthetic dimethyl ether (III) melted slightly higher than the dimethyl ether derived from the natural cardol, no depression in melting point was observed using mixtures of the two in several proportions. Furthermore, the melting point was in good agreement with that reported by Backer and Haack[4] for tetrahydrocardol dimethyl ether obtained from cashew nut shells grown in Surinam and Java.

The synthetic tetrahydrocardol (IV) although contaminated with a small amount of the dimethyl ether, was not further purified prior to clinical testing. As previously reported,[3] the nitrogen-free synthetic tetrahydrocardol gave essentially the same skin reactions as the nitrogen contaminated tetrahydrocardol derived from the natural sources. It may be concluded, therefore, that the vesicant activity of raw commercial cashew nut shell liquid is not due to any nitrogen containing compounds that may be present in small amounts.

CHART I



Experimental

Physical and analytical data on the substances isolated in pure form are presented in Table I. All melting points are corrected.

I. **Indian Cashew Nut Shell Liquid (Solvent Extracted).**

Anacardic Acid.—The shells of five pounds of cashew nuts obtained from India were extracted with ether according to the method of Backer and Haack,[4] and the ether extract was filtered. After evaporation of the solvent, the oily residue was dissolved in two liters of petroleum ether, washed with saturated sodium chloride solution, dried with anhydrous magnesium sulfate, filtered free of drying agent, treated with 40 g. of Norite, and filtered again. Upon complete removal of the petroleum ether *in vacuo*, 696 g. of reddish brown oily liquid was obtained.

TABLE I

Compound	M. p., °C.	Appearance	Crystallizing solvent	Empirical formula	Analyses, % Carbon Calcd.	Carbon Found	Hydrogen Calcd.	Hydrogen Found
I. Indian Cashew Nut Shell Liquid (Solvent Extracted)								
Anacardic acid		Yellow needles	Pet. ether	$C_{22}H_{32}O_3$				
Tetrahydroanacardic acid	89.5–90.0[a]	Colorless needles	Benzene	$C_{22}H_{36}O_3$	75.80	75.85	10.42	10.50
Cardol	[b]	Pale yellow viscous oil		$C_{21}H_{32}O_2$	79.69	80.33	10.21	9.97
Tetrahydrocardol	95.5–96.0	Colorless needles	Benzene	$C_{21}H_{36}O_2$	78.69	78.71	11.32	11.19
Tetrahydrocardol dimethyl ether	47.5–48.5[c]	Colorless needles	Methanol	$C_{23}H_{40}O_2$	79.28	79.53	11.56	11.85
II. Synthesis of Tetrahydrocardol and the Dimethyl Ether								
Chart I, Cpd. I	61.5–62.0	Colorless needles	Pet. ether	$C_{23}H_{40}O_3$	75.77	75.83	11.06	11.12
Chart I, Cpd. II	41.0–41.5	Colorless needles	Methanol	$C_{23}H_{38}O_2$	79.72	80.07	11.05	11.23
Chart I, Cpd. III	49.5–50.0[c]	Colorless needles	Pet. ether	$C_{23}H_{40}O_2$	79.28	79.53	11.56	11.58
Chart I, Cpd. IV	91.0–91.5	Colorless needles	Pet. ether	$C_{21}H_{36}O_2$	78.69	79.01	11.32	11.79
III. Commercial Shell Liquid								
Tetrahydrocardol	95.0–96.0	Colorless needles	Skelly D					

[a] Backer and Haack[4] reported a melting point of 91.0 to 91.5 for tetrahydroanacardic acid derived from cashew nut shell oil from Surinam and Java. [b] B. p. 211–212° at 1.5 mm. [c] Backer and Haack[4] reported a melting point of 48.5–49.0° for dimethyltetrahydrocardol derived from Surinam and Java cashew nut shell oil, and Furukawa, *Sci. Papers Inst. Phys. Chem. Research (Tokyo)*, 26, 179 (1934), reported a melting point of 53.5–54.0°.

A 200-g. sample of the above oily liquid was dissolved in 750 cc. of 95% ethanol and treated with 211 g. of lead hydroxide to precipitate the lead anacardate. The precipitate was removed by filtration and the alcoholic filtrate was saved for recovery of the cardol (see below). After washing with alcohol, the precipitated crude lead anacardate was suspended in 750 cc. of water and decomposed with 300 g. of *p*-toluenesulfonic acid at 100° for one hour. The brown oil which floated to the top was extracted with ether, washed with saturated sodium chloride solution, and dried with anhydrous magnesium sulfate. After removal of the drying agent, the ether solution was concentrated, and the residual oil was reprocessed in the same manner through the use of the lead salt. The twice processed oil was then dissolved in 500 cc. of petroleum ether, washed and dried as above. About 100 cc. of this stock solution was diluted with an additional volume of 100 cc. of petroleum ether, 20 g. of Darco carbon was added, and after standing a few minutes the carbon was filtered off. The petroleum ether solution was then concentrated to a brown viscous liquid which yielded 18 g. of crystalline anacardic acid, when cooled to 0°. The crystals melted at about room temperature and no further attempt was made at purification.

Tetrahydroanacardic Acid.—A 5.771-g. sample of the above anacardic acid was catalytically hydrogenated in 75 cc. of ethyl acetate using 0.5 g. of palladium oxide as catalyst. The system absorbed 866.0 cc. of hydrogen at 762 mm. and 25° (theoretical absorption for two olefinic double bonds, 818.0 cc.). After removing the catalyst and evaporating the solvent, the remaining white solid was recrystallized four times from petroleum ether to yield poorly defined crystals of m.p. 89.5–90.0°. A better crystalline form was obtained by dissolving the above crystals in 40 cc. of petroleum ether and absorbing the solution on a column (3.0 cm. × 15 cm.) containing 10 g. of carbon (Darco G-60). Upon elution with 190 cc. of benzene a white solid of lower melting point was obtained, but the next 255 cc. of benzene passing through the column under two pounds nitrogen pressure extracted a white solid made up of well defined needles (microscopic examination).

Cardol.—The cardol alcoholic filtrate was concentrated, some excess lead anacardate that precipitated was filtered off, and the alcohol was diluted with water. The alcohol water mixture was extracted with petroleum ether, dried with anhydrous magnesium sulfate, filtered and evaporated. The remaining reddish brown oil was then distilled at 2.0–2.5 mm. using a 25 cc. spitzkolbe flask. After a small forerun of presumably monophenol, a pale yellow very viscous liquid distilled over at 215–235° (Wood's metal-bath[15] at 290–320°). This fraction was redistilled in a 15 cc. spitzkolbe flask, and a middle fraction cut at 211–212°(1.5 mm.) (bath at 305–308°) was taken for analysis; yield 4.0 g.

Tetrahydrocardol.—A 2.255-g. sample of the above cardol was catalytically hydrogenated in 50 cc. of 95% ethyl alcohol using 0.2 g. of palladium oxide as catalyst. The system absorbed 441.4 cc. of hydrogen at 27.8° and 757 mm. pressure, corresponding to 2.52 double bonds[16] (theoretical for two olefinic double bonds, 351.5 cc.). After removing the catalyst and evaporating off the solvent, the remaining white solid was recrystallized five times from benzene.

Both cardol and tetrahydrocardol gave a positive test for resorcinal structure with mercuric nitrate in 75% ethyl alcohol solution (*i. e.*, a stable flocculent white precipitate).[17]

Tetrahydrocardol Dimethyl Ether.—A 0.6-g. sample of the above tetrahydrocardol was dissolved in 50 cc. of methanol in a 200-cc. round-bottom three-neck flask equipped with stirrer, reflux condenser and dropping funnel. After the addition of 0.3 g. of potassium hydroxide dissolved in the minimum amount of methanol, 0.5 g. of dimethyl sulfate was added dropwise and the reaction mixture heated to boiling on the steam-bath. The addition of alkali and dimethyl sulfate was then repeated twice more. During each methylation process the reaction mixture changed from a red-brown color while alkaline to a yellow color in acid solution. After pouring the reaction mixture into water the oily product was extracted with benzene. The benzene solution was washed several times with water and then the benzene and residual water were removed by distillation. The oily residue was distilled at 0.1 mm. (bath at 176–200°) using a molecular still. The solid product was recrystallized several times from methanol using Darco carbon to remove colored impurities.

No depression in melting point was observed when the above product was mixed in varying proportions with the completely synthetic material described below.

II. Synthesis of Tetrahydrocardol and the Dimethyl Ether.

3,5-Dihydroxybenzoic Acid.—Using the method outlined in "Organic Syntheses,"[18] 200 g. of benzoic acid was converted to the barium salt of 3,5-disulfobenzoic acid in 630 g. yield. The product was then treated in a copper dish with 300 g. of potassium hydroxide and 300 g. of sodium hydroxide as a fused liquid at 270–310°, and the melt yielded, after extraction, concentration, and acidification, 140 g. of crude 3,5-dihydroxybenzoic acid which was used without further purification.

3,5-Dimethoxybenzoic Acid.—The method of "Organic Syntheses" for trimethylgallic acid was used.[19] The 140 g. of crude 3,5-dihydroxybenzoic acid was methylated with 270 cc. of dimethyl sulfate and 180 g. of sodium hydroxide in 1 liter of water. After recrystallization from ethyl alcohol (1.5 liters) and sublimation of the insoluble white residue, 131 g. of the acid was obtained; m. p. 179–182° (lit. m. p. 181–182°).

3,5-Dimethoxybenzoyl Chloride.—The acid chloride was prepared according to the method of Kostanecki and Lampe.[20] A 50-g. sample of the 3,5-dimethoxybenzoic acid was mixed with 60 g. of phosphorus pentachloride to yield on distillation at 20 mm. a fraction boiling at 157–80° (bath at 190–195°) consisting of 36.0 g. of pale yellow 3,5-dimethoxybenzoyl chloride.

3,5-Dimethoxybenzaldehyde.—A Rosenmund reduction was used to convert the acid chloride to the aldehyde according to the method of Mauthner.[21] The 36.0-g. sample of acid chloride prepared above was dissolved in 90 cc. of xylene and reduced under a stream of hydrogen at 140° using 10 g. of palladium on Darco carbon as the catalyst. The standard alkali, used to follow the course of the reaction by absorbing the hydrogen chloride in the evolved stream of hydrogen, was neutralized in six hours. After cooling, sweeping out with nitrogen, and filtering off the catalyst, the filtrate was distilled at 11 mm. A large forerun of dimethoxytoluene was obtained, and 12.0 g. of the aldehyde distilled at 138–142° (bath at 160–174°). A 11.0 g. (36%) yield was obtained after recrystallization from ligroin.

3,5-Dimethoxy-(1′-hydroxypentadecyl)-benzene (I).—The method of Backer and Haack[4] was applied to the synthesis of the remaining compounds in this series. A 70.5-g. sample of tetradecyl bromide was converted to the Grignard reagent with 6.1 g. of magnesium turnings in 80 cc. of dry ether. A solution of 13.0 g. of the above aldehyde in 50 cc. of ether was added with cooling and worked up according to the directions of Backer and Haack. After recrystallizations from first ethanol, second ligroin, and several times from petroleum ether, the melting point became constant; yield 17.0 g. (60%).

3,5-Dimethoxypentadecenyl-1′-benzene (II).—A 15-g. sample of (I) was dehydrated by using 2.0 g. of fused po-

(15) A Wood's metal-bath was used during all distillations.

(16) This ratio of "found" to "theoretical" hydrogen absorption was also observed by Backer and Haack.[4] They ascribed it to the presence of highly unsaturated impurities. Experiences in this Laboratory indicate that the olefinic character of cardol and its phenolic associates requires further experimentation.[12]

(17) Butenandt and Stodola, *Ann.*, **539–40**, 51 (1939).

(18) "Organic Syntheses," **21**, 27 (1941).

(19) "Organic Syntheses," Coll. Vol. I, John Wiley and Sons, Inc., New York, N. Y., 1941, p. 537.

(20) Kostanecki and Lampe, *Ber.*, **41**, 1329 (1908).

(21) Mauthner, *J. prakt. Chem.*, **100**, 176 (1920).

tassium bisulfate at 145° in the presence of xylene as a solvent. Upon distillation of the xylene, water generated in the reaction was removed. After all the xylene was distilled, the reaction mixture was heated to 180–190° for one half-hour. The yellow, bluish fluorescent liquid was dissolved in alcohol, filtered free of potassium bisulfate and reduced with palladium and hydrogen without further purification. A sample for analysis was prepared by heating 1 g. of analytically pure (I) with 0.1 g. of potassium bisulfate at 180–200° for fifteen minutes in a sublimation still. After cooling to 100°, water generated was removed by evacuating to 15 mm. pressure. The residue was sublimed at 0.03 mm. (bath at 170–190°), yielding a white solid which was purified by four recrystallizations from methyl alcohol.

3,5-Dimethoxypentadecylbenzene (III).—A 13.0-g. sample of crude (II) was dissolved in 75 cc. of 95% ethanol and reduced with hydrogen in the presence of 1.0 g. of palladium-on-carbon. A volume of 755.5 cc. of hydrogen was absorbed at 30.2° and 770 mm. pressure. [Theoretical absorption 810 cc., indicating the presence of saturated impurities.] Upon distillation of the reduced compound, 4.5 g. of material melting at 46.5–50.0° was obtained as an easily solidified oil boiling at 190–192° at 0.3 mm. pressure, bath at 271–320°. A large residue of polymerized material was left in the distilling flask. A product of sharp and constant melting point was obtained on two recrystallizations from petroleum ether.

No depression in melting point was observed when (III) was mixed in varying proportions with the tetrahydrocardol dimethyl ether (m. p. 47.5–48.5°) derived, as described earlier, from the solvent extracted cashew nut shell oil.

3,5-Dihydroxypentadecylbenzene (IV) (Tetrahydrocardol).—A 1.0-g. sample of the above 3,5-dimethoxypentadecylbenzene was demethylated by heating with 30 cc. of hydriodic acid (d. 1.70), stabilized with hypophosphorous acid in a bomb tube at 170–180° for twenty-two hours. After cooling, the mixture was diluted with 150 cc. of water and extracted with ether. The ether solution was washed with sodium bisulfite, water, and then dried with anhydrous magnesium sulfate. After evaporation of the ether the residue was sublimed at 0.03 mm., bath at 170–190°. The resulting white solid was recrystallized twice from petroleum ether to give colorless needles melting sharply at 91–91.5°. Further attempts to raise the melting point were unsuccessful, and other attempts at demethylation failed to give any product melting above 91–92°.

The tetrahydrocardol derived from the solvent extracted oil, as described earlier, melted at 95.5–96°, and it is probable, therefore, that the synthetic product (III) contained small amounts of the dimethyl ether precursor. The high analytical values for carbon and hydrogen are in line with this supposition. When the synthetic product (III) was mixed with an equal weight of the natural tetrahydrocardol the resulting mixture melted within the 4° temperature range separating the melting points of the two samples.

III. **Tetrahydrocardol from the Commercial Shell Liquid.**—A 750-g. sample of Hydrogenated Cardanol, number 5573,[22] was distilled at 1 mm. pressure. Most of the distillate was the hydrogenated monophenol, but the higher boiling fractions contained increasing amounts of the reduced dihydric phenol, tetrahydrocardol. The last fraction (35 g.) taken at 230–255° had a melting point of 82–84°, showing it to be fairly pure tetrahydrocardol. After eight recrystallizations from benzene the melting point was 93–94°. Molecular distillation failed to raise the melting point any further and the material was finally purified by absorption on a mixed column of Norite A and Celite. The column (20 mm. × 30 cm.) was prepared by using a mixture of 15 g. of Norite A and 10 g. of Celite suspended in benzene. A 2 g. sample of the tetrahydrocardol (m. p. 93–94°) was dissolved in 50 cc. of warm benzene and passed through the column under 2 lb. of nitrogen pressure. The column was then washed with two 50-cc. portions of cold benzene and no solids were found in the washings. On passing 35 cc. of a mixture of 75% benzene and 25% ethyl acetate through the column, 1 g. of solid material melting at 93.5–95° was obtained. Succeeding fractions melted lower. The 1 g. of solid material was dissolved in 125 cc. of hot benzene to which was added 8 g. of Norite A and 5 g. of Celite. The suspension was stirred and filtered while hot. On evaporating the benzene *in vacuo* and recrystallizing the solid residue from Skelly D, white needles melting at 95–96° were obtained. No depression in melting point was observed when the above material was mixed in varying proportions with the tetrahydrocardol (m. p. 95.5–96°) derived as described earlier from the solvent extracted cashew nut shell oil. It may be concluded therefore that the carbon skeletons of the cardol components of solvent extracted and of the commercial cashew nut shell liquid are the same.

(22) Supplied by the Irvington Varnish and Insulator Co., Irvington, N. J. The raw commercial shell liquid is given a light chemical treatment with materials such as hydrocarbon sulfates and sulfuric acid, steam distilled or distilled *in vacuo*, and then hydrogenated.[11]

Acknowledgment.—This investigation was carried out under a grant from the Irvington Varnish and Insulator Company, Irvington, N. J. The authors wish also to thank Miss Frances Marx who carried out the microanalyses reported in this communication.

Summary

It has been demonstrated that the vesicant activity of cashew nut shell liquid, found most prevalent in the cardol fraction, is not due to the presence of nitrogenous compounds in the liquid. The carbon skeleton of tetrahydrocardol has been confirmed as 5-pentadecylresorcinol by synthesis. The tetrahydrocardol derived from solvent extracted Indian cashew nut shell liquid has been shown to be identical with that derived from the commercial liquid of the same source, proving that the heat treatment used in obtaining the commercial liquid from the shells does not alter the carbon skeleton of the dihydric phenol component. Tetrahydrocardol derived from solvent extracted Indian cashew nut shell liquid has been shown to have the same physical properties as that previously reported from the cashew nut grown in Java and Surinam.

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