A solution of 3 g. of this acid in 50 cc. of alcohol was hydrogenated catalytically as described for the sapinic acids, interrupting the operation when one mole of hydrogen had been added (ten minutes). The product was worked up in the usual way, as in the case of the hydrogenated sapinic acids. The crude solid acid was crystallized first from methanol and then from acetone, six times in all. It formed colorless needles, m. p. about 154.5–157° (corr.), $[\alpha]^{32}_D$ +17.54°.

Anal. Calcd. for $C_{20}H_{32}O_2$: C, 78.88; H, 10.60. Found: C, 78.46; H, 10.50.

In view of the unsatisfactory melting point, it is unlikely that this is the pure dihydro derivative of Steele's abietic acid. More probably, it is a mixture of isomers.

Summary

1. The sapinic acids of *Pinus palustris*, *P. caribbea*, *P. taeda*, *P. serotina*, *P. silvestris* and *Picea excelsa*, consist chiefly of a mixture of *d*-pimaric and *l*-sapietic acids. This is in accord with the findings of Palkin and Harris[5] in the case of *P. palustris* and of Dupont,[4a] and Ruzicka, Balaš and Vilim[4b] for *P. maritima*.

2. The presence of the former is proved by the formation of dihydropimaric acid when the sapinic acids are hydrogenated catalytically; and, of the latter, by the fact that, when refluxed with glacial acetic acid, the sapinic acids yield Steele's abietic acid as one of the products.

3. The stability of *d*-pimaric acid and its existence in the sapinic acids explains its presence in ordinary colophony.[16]

(16) (a) Rimbach, *Ber. pharm. Ges.*, **6**, 61 (1896); (b) Hosking and McFadyen, *J. Soc. Chem. Ind.*, **53**, 195T (1934).

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[CONTRIBUTION FROM THE CHEMICAL LABORATORIES OF COLUMBIA UNIVERSITY]

The Synthesis of Certain Phenylated Benzoxazoles and Derivatives[1]

BY VLADIMIR J. MIKESKA AND MARSTON TAYLOR BOGERT

The investigations of thiazole compounds conducted in these laboratories, especially on the connection between chemical constitution and tinctorial properties,[2] have made it seem worth while to carry out some similar studies in the closely related oxazole series.

The structural similarity between the oxazoles, thiazoles and imidazoles is paralleled by a close resemblance in methods of preparation and in properties of analogous compounds in the three series. Thus, in the basicity of their salts, the fluorescence of their solutions,[3] and odors, they are much alike. Auwers and Ernst,[4] who examined a large number of analogous compounds in the three groups in the helium region of the spectrum at 20°, found that their dispersion spectra corresponded closely, and that it seemed to make but little difference in the spectrum whether the grouping present in the cycle was

$$—O—\underset{|}{C}=N—,\quad —S—\underset{|}{C}=N—\ \text{or}\ —\underset{|}{N}—\underset{|}{C}=N—.$$

In all three series, the monocyclic types are most easily hydrolyzed, then the aliphatic 2-R derivatives of the benzo (dicyclic) type, the most stable derivatives being the 2-aryl compounds, like 2-phenylbenzoxazole. Of the three series, the oxazoles are most easily hydrolyzed,[5] even methylation breaking open the ring when 2-methylbenzoxazole is heated with methyl iodide.[6]

Clark[7] has carried out some interesting experiments on the opening of the cycle by the action of potassium hydroxide upon the methiodide.

Böttcher[8] was unable to effect ring closure by reduction of $CH_3COOC_6H_4NO_2$-(*o*), although this was accomplished easily by reduction of either C_6H_5-$COOC_6H_4NO_2$-(*o*) (2) or $C_6H_5COOC_{10}H_6NO_2$ (3).

For our attack upon the problem, the 2-R-5-phenyl and 2-R-7-phenylbenzoxazoles were used, because of the availability of the important industrial by-products *p*- and *o*-hydroxy diphenyls, from which they are easily synthesized. These syntheses are recorded in the present paper. The production of dyes from the phenylated benzoxazoles so obtained and a discussion of the tinctorial properties of these dyes, will form the subject of another communication.

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(1) Based upon the dissertation submitted by V. J. Mikeska, June, 1934, for the Ph.D. degree under the Faculty of Pure Science, Columbia University, New York, N. Y., to which dissertation the reader is referred for further experimental details and literature citations.—M. T. B.

(2) (a) Bogert and Bergeim, *Color Trade J.*, **15**, 63 (1924); (b) Bogert and Chertcoff, THIS JOURNAL, **46**, 2864 (1924); (c) Bogert and Allen, *Ind. Eng. Chem.*, **18**, 532 (1926); (d) Bogert and Allen, THIS JOURNAL, **49**, 1315 (1927).

(3) Henrich, *Ber.*, **54**, 2492 (1921).

(4) Auwers and Ernst, *Z. physik. Chem.*, **122**, 217 (1926).

(5) Skraup, *Ann.*, **419**, 33 (1919).

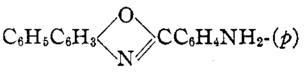
(6) Fischer, *J. prakt. Chem.*, [2] **73**, 436 (1906).

(7) Clark, *J. Chem. Soc.*, **129**, 232 (1926).

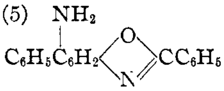
(8) Böttcher, *Ber.*, **16**, 629, 1933 (1883).

For the synthesis of the 5-phenyl derivatives, 3-nitro-4-hydroxydiphenyl was reduced to the corresponding amine and this in turn was condensed with *p*-nitrobenzoyl chloride to the 2-*p*-nitrophenyl-5-phenylbenzoxazole, reduction of which yielded the corresponding amino derivative (A).

For the preparation of the analogous 7-phenylbenzoxazoles, 3,5-dinitro-2-hydroxydiphenyl was converted first to the benzoate and this then reduced, with simultaneous cyclization, to the 2,7-diphenyl-5-aminobenzoxazole (B).

(5)  (A)

$$C_6H_5C_6H_3\overset{O}{\underset{N}{\langle\,\rangle}}CC_6H_4NH_2\text{-}(p)$$

(5) (7)  (B)

$$C_6H_5\overset{NH_2}{\overset{|}{C_6}}H_2\overset{O}{\underset{N}{\langle\,\rangle}}CC_6H_5$$

Experimental

Raw Material.—In the manufacture of phenol by the fusion of sodium benzenesulfonate with sodium hydroxide and rectification of the crude product, there remain in the still residues certain higher boiling phenolic constituents, diphenylsulfone and other by-products. Through the courtesy of Weiss and Downs, Inc., of New York, and of The Bakelite Corporation of Bloomfield, N. J., we were provided with a supply of this crude still residue and also with a small quantity of a distillate composed mainly of a mixture of hydroxydiphenyls. To both of these firms we wish to express our thanks for their assistance. The crude still residue, which was our chief source material, was worked up as follows.

After adding an excess of dilute (about 10%) sodium hydroxide solution, the mixture was boiled and stirred vigorously for at least fifteen minutes, then diluted with about 2 volumes of cold water and filtered from the separated **diphenylsulfone** (I), which was purified by distillation under diminished pressure, crystallization of the distillate from alcohol and sublimation. The sublimed product melted at 128° (corr.), in agreement with the figure reported by Otto,[9] and this melting point was not altered when mixed with a sample of the pure sulfone, of the same melting point, prepared by the direct sulfonation of benzene as described by Mitscherlich.[10]

It was further identified by the production therefrom of a *dinitro derivative* (II), m. p. 197°, which figure agrees with that given by Gericke[11] for dinitrodiphenylsulfone.

The *o*- and *p*-hydroxydiphenyls were isolated from the alkaline filtrate from the diphenylsulfone.

When this filtrate was acidified with hydrochloric acid, both hydroxy derivatives were precipitated, as well as tarry material. On filtration, some of this tar ran through the filter in an emulsified or colloidal state, together with most of the phenol present. The precipitate of crude hydroxydiphenyls was washed, dried and distilled under reduced pressure (30 mm.), the distillation being continued until there was evidence of decomposition products coming over. The mixture of *o*- and *p*-hydroxydiphenyls so obtained was extracted with hot gasolene and the undissolved ***p*-hydroxydiphenyl** (III) was rectified. The distillate obtained in this rectification, when crystallized from alcohol, appeared in bunches of colorless minute silky needles or in flakes, both of which forms melted sharply at 164° (corr.). Raiford[12] reported the m. p. as 163°.

The product was further identified by the preparation therefrom of the following derivatives: *4-acetoxydiphenyl*, m. p. 88° (corr.), literature[12] m. p. 88°; *4-methoxy*, m. p. 89.5° (corr.), literature[13] m. p. 90°; *3-nitro-4-hydroxy*, m. p. 67° (corr.), literature[12] m. p. 66°; *3-amino-4-hydroxy*, m. p. 209° (corr.), literature[12] m. p. 208°.

The gasolene filtrate from the *p*-isomer was concentrated to one-fourth its volume or less and, as it cooled, the ***o*-hydroxydiphenyl** (IV) separated in colorless crystals which were purified by distillation at 30 mm. pressure. The fraction collected at about 190° was nearly pure *o*-hydroxydiphenyl. Crystallized from alcohol, it formed massive colorless glassy crystals, m. p. 67.5° (corr.), which coincides with the figure reported by Norris, Macintire and Corse.[14]

For further identification, the *3,5-dinitro derivative* prepared from this product melted at 204° (corr.), as compared with a m. p. of 203–204° recorded by Borsche and Scholten.[15]

Summarizing our results, the yields of the various products isolated from this particular still residue were approximately as follows: diphenylsulfone 33%, *p*-hydroxydiphenyl 10%, *o*-hydroxydiphenyl 11%; phenol, water, unidentified higher-boiling constituents, tar and loss 46%.

Derivatives of *p*-Hydroxydiphenyl

3-Nitro-4-hydroxydiphenyl Sulfonic Acid (V).—A solution of 20 g. of 3-nitro-4-hydroxydiphenyl (m. p. 67°, corr.) in 60 cc. of concentrated sulfuric acid was stirred for three hours at 70°. There resulted a water-soluble sulfo acid, whose barium salt gave a yellow solution, unless barium entered the phenolic group also, when a red precipitate separated. Excess of sulfuric acid was precipitated by titration with barium hydroxide solution, the appearance of the yellow barium sulfonate changing the color of the solution and giving a clear end-point. A slight excess of barium hydroxide was used. The mixture was heated, allowed to stand for twenty-four hours and filtered. The filtrate containing the barium sulfonate was then titrated with more barium hydroxide solution, giving a deep canary yellow solution. The end-point in this titration was the appearance of the red color, or red precipitate, due to the entrance of the barium into the phenolic group also. By concentration of the yellow solution, the barium sulfonate crystallized in bright canary-yellow flakes; yield, 80%.

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(9) Otto, *Ann.*, **136**, 160 (1865).

(10) Mitscherlich, *Ibid.*, **12**, 208 (1834).

(11) Gericke, *Ibid.*, **100**, 211 (1856).

(12) Raiford, THIS JOURNAL, **47**, 1456 (1925).

(13) Werner, *Ann.*, **322**, 167 (1902).

(14) Norris, Macintire and Corse, *Am. Chem. J.*, **29**, 123 (1903).

(15) Borsche and Scholten, *Ber.*, **50**, 600 (1917).

3-Nitrodiphenyl-4-*p*-toluene sulfonate (VI) was prepared by treating 5 g. of 3-nitro-4-hydroxydiphenyl with a solution of 5.2 g. of *p*-toluenesulfochloride in 5 g. of dimethylaniline and heating the mixture for a day at 100°. It was then acidified, the precipitate collected, dried, pulverized and extracted with 1% caustic alkali, to remove traces of unchanged initial materials. The residual ester was then purified by crystallization from alcohol and decolorization. The product formed bright yellow flakes, m. p. 114.8° (corr.); yield, 66%.

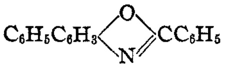
3-Nitrodiphenyl-4-*p*-nitrobenzoate (VII).—To a solution of 60 g. of 3-nitro-4-hydroxydiphenyl in 250 cc. of pyridine, there was added slowly, with stirring, 55 g. of well ground *p*-nitrobenzoyl chloride, keeping the temperature of the mixture below 25°. The reaction was completed in three hours and the mixture was poured into 400 cc. of 10% caustic alkali solution, let stand for an hour and filtered. Decolorized and crystallized from alcohol, the product appeared in colorless silky crystals, m. p. 169° (corr.); yield, 82%.

Reduced in glacial acetic acid solution by stannous chloride and hydrochloric acid, it yielded the 2-*p*-aminophenyl-5-phenylbenzoxazole.

3-Amino-4-hydroxydiphenyl was obtained by reduction of the corresponding nitro derivative, as reported by Raiford,[12] and formed minute colorless scales, m. p. 209° (corr.), in agreement with the literature;[12,16] yield, 65%.

3-(*p*-Nitrobenzoylamino)-4-hydroxydiphenyl (VIII).—In the synthesis of 2-*p*-nitrophenyl-5-phenylbenzoxazole from 3-amino-4-hydroxydiphenyl and *p*-nitrobenzoyl chloride (see beyond), the crude oxazole was extracted with warm normal sodium hydroxide, to remove by-products and unchanged initial materials. These alkali extracts were treated with a current of carbon dioxide, which precipitated the phenol and not the *p*-nitrobenzoic acid. This precipitate, when decolorized and crystallized from alcohol, gave the hydroxydiphenyl derivative in canary-yellow flakes, m. p. 249.3° (corr.); yield, 12%.

2,5-Diphenylbenzoxazole, (5)



$$C_6H_5C_6H_3\left\langle\begin{matrix}O\\N\end{matrix}\right\rangle CC_6H_5$$

(IX).—A mixture of 3 g. of finely ground 3-amino-4-hydroxydiphenyl with 5% more than the calculated quantity of benzoyl chloride was boiled for thirty minutes and then distilled. After removal of the excess benzoyl chloride, the benzoxazole distilled and congealed as it cooled. It was pulverized, digested for three hours with 2% sodium hydroxide to eliminate contaminants, washed thoroughly, decolorized and crystallized from alcohol, when it appeared in colorless silky flakes, m. p. 132.8° (corr.); yield, 1.5 g., or 35%.

2-(*p*-Nitrophenyl)-5-phenylbenzoxazole (X).—An intimate mixture of 3.3 g. of 3-amino-4-hydroxydiphenyl with 4 g. of *p*-nitrobenzoyl chloride was heated for thirty minutes at 210°. The cooled melt was pulverized and extracted with warm normal sodium hydroxide, to remove by-products and unchanged initial material. The residue was washed thoroughly, dried and extracted repeatedly with small amounts of toluene. The crude oxazole recovered from these toluene extracts was decolorized and crystallized twice from glacial acetic acid, giving a colorless pulverulent solid, m. p. 288.8° (corr.); yield, 52%.

2-(*p*-Aminophenyl)-5-phenylbenzoxazole (XI).—A solution of 8 g. of 3-nitrodiphenyl-4-*p*-nitrobenzoate in 200 cc. of glacial acetic acid at 100° was treated gradually with a solution of 60 g. of stannous chloride in 130 cc. of concentrated hydrochloric acid and the mixture was boiled for six hours. The complex tin salt which separated was removed, washed with water, dried, pulverized, and digested for six hours at 40° with normal sodium hydroxide, to decompose the tin complex and eliminate the tin. The crude oxazole when decolorized and crystallized from alcohol, formed pale yellowish needles, m. p. 174.2° (corr.); yield, 63%.

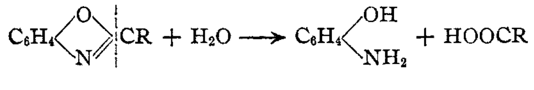
The same product was obtained by reduction of the 2-(*p*-nitrophenyl)-5-phenylbenzoxazole in a similar manner; yield, 75% (XII).

The alcohol solution of this compound exhibited a beautiful violet fluorescence, scarcely distinguishable from that produced by dehydrothio-*p*-toluidine.

2-(*p*-Benzenediazochloride)-5-phenylbenzoxazole Hydrochloride (XIII).—The general method of Erdmann[17] was followed. A suspension of 1.5 g. of 2-*p*-aminophenyl-5-phenylbenzoxazole in 5 cc. of concentrated hydrochloric acid was cooled to 0–10° and diazotized by the gradual addition of the requisite amount of a 10% sodium nitrite solution. The mixture was allowed to stand (at room temperature) until a clear solution was secured, when it was diluted carefully until a precipitate appeared which was removed and dried. This diazochloride hydrochloride formed a yellow amorphous solid, m. p. 130.5° (corr.); yield, 42%. Boiled with dilute sulfuric acid, it gave the 2-*p*-hydroxyphenyl-5-phenylbenzoxazole.

2-*p*-Aminophenyl-5-phenylbenzoxazole Disulfonic Acid (XIV).—A solution of 4 g. of 2-*p*-aminophenyl-5-phenyl-benzoxazole in 10 cc. of concentrated sulfuric acid was cooled to 20° and treated gradually with 15 cc. of fuming (60% free SO_3) sulfuric acid, maintaining the temperature below 55°, and protecting the solution from absorption of moisture by calcium chloride guard tubes. After stirring the mixture for twelve hours, it was cooled and poured upon ice. The colorless precipitate was removed, dissolved in dilute ammonium hydroxide, the solution filtered and the filtrate precipitated by acidification with hydrochloric acid. The precipitated sulfo acid was colorless and amorphous; yield, 80%.

When this disulfo acid was fused with caustic alkali, all of the products isolated were soluble in water but not in neutral organic solvents. Since this reaction results ordinarily in the cleavage of a benzoxazole, thus



$$C_6H_4\left\langle\begin{matrix}O\\N\end{matrix}\right\rangle CR + H_2O \longrightarrow C_6H_4\left\langle\begin{matrix}OH\\NH_2\end{matrix}\right. + HOOCR$$

it follows that both cleavage products in the case of our disulfo acid carried a sulfonic acid group. *p*-Aminobenzoic acid dissolves quite readily in ether, but ether extraction of our products yielded nothing.

These results indicate that the original disulfo acid, like the corresponding thiazole compound,[18] carries one sul-

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[16] Bell and Kenyon, *J. Chem. Soc.*, **129**, 3044 (1926).

[17] Erdmann, *Ann.*, **247**, 328 (1888).

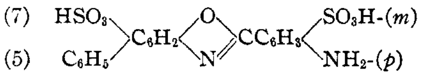
[18] Bogert and Snell, *Color Trade J.*, **14**, 109 (1924).

ANALYSES

		Calculated, %				Found, %			
		C	H	N	S	C	H	N	S
I	$C_{12}H_{10}O_2S$	66.02	4.62			66.03	4.64		
II	$C_{12}H_5O_6N_2S$	46.75	2.60	9.09		46.72	2.60	9.15	
III	$C_{12}H_{10}O$	84.70	5.90			84.70	5.88		
IV	$C_{12}H_{10}O$	84.70	5.90			84.68	5.93		
V	$C_{24}H_{16}O_{12}N_2Ba$			3.86				3.71	[a]
VI	$C_{19}H_{15}O_5NS$			3.79	8.67			3.36	8.75
VII	$C_{19}H_{12}O_6N_2$	62.63	3.29	7.69		62.79	3.16	7.28	
VIII	$C_{19}H_{14}O_4N_2$	68.26	4.27	8.38		68.62	4.32	8.01	
IX	$C_{19}H_{13}ON$	84.13	4.80	5.16		84.02	4.94	5.11	
X	$C_{19}H_{12}O_3N_2$	72.15	4.18	8.86		72.29	3.83	8.47	
XI	$C_{19}H_{14}ON_2$	79.70	4.92	9.55		79.80	5.14	9.55	
XII	$C_{19}H_{14}ON_2$	79.70	4.92			79.27	4.99		
XIII	$C_{19}H_{13}ON_3Cl_2$								[b]
XIV	$C_{19}H_{14}O_7N_2S_2$			6.37	14.13			6.27	14.31
XV	$C_{19}H_{13}O_2N$			4.87				4.69	
XVI	$C_{19}H_{12}O_6N_2$	62.63	3.29			62.91	3.28		
XVII	$C_{19}H_{14}ON_2$	79.70	4.92			79.39	4.60		
XVIII	$C_{19}H_{16}O_5N_2S$	59.34	4.19			58.92	4.05		

[a] Ba calcd., 19.00; found, 18.46. [b] Cl calcd., 19.20; found, 18.92.

fonic acid group on each of the two benzene nuclei, the most likely structure being the following.



2-*p*-Hydroxyphenyl-5-phenylbenzoxazole (XV).—When a solution of 2 g. of the diazo chloride (XIII) in a liter of 20% sulfuric acid was boiled for twelve hours and then cooled, this phenol separated. From alcohol, it crystallized in cream colored flakes, which were dried at 120° and then melted at 270° (corr.); yield, 65%. Its solution in concentrated sulfuric acid exhibited a sky-blue fluorescence. Under identical conditions, the corresponding amine gave a lighter violet blue fluorescence.

Derivatives of *o*-Hydroxydiphenyl

3,5-Dinitrodiphenyl-2-benzoate (XVI).—A solution of 10 g. of sodium 3,5-dinitrodiphenyl-2-phenolate[15] in acetone was stirred for two hours with an excess of benzoyl chloride. The precipitated benzoyl derivative was removed and a second crop obtained by the addition of water and ether to the filtrate. The combined precipitates, after thorough washing with water, alcohol and ether, were crystallized from alcohol and pale yellowish crystals obtained, which melted at 119.5° (corr.); yield, 65%.

2,7-Diphenyl-5-aminobenzoxazole (XVII) was obtained by reduction of the above benzoate in essentially the same way as the 2-*p*-aminophenyl-5-phenylbenzoxazole (XI) was prepared from the corresponding benzoate (VII). Decolorized and crystallized from alcohol, it formed pale yellowish needles, m. p. 220.8° (corr.); yield, 61%. Its alcoholic solutions exhibited a greenish fluorescence.

Sulfonic Acid (XVIII).—To a solution of 8 g. of the above oxazole (XVII) in 20 cc. of concentrated sulfuric acid at 20°, 40 cc. of fuming (50% free SO_3) sulfuric acid was added at such a rate that the temperature did not rise above 55°. After the initial reaction was over, the temperature of the solution was held at 55° until the sulfonation was complete (six hours). The mixture was then poured upon ice, the white precipitate collected, washed, dissolved in sodium carbonate solution, reprecipitated by hydrochloric acid, this solution and reprecipitation repeated. The product crystallized with one molecule of water and decomposed above 375°.

When fused with potassium hydroxide at 250–270° for ten minutes, the only product isolated and identified was benzoic acid. It seems probable, therefore, that the sulfo group was on the benzoxazole portion of the molecule.

Summary

1. From commercial phenol still residues, *p*- and *o*-hydroxydiphenyls have been isolated and converted into the new dye intermediates, 2-*p*-aminophenyl-5-phenylbenzoxazole, 2,7-diphenyl-5-aminobenzoxazole, and their sulfo acids.

2. A number of new intermediate and final products have been synthesized and their properties recorded.

NEW YORK, N. Y.

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