TABLE I
ARSONIC ACIDS AND ARSINE OXIDES DERIVED FROM NAPHTHALENE AND BIPHENYL

Compound, R = Arsono	Description	Yield, %	Formula	As analyses, % Calcd.	As analyses, % Found	N analyses, % Calcd.	N analyses, % Found
6-R-2-naphthoic acid	White powder	22	$C_{11}H_9O_5As$	25.3	25.5		
4-R-1-naphthol	White needles	2.5	$C_{10}H_9O_4As$	27.9	27.9		
3-Nitro-4,4'-di-R-biphenyl[a]	Yellow powder	19.4	$C_{12}H_{11}O_8NAs$	33.5	33.6	3.1	3.3
3-Nitro-4-amino-4'-R-biphenyl	Brown powder	14.9	$C_{12}H_{11}O_5N_2As$	22.2	22.3	8.3	8.0
3-Nitro-4-hydroxy-4'-R-biphenyl	Red powder	75	$C_{12}H_{10}O_6NAs$	22.1	22.0	4.1	4.3
4-Nitro-4'-R-biphenyl	Pale yellow needles	34	$C_{12}H_{10}O_5NAs$	23.2	22.9	4.3	4.4
4-Amino-4'-R-biphenyl	White needles	80	$C_{12}H_{12}O_3NAs$	25.6	25.4	4.8	4.8
4-Acetamido-4'-R-biphenyl	White needles	100	$C_{14}H_{14}O_4NAs$	22.4	22.6	4.2	4.1
4-Carboxy-4'-R-biphenyl	White powder	14	$C_{13}H_{11}O_5As$	23.3	23.4		
4,4'-Di-R-biphenyl	White prisms	3.4	$C_{12}H_{12}O_6As_2$	37.3	36.9		
R = Arsenoso							
2-R-naphthalene	White powder	90	$C_{10}H_7OAs$	34.2	34.0		
4-Acetamido-1-R-naphthalene[b]	White needles	71	$C_{12}H_{10}O_2NAs$	27.2	27.2	[c]	
2-Acetamido-1-R-naphthalene[d]	White powder	65	$C_{12}H_{10}O_2NAs$	27.2	27.3	[c]	
6-R-2-naphthamide	White powder	91	$C_{11}H_8O_2NAs$	28.7	28.3	5.4	5.4
4-Carbamyl-4'-R-biphenyl[e]	White powder	85	$C_{13}H_{10}O_2NAs$	26.1	26.0	4.9	4.7
4-Amino-4'-R-biphenyl[f]	White powder	100	$C_{12}H_{10}ONAs \cdot 2H_2O$	25.4	25.3	4.8	4.8
4-Acetamido-4'-R-biphenyl[g]	White powder	100	$C_{14}H_{12}O_2NAs \cdot H_2O$	23.4	23.5	4.4	4.4

[a] M. p. 249.5–250.5° (all melting points are corrected). [b] M. p. 272°. [c] We have been unable to obtain satisfactory nitrogen analyses on many naphthalenearsonic acids and arsine oxides containing nitrogen attached directly to the ring. Kjeldahl determinations were entirely unsatisfactory. Using the Dumas procedure, even with the addition of potassium chlorate, the results were erratic and we were never able to obtain the theoretical value. [d] M. p. 256.5°. [e] M. p. 271–273°. [f] M. p. 221–222°. [g] M. p. 297.5–298.5°.

group with ferrous hydroxide, or catalytically, using Raney catalyst, was unsatisfactory.

Table I lists the new compounds, or compounds prepared by a new procedure. Except as noted in the text, the arsine oxides were prepared by sulfur dioxide reduction of the corresponding arsonic acids in the usual manner. They were insoluble in water and the usual organic solvents. 4-Arsono-1-naphthol was recrystallized from hot water. The remaining crystalline compounds were crystallized from alcohol.

Summary

Several new arsonic acids derived from naphthalene and biphenyl have been prepared, and more convenient methods have been described for the preparation of other known compounds. The arsonic acids have been reduced to the corresponding arsine oxides.
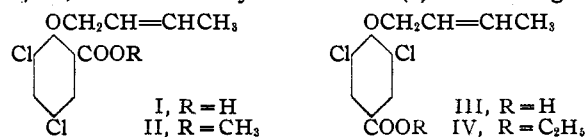
BALTIMORE, MD.   RECEIVED JANUARY 5, 1942

The Rearrangement of 4-Crotyloxy-3,5-dichlorobenzoic Acid

BY D. S. TARBELL AND J. W. WILSON[1]

In a previous paper[2] it was shown that O-crotyl-3,5-dichlorosalicylic acid (I) rearranges

I, R = H
II, R = CH₃

III, R = H
IV, R = C₂H₅

smoothly at 125° with loss of carbon dioxide to give 2,4-dichloro-6-(α-methylpropenyl)-phenol. This reaction therefore goes with inversion

(attachment of the γ-carbon atom) just as the ordinary Claisen rearrangement does. The present paper reports a study of a similar compound, 4-crotyloxy-3,5-dichlorobenzoic acid (III), in which the substituted allyl group migrates to the para position.

The crotyl ether of ethyl 3,5-dichloro-4-hydroxybenzoate (IV) was obtained using aqueous sodium hydroxide–acetone as the reaction medium. Saponification of the ester yielded 4-crotyloxy-3,5-dichlorobenzoic acid (III), which was

obtained pure only after many recrystallizations; the structure III was proved by oxidation with permanganate to 2,6-dichloro-4-carboxyphenoxy-acetic acid (V). Attempts to synthesize V by condensing ethyl bromoacetate with ethyl 3,5-dichloro-4-hydroxybenzoate and hydrolyzing, were unsuccessful, but the structure V is proved unequivocally by its percentage composition and neutral equivalent.
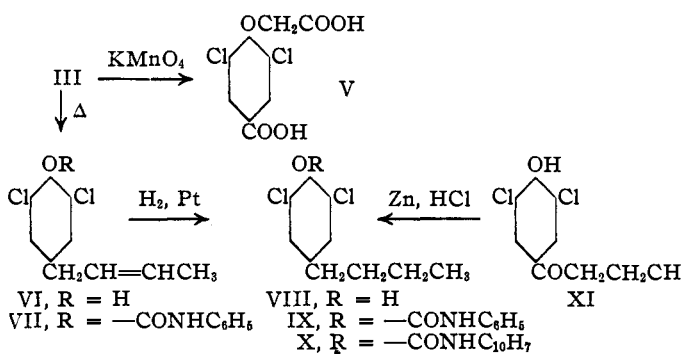
A trial run showed that III evolved about 85% of the theoretical amount of carbon dioxide in three hours at 157–159°, to be contrasted with the corresponding figure of 79% reaction in six minutes at 124–129° for I. Rearrangement of a larger sample at 165–175° for ninety minutes yielded 10% of high-melting, sodium bicarbonate-soluble material, probably a mixture of unchanged ether and 3,5-dichloro-4-hydroxybenzoic acid, and 61% of homogeneous rearrangement product, 4-crotyl-2,6-dichlorophenol (VI). The material unaccounted for was higher-boiling and partially solid.

The structure of VI was shown by its formation of a phenylurethan VII, m. p. 149–150°, and by reduction to 4-n-butyl-2,6-dichlorophenol, VIII, which was characterized by preparation in high yield of the phenyl- and α-naphthyl-urethans (IX and X). These, strangely enough, melted at the same temperature but gave a large depression on mixing. The same urethans were obtained from VIII, which had been prepared by Clemmensen reduction of 3,5-dichloro-4-hydroxybutyrophenone (XI),[3] and the respective urethans

showed no depression of mixed melting points.

It was observed, however, that the phenyl-urethan of the rearrangement product (VII, m. p. 149–150°) and of the reduced product (IX, m. p. 143–144°) did not show a depression in mixed melting point, the mixture not starting to melt below 143°. This made it advisable for the sake of completeness to synthesize the isomer of VIII, 4-s-butyl-2,6-dichlorophenol, which would be formed from III if rearrangement took place with inversion. The synthesis was carried out readily by the scheme previously used[2]; 3,5-dichloro-4-hydroxy-acetophenone was prepared by the Fries reaction from 2,6-dichlorophenyl acetate, and was treated with an excess of ethyl-magnesium bromide. The resulting tertiary carbinol, 2-(3,5-dichloro-4-hydroxy-phenyl)-butanol-2, was dehydrated by heating with a crystal of iodine, and the unsaturated product reduced to give 4-s-butyl-2,6-dichlorophenol. This compound is a solid, m. p. 68–70°, and its phenylurethan melts at 100–101°. Therefore the structure of the rearrangement product is shown conclusively to be VI.

This conclusion establishes the fact that the rearrangement to the para position with expulsion of carbon dioxide takes place without inversion just as does the rearrangement in the usual case.[4] It is also noteworthy that the para rearrangement requires a temperature 50° higher than the ortho, as shown by the comparison of I and III; in the best-known case[5] of the usual rearrangement the para actually goes a little more rapidly than the ortho.

An experiment showed that the rearrangement of III did not take place in dimethylaniline, just as in the previous case,[2] and therefore the reaction presumably does not involve the anion of III. Thus the rearrangement and decarboxylation of O-allylhydroxy acids is an entirely different reaction from the base-catalyzed decarboxylation of the hydroxy acids such as 3,5-dichloro-4-hydroxybenzoic acid.[6] However, Hahn and Wassmuth[7] found that methyl 4-allyloxy-3,5-dimethoxybenzoate was hydrolyzed and rearranged

(3) When the preparation of this ketone was attempted from 2,6-dichlorophenyl butyrate by the Fries reaction using the technique recommended for the formation of p-hydroxyketones (nitrobenzene as solvent and long standing at room temperature) the product consisted of 2,6-dichlorophenol (57%) and unchanged ester (29%). Using no solvent and a temperature of 140–150° (conditions usually used for the Fries rearrangement to the ortho position) a satisfactory yield of the product was obtained. This behavior does not seem to have been observed in previous applications of the Fries reaction [cf. Blatt, Chem. Rev., 27, 413 (1940)].

(4) Tarbell. Chem. Rev., 27, 526 (1940). The only exception to this rule is reported by Mumm, Hornhardt and Diederichsen, Ber., 72, 100 (1939).

(5) Kincaid and Tarbell, THIS JOURNAL, 61, 3085 (1939); Tarbell and Kincaid, ibid., 62, 728 (1940).

(6) Cf. Claisen, Ann., 418, 76 (1919), and preparation of 2,6-dichlorophenol in the experimental part.

(7) Hahn and Wassmuth, Ber., 67, 696 (1934).

simultaneously by boiling with sodium hydroxide to hydrolyze the ester group.

Allyl 2,6-dichlorophenyl ether was studied to find the effect of the carboxyl in promoting the rearrangement. This ether rearranges much less smoothly than III, and gives two products, the expected 4-allyl-2,6-dichlorophenol, and 2-allyl-6-chlorophenol, together with some evolution of hydrogen chloride. The structure of the second product, which must be the result of an intermolecular reaction, was established by comparing it with 2-allyl-6-chlorophenol prepared from allyl 2-chlorophenyl ether. These observations parallel those of Hurd and Webb on allyl 2,6-dibromophenyl ether.[8]

Experimental[9]

Ethyl 3,5-Dichloro-4-hydroxybenzoate.—A mixture of 83 g. of ethyl 4-hydroxybenzoate and 142 g. of sulfuryl chloride (5% excess) was heated on the steam-bath one hour and the excess sulfuryl chloride removed. Since the gain in weight was only about 85% of the theoretical, additional sulfuryl chloride (34 g.) was added and the excess removed after refluxing for one hour. Recrystallization from 80% alcohol gave 102 g. (81%) of ethyl 3,5-dichloro-4-hydroxybenzoate, melting with decomposition at 108–116°.[10] An additional 6 g. was recovered from the filtrate (total yield, 85%). The ester comes out as a monohydrate; after long drying *in vacuo* over phosphorus pentoxide, it melted at 111–112° and did not decompose even when heated to 210°. The loss in weight corresponded to one molecule of water. The ester can be extracted from ether solution with sodium bicarbonate solution and can be titrated with sodium hydroxide, using phenolphthalein or a pH meter; neutral equivalent calcd. (for monohydrate), 253; found, 249, 256.

3,5-Dichloro-4-hydroxybenzoic Acid.—The hydrated ester (121 g.) was saponified by warming on the steam-bath for thirty minutes with Claisen's alkali (300 cc.). The product was worked up in the usual way and recrystallized from a mixture of 500 cc. of ethanol and 250 cc. of water; yield from two crops, 94 g. (95%); m. p. 264–266° with decomposition. Recrystallization from 1 liter of 80% acetic acid and collection of three crops yielded 88 g. (89%) of white needles; m. p. 268–269°.[11]

4-Crotyloxy-3,5-dichlorobenzoic Acid (III).—The preparation of this ether was tried in methyl and ethyl alcohol with ethyl 3,5-dichloro-4-hydroxybenzoate, crotyl bromide and sodium alkoxide with poor results, apparently due to preferential formation of alkyl crotyl ethers. The phenolic ester was recovered unchanged after heating its sodium salt with crotyl bromide in xylene on the steam-

bath for twenty-six hours. The best results were obtained in aqueous acetone with sodium hydroxide. A mixture of 30 g. of ethyl 3,5-dichloro-4-hydroxybenzoate, 5.3 g. of sodium hydroxide, 23 g. of crotyl bromide, 250 cc. of acetone and 100 cc. of water was refluxed thirty-six hours. The mixture was diluted with water, and the oil, which was obtained by extraction with petroleum ether and removal of the solvent, was saponified by warming for ten minutes with Claisen's alkali. The alkaline solution was diluted, acidified and the white precipitate collected and crystallized from petroleum ether. Since 3,5-dichloro-4-hydroxybenzoic acid is very insoluble in this solvent, this step removes the bulk of this impurity. The long white needles obtained weighed 22 g. (63%) and melted at 141–146°. The pure compound melts at 150–152°, but many recrystallizations (petroleum ether, benzene, or alcohol as solvents) are necessary; repeated crystallization finally gave 7.3 g. (22%) of pure compound, and 11.9 g. (35%) of less pure material; m. p. 144–147°.

Anal. Calcd. for $C_{11}H_{10}O_3Cl_2$: C, 50.6; H, 3.9; neut. equiv., 261. Found: C, 50.6; H, 4.0; neut. equiv., 260.

2,6-Dichloro-4-carboxyphenoxyacetic Acid (V).—A mixture of 1.6 g. of 4-crotyloxy-3,5-dichlorobenzoic acid and 0.3 g. of sodium carbonate in 100 cc. of water was stirred vigorously while a solution of 3.2 g. of potassium permanganate in 110 cc. of water was added dropwise. After standing overnight the manganese dioxide was removed by filtration, the solution acidified, boiled to dissolve the precipitate, filtered and allowed to crystallize. White crystals were obtained; m. p. 248–250° (unchanged by recrystallization from water or benzene–petroleum ether); yield, 1.26 g. (78%). Attempts to prepare this compound from ethyl 3,5-dichloro-4-hydroxybenzoate and ethyl bromoacetate were unsuccessful.

Anal. Calcd. for $C_9H_6O_5Cl_2$: C, 40.8; H, 2.3; neut. equiv., 132.5. Found: C, 41.0; H, 2.3; neut. equiv., 133.

Rearrangement of 4-Crotyloxy-3,5-dichlorobenzoic Acid.—The acid (4.25 g.) was heated in a bath at 165–175° for ninety minutes. Evolution of gas began before the material had melted completely and became quite rapid. The product, which crystallized partially on cooling was dissolved in ether and extracted with sodium bicarbonate solution. Acidification of the extract yielded 0.34 g. (10%) of high-melting material which was probably 3,5-dichloro-4-hydroxybenzoic acid. The unextracted material was distilled and several fractions collected; the first two, of combined weight 2.17 g. (61% of rearrangement product) had b. p. 117–121° (3 mm.); $n^{23}D$ 1.5634, 1.5635.

The phenylurethan of 4-crotyl-2,6-dichlorophenol was obtained and. melts at 149–150°. *Anal.* Calcd. for $C_{17}H_{15}O_2NCl_2$: C, 60.7; H, 4.5. Found: C, 60.5; H, 4.5.

The rearrangement did not take place when the acid was heated in dimethylaniline at 152–155° for twenty minutes, 10% of the theoretical amount of carbon dioxide being evolved. This acid, as shown below, decarboxylates readily in dimethylaniline at 150°. There was no evidence for normal rearrangement.

2,6-Dichlorophenol by Decarboxylation of 3,5-Dichloro-4-hydroxybenzoic Acid.[12]—A mixture of 83.1 g. of the acid

(8) Hurd and Webb, THIS JOURNAL, **58**, 2190 (1936).

(9) All melting points corrected; analyses by R. W. King and J. W. Wilson.

(10) Mazzara, *Gazz. chim. ital.*, **29**, I, 383 (1899) [*Chem. Zentr.*, **70**, II, 479 (1899)], prepared the compound by this method and reported a melting point of 116°.

(11) Leulier and Pinet [*Bull. soc. chim.*, [4] **41**, 1362 (1927)] give 265°.

(12) Blicke, Smith and Powers [THIS JOURNAL, **54**, 1465 (1932)] carried out this decarboxylation in quinoline.

and 200 g. of freshly distilled dimethylaniline was heated slowly in an oil-bath. Evolution of gas commenced when the liquid was at 130°, and was vigorous at 155°. The solution was heated to 190° for one hundred minutes, at which time evolution of gas had ceased. After cooling, the solution was poured into 200 cc. of concentrated hydrochloric acid, and the phenol extracted with four 100-cc. portions of ether. Evaporation of the ether and crystallization of the residual oil from 300 cc. of petroleum ether (b. p. 40–60°) gave 34.0 g.; m. p. 66–68°. Recrystallization of second and third crops yielded an additional 17.1 g. of phenol of equal purity; total yield, 51.1 g. (78%).

4-n-Butyl-2,6-dichlorophenol (VIII, R = H). A. By Reduction of 4-Crotyl-2,6-dichlorophenol.—The rearrangement product (1.60 g.) was reduced in alcohol with Adams catalyst and the product distilled; 4-n-butyl-2,6-dichlorophenol (1.37 g.), b. p. 111–115° (3 mm.), n^{23}D 1.5398, was obtained.

The phenylurethan, obtained in high yield, melts at 143–144°.

Anal. Calcd. for $C_{17}H_{17}O_2NCl_2$: C, 60.4; H, 5.1. Found: C, 60.6; H, 4.9.

The α-naphthylurethan melts at 142–143°. *Anal.* Calcd. for $C_{21}H_{19}O_2NCl_2$: C, 64.9; H, 4.9. Found: C, 64.9; H, 4.6.

B. By Reduction of 3,5-Dichloro-4-hydroxybutyrophenone (XI).—The modified Clemmensen procedure of Martin[13] was followed. From 6.05 g. of the butyrophenone was obtained 4.36 g. (77%) of colorless liquid, b. p. 112–115° (2 mm.). *Anal.* Calcd. for $C_{10}H_{12}OCl_2$: C, 54.8; H, 5.5. Found: C, 54.7; H, 5.5. The phenyl- and α-naphthylurethans prepared from this product were identical in properties with those of the product prepared in A, and gave no depression of mixed melting point with the corresponding derivative. The phenylurethan melts at practically the same point as the α-naphthylurethan but the mixed melting point is depressed.

2,6-Dichlorophenyl Butyrate.—2,6-Dichlorophenol (21.5 g.) (prepared by the method of Huston and Neeley,[14] 23.5 g. of butyric anhydride and 12.8 g. of pyridine heated for ninety minutes on the steam-bath yielded 28.1 g. (91%) of 2,6-dichlorophenyl butyrate, b. p. 118–119° (3 mm.); n^{24}D 1.5155; d^{25}_{25} 1.246; MD calcd., 56.3; found, 56.1.

Anal. Calcd. for $C_{10}H_{10}O_2Cl_2$: C, 51.5; H, 4.3. Found: C, 51.6; H, 4.4.

3,5-Dichloro-4-hydroxybutyrophenone (XI).—2,6-Dichlorophenyl butyrate after standing for twenty-two hours in nitrobenzene with aluminum chloride at room temperature formed none of the ketone but gave about 57% of 2,6-dichlorophenol. A 59% yield of the butyrophenone was obtained by heating a mixture of 8.0 g. of the ester and 5.5 g. of anhydrous aluminum chloride for one hour at 140–150°. The reaction mixture was decomposed with ice and hydrochloric acid, extracted with ether and the ether solution extracted with 10% sodium hydroxide. Acidification of the alkaline extract precipitated a brown liquid which solidified on cooling and shaking. Two crystallizations from petroleum ether (b. p. 60–70°) gave 4.71 g. of white plates; m. p. 96–97°.

(13) Martin, THIS JOURNAL, **58**, 1438 (1936).
(14) Huston and Neeley, *ibid.*, **57**, 2176 (1935).

Anal. Calcd. for $C_{10}H_{10}O_2Cl_2$: C, 51.5; H, 4.3. Found: C, 51.6; H, 4.5.

2,6-Dichlorophenyl Acetate.—This ester was prepared in the same manner as the butyrate. From 11.7 g. of the phenol was obtained 13.6 g. (93%) of the ester, b. p. 125–126° (17 mm.); n^{23}D 1.5281; d^{25}_{25} 1.335; MD calcd., 46.9; found, 47.2.

Anal. Calcd. for $C_8H_6O_2Cl_2$: C, 46.9; H, 3.0. Found: C, 46.9; H, 3.0.

3,5-Dichloro-4-hydroxyacetophenone.—The procedure described for the preparation of 3,5-dichloro-4-hydroxybutyrophenone (XI) was followed. From 13.0 g. of the ester and 10.0 g. of anhydrous aluminum chloride heated for forty-five minutes at 140–150° was obtained 9.0 g. (69%) of white needles after recrystallization from benzene; m. p. 164–165.5°.

Anal. Calcd. for $C_8H_6O_2Cl_2$: C, 46.9; H, 3.0. Found: C, 47.1; H, 3.0.

2-(3,5-Dichloro-4-hydroxyphenyl)-butanol-2.—This compound was prepared from 3,5-dichloro-4-hydroxyacetophenone and ethylmagnesium bromide by the procedure described for the isomeric compound.[2] The yield was 56%; the reaction was interrupted by an accident soon after the ketone had been added, and 12% of the ketone was recovered unchanged. The product crystallizes as white needles from petroleum ether–benzene; m. p. 116–117°.

Anal. Calcd. for $C_{10}H_{12}O_2Cl_2$: C, 51.1; H, 5.2. Found: C, 51.4; H, 5.3.

2,6-Dichloro-4-(α-methylpropenyl)-phenol.—This substance (or a double bond isomer) was prepared from 4.08 g. of the carbinol described above by heating a few minutes at 185° with a crystal of iodine and distilling. The yield was 3.34 g. (88%) of colorless liquid; b. p. 161–163° (17 mm.); n^{23}D 1.5887. The liquid gradually turns yellow.

4-s-Butyl-2,6-dichlorophenol.—2,6-Dichloro-4-(α-methylpropenyl)-phenol (3.28 g.) was reduced with Adams catalyst for two and one-half hours in alcohol. The yield of colorless liquid, b. p. 110–112° (2 mm.), was 3.12 g. (94%). It soon solidified and was recrystallized from petroleum ether (b. p. 60–70°), giving white crystals; m. p. 68–70°; yield of recrystallized product, 74%.

Anal. Calcd. for $C_{10}H_{12}OCl_2$: C, 54.8; H, 5.5. Found: C, 55.1; H, 5.2.

The phenylurethan melts at 100–101°. *Anal.* Calcd. for $C_{17}H_{17}O_2NCl_2$: C, 60.4; H, 5.1. Found: C, 60.4; H, 5.1.

Allyl 2,6-Dichlorophenyl Ether.—2,6-Dichlorophenol (49.5 g.), 42 cc. of allyl bromide, 42 g. of anhydrous potassium carbonate and 250 cc. of methyl ethyl ketone yielded 54.1 g. (88%) of allyl 2,6-dichlorophenyl ether, b. p. 89–90° (2 mm.); n^{25}D 1.5394; d^{25}_{25} 1.239; MD calcd., 50.9; found, 51.3.

Anal. Calcd. for $C_9H_8OCl_2$: C, 53.2; H, 4.0. Found: C, 53.2; H, 4.0.

Rearrangement of Allyl 2,6-Dichlorophenyl Ether.—A sample of 13.55 g. of the ether was heated in a nitrogen atmosphere at 193–200° for ninety minutes; the liquid darkened and some hydrogen chloride was evolved. The product was separated into neutral and alkali-soluble

fractions with Claisen alkali. Distillation of the neutral fraction gave 0.68 g. (5%) of unchanged ether and 0.47 g. (3.5%) of undistillable material. The acidic fraction on distillation yielded 8.84 g. (65% by weight) and 2.49 g. (18%) of tar. The main fraction was redistilled and the presence of a higher-boiling fraction (about 57%) and a lower-boiling substance (about 10%) was indicated. Rearrangement of 55 g. of the ether and more extensive fractionation of the product allowed the separation of the two components, and their identification as follows:

4-Allyl-2,6-dichlorophenol (the expected rearrangement product) was obtained crystalline from the higher-boiling fractions; b. p. 104–108° (3 mm.); m. p. 33–35°. *Anal.* Calcd. for $C_9H_8OCl_2$: C, 53.2; H, 4.0; Cl, 34.9. Found: C, 53.2; H, 4.0; Cl, 34.8.

2-Allyl-6-chlorophenol was obtained from the lower-boiling fractions, and characterized as the α-naphthyl-urethan, m. p. 125–126°, which gave no depression when mixed with the derivative prepared below from the rearrangement product of allyl 2-chlorophenyl ether.

Allyl 2-Chlorophenyl Ether.—A mixture of 9.0 g. of sodium hydroxide, 50 cc. of water, 100 cc. of acetone, 25.7 g. of 2-chlorophenol and 30.3 g. of allyl bromide was refluxed one hour and worked up in the usual way. The yield was 90%; b. p. 108–110° (15 mm.); $n^{25}D$ 1.5388; d^{25}_{25} 1.132; M_D calcd., 46.2; found, 46.6.

Anal. Calcd. for C_9H_9OCl: C, 64.1; H, 5.4. Found: C, 64.0; H, 5.3.

2-Allyl-6-chlorophenol.—A sample of 2.59 g. of the ether was refluxed gently over a free flame for ten minutes, during which the boiling temperature rose from 220 to 223.5° and the liquid turned light red. It was then distilled, and 2.31 g. (89%) collected at 215–220° (750 mm.); $n^{25}D$ 1.5447. There was no undistillable residue, the remainder being held back in the column of the distilling flask. The distillate was pure, as shown by redistillation under diminished pressure, collecting two fractions at 61–63° (1 mm.) having $n^{25}D$ 1.5447 and 1.5445.

Anal. Calcd. for C_9H_9OCl: C, 64.1; H, 5.4. Found: C, 64.1; H, 5.4.

The α-naphthylurethan was prepared, m. p. 125–126°, and gave no depression with the derivative prepared from the rearrangement product of allyl 2,6-dichlorophenyl ether.

Anal. Calcd. for $C_{20}H_{15}O_2NCl$: C, 71.1; H, 4.8. Found: C, 71.3; H, 4.9.

Summary

1. 4-Crotyloxy-3,5-dichlorobenzoic acid rearranges without inversion to give 4-crotyl-2,6-dichlorophenol; the rearrangement does not take place in the presence of dimethylaniline.

2. 4-s-Butyl-2,6-dichlorophenol and 4-n-butyl-2,6-dichlorophenol have been synthesized and characterized. An abnormal Fries reaction was observed during the synthetic work.

3. Allyl 2,6 dichlorophenyl ether rearranges more slowly than 4-crotyloxy-3,5-dichlorobenzoic acid and gives 2-allyl-6-chlorophenol in addition to the normal product.

ROCHESTER, NEW YORK   RECEIVED JANUARY 23, 1942

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, COLUMBIA UNIVERSITY]

The Synthesis of 3',5'-Diiodothyronine

BY PAUL BLOCK, JR., AND GARFIELD POWELL

Although several isomers and analogs of thyroxine have been prepared since the original synthesis of this important hormone-like compound by Harington,[1] the absence from the list of the closely related substance, 3',5'-diiodothyronine (I), has heretofore constituted a gap in the series.
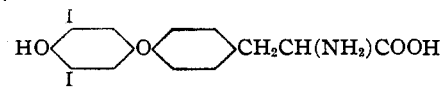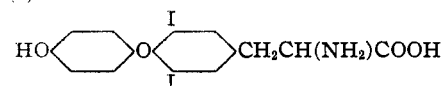
This compound, the synthesis of which we now report, has interest both chemically and physi-

(1) Harington, *Biochem. J.*, **21**, 169 (1927).

ologically. Harington long ago reported his inability to obtain any pure compound from the iodination of thyronine, the completely uniodinated thyroxine. We have amply confirmed this observation. The use of various methods of iodination invariably led to a decomposing mixture of uncertain iodine content. The present synthesis proves that pure 3',5'-diiodothyronine is a comparatively stable compound, and furnishes a foundation for an investigation of the question of why 3,5-diiodothyronine (II) can be iodinated smoothly to the tetraiodo compound, thyroxine, while thyronine itself cannot be iodinated at all.

We were enabled to synthesize 3',5'-diiodothyronine along the lines laid down for the synthesis of thyroxine by Harington after we had found a method for hydrolyzing ethers of ortho iodophenols