quickly prepared and melted in a convenient temperature range.

Since the basic function of the amino group is suppressed by this reaction, the derivatives behave as ordinary carboxylic acids. The neutral equivalent of the derivative can therefore be used as a criterion of identity. This is particularly useful when the melting points of two derivatives are separated by only a few degrees.

A solution of phthalyl L-leucine when examined polarimetrically was found to be optically active. This confirms the findings of Fox[4] and Reese.[5] Phthalyl L-glutamic acid likewise was found to be optically active. Since racemization does not appear to occur during their preparation, phthalyl derivatives should be valuable for the rapid characterization of optically active amino acids.

Tryptophan, tyrosine, serine and taurine did not give the desired derivatives.

Preparation of Phthalyl Derivatives of Amino Acids.—In a Pyrex test-tube is placed a mixture of 0.5 g. of an amino acid and 1.0 g. of phthalic anhydride. The tube is then placed in an oil-bath, which has previously been heated to 180–185°, for fifteen minutes. During the first ten minutes, the mixture is stirred occasionally and the phthalic anhydride which sublimes and deposits on the walls of the tube is pushed down into the reaction mixture by means of a glass rod. The mixture is left undisturbed during the remaining five minutes. At the end of fifteen minutes, the test-tube is carefully removed and cooled until the liquid mass solidifies. It is then inverted and the excess phthalic anhydride sublimed on the walls is scraped out. The residue is recrystallized from 10% ethyl alcohol or water. Most of the phthalyl amino acids are very soluble in dilute alcohol. When alcohol is used, some of the derivatives oil out if too concentrated a solution of the derivative is made or if the solution is cooled too rapidly.

When working with a specific amino acid it is desirable to use an approximately one to one molar ratio of amino acid to phthalic anhydride.

Summary

A series of phthalyl derivatives of amino acids has been prepared by a general procedure and it has been shown that phthalic anhydride is a useful reagent for the identification of most of the simple amino acids.

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(4) Fling, Minard and Fox, This Journal, **69**, 2468 (1947).

(5) Reese, *Ann.*, **242**, 9 (1887).

[Contribution from Kedzie Chemical Laboratory, Michigan State College]

Condensation of Some Tertiary Octyl Alcohols with Phenol

By Ralph C. Huston, William K. Langdon[1a] and Louis J. Snyder[1b]

In previous communications from this Laboratory,[2] the condensations of eleven tertiary alcohols with phenol have been described. The present paper reports the condensation of the five tertiary alcohols shown in Table I.

These alcohols were prepared as described by Huston and co-workers[3] and condensed with phenol in the presence of anhydrous aluminum chloride. The yields of the *p*-*t*-octylphenols varied from 36 to 80%. No isomers or disubstituted products were isolated. In addition to the benzoyl esters and α-naphthylurethans of these *p*-*t*-octylphenols, the phenylurethans of three of them were prepared.

The position of the alkyl group in each phenol was proven by oxidation of the corresponding nitro-octylbenzene,[4] by heating in a Carius tube with 6 *N* nitric acid at 130°, to yield only *p*-nitrobenzoic acid. The corresponding *t*-octylbenzene[3] was also converted into the phenol by nitration, reduction to the amine, diazotization and hydrolysis.[2] The phenol thus synthesized was shown to be identical with the one obtained through direct condensation of the alcohol and phenol by means of melting point and mixed melting point determinations. The assignment to the alkyl group of the phenol the same structure as that of the alkyl group of the alcohol from which it is formed is based upon the following considerations:

(a) There are theoretically possible seventeen *p*-*t*-octylyhenols.

(b) In the rearrangement of alkyl groups during processes of condensation, primary groups may change to secondary or tertiary, secondary may change to tertiary, and tertiary may change to tertiary. Instances of the formation of appreciable yields of isomeric primary or secondary groups from tertiary groups are not known.[2b]

(c) Fifteen different *p*-*t*-octylphenols, corresponding to the fifteen tertiary octyl alcohols, other than 2,3,3-trimethyl-2-pentanol and 2,2,3-trimethyl-3-pentanol, have been described[2,5] or are described in this article.

When 2,3,3-trimethyl-2-pentanol is condensed with phenol, *two* *p*-*t*-octylphenols are formed, neither of which is identical with any of the other fifteen. The condensation of 2,2,3-trimethyl-3-pentanol with phenol gives the same two *p*-*t*-octyl-

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(1) Present location: (a) Wyandotte Chemical Corp., Wyandotte, Mich.; (b) Ethyl Corp., Baton Rouge, La.

(2) (a) Houston and Guile, This Journal, **61**, 69 (1939); (b) Huston and Meloy, *ibid.*, **64**, 2655 (1942).

(3) Huston, Goerner, *et al.*, *ibid.*, **70**, 1090 (1948).

(4) Malherbe, *Ber.*, **52**, 319 (1919).

(5) Huston and Krantz, *J. Org. Chem.*, **13**, 63 (1948).

TABLE I

SOME TERTIARY OCTYL PHENOLS AND DERIVATIVES

Alcohols		3-Methyl-3-heptanol	3-Ethyl-3-hexanol	2,4-Dimethyl-4-hexanol	3,4-Dimethyl-3-hexanol	2-Methyl-3-ethyl-3-pentanol
p-*t*-Octylphenols, yield, %		80	36	61	40	54
B. p., °C. (mm.)		293.7 (758) 128–130 (3)	265 (741) 134–137 (6)	287.5 (758) 125 (3)	294 (758) 130–133 (3)	270 (756)^a 110–112 (2)
n^{20}_D		1.5164	1.5212 (14.5°)	1.5162	1.5247	
d^{20}_4		0.9516	0.9561 (d^{20}_{20})	0.9530	0.9717	
Carbon, % (calcd. 81.50)		81.38	81.60	81.47	81.41	81.42
Hydrogen, % (calcd. 10.75)		10.78	10.92	10.73	10.57	10.69
Benzoyl esters, m. p., °C.		122	40–40.5	123	125	38.2–38.6
Carbon, % (calcd. 81.25)		81.13	81.18	81.18	81.23	81.06
Hydrogen, % (calcd. 8.44)		8.23	8.42	8.31	8.29	8.64
α-Naphthyurethans	M. p., °C.	94	106.7–107	90	129	128–128.5
	N, % (calcd. 3.73)	3.58	3.66	3.67	3.51	3.68
Phenylurethans	M. p., °C.	104		94	119	
	N, % (calcd. 4.30)	4.28		4.21	4.18	
p-Nitro-*t*-octylbenzenes	B. p., °C.	145–147 (3)	125–130 (3)	160–163 (9)	159–160 (9)^b	130–135 (6)
	N, % (calcd. 5.95)	5.72	6.07	5.81		5.97
p-Amino-*t*-octylbenzenes	B. p., °C.	129–130 (3)	120–125 (3)	130–131 (3)	134–136 (3)	125–130 (6)
	N, % (calcd. 6.82)	6.74	6.80	6.67		6.75

^{a} M. p. 33.5–34°. ^{b} Distilled with decomposition.

phenols. These are now being studied in this Laboratory. The only other evidence of rearrangement noted is the formation of some 2,4,4-trimethyl-2-*p*-hydroxyphenylpentane together with 2,3,4-trimethyl-2-*p*-hydroxyphenylpentane when 2,3,4-trimethyl-2-pentanol is condensed with phenol.[5]

(d) Seventeen different *p*-*t*-octylphenols have been formed by the condensation of seventeen isomeric octyl alcohols. In cases where only one phenol is isolated, the assignment of the structure of the alkyl group of the alcohol to the side chain of the octylphenol is justified.

Experimental

Melting points and boiling points are uncorrected.

The alcohols were prepared as indicated by Huston, Goerner, *et al.*,[3] with one exception. Part of the 3-ethyl-3-hexanol was made by adding one mole of chloroacetyl chloride to slightly over three moles of ethyl Grignard reagent. The ether was then removed and the dry reaction mixture heated on the steam-bath for twenty-four hours in order to insure the hydrocarbon type of synthesis on the α-carbon atom. The average yield was 75%.

Condensations with Phenol. (a) Using 3-Ethyl-3-hexanol and 2-Methyl-3-ethyl-3-pentanol.—Thirty-two grams (0.25 mole) of octyl alcohol, 47 g. (0.5 mole) of phenol and 200 ml. of petroleum ether were mixed in a 500 ml., three-neck flask equipped with a thermometer, condenser and mechanical stirrer. Anhydrous aluminum chloride (17 g., 0.125 mole) was added portionwise during the course of an hour. The temperature was maintained between 25 and 30° by external cooling when necessary.

(b) **Using the Other Three *t*-Octyl Alcohols.**—The proportions of reactants were: alcohol, 32.5 g. (0.25 mole); phenol, 23.5 g. (0.25 mole); aluminum chloride, 17 g. (0.125 mole); petroleum ether, 80 ml. The method was the same as in (a).

After the addition of the aluminum chloride, stirring was continued for four hours and the reaction mixture allowed to stand overnight. After hydrolysis by ice and hydrochloric acid, the layers were separated and the aqueous layer extracted with ether. The combined ether–petroleum ether layers were washed with 10% sodium carbonate solution and dried. Distillation through a modified Claisen flask with a 30 to 45 cm. Vigreux column gave the following fractions: (1) b. p. below 65° (5 to 10 mm.), probably unreacted alcohol or the corresponding chloride; (2) b. p. 65 to 100° (5 mm.), chiefly recovered phenol; (3) b. p. 100 to 140° (3 mm.). The last fraction was redistilled until a product with a narrow boiling point range was obtained. 2-Methyl-3-ethyl-3-(*p*-hydroxyphenyl)-pentane, the only solid phenolic product, was recrystallized from petroleum ether.

The benzoyl esters were prepared by the method of Shriner and Fuson.[6] Since the esters did not solidify when poured into water, it was necessary to separate the oil, extract the aqueous layer with ether, wash the ether extract successively with dilute acid and sodium carbonate solution and distil under diminished pressure. The esters crystallized at once or when chilled in the refrigerator. They were recrystallized from petroleum ether or ethyl alcohol.

The phenylurethans and α-naphthylurethans prepared by the method of Bickel and French[7] or by the method of French and Wirtel,[8] were recrystallized from alcohol or petroleum ether.

Summary

1. Five *t*-octyl alcohols have been condensed with phenol in the presence of aluminum chloride.

2. The benzoyl esters and α-naphthylurethans of the resulting *p*-*t*-octylphenols have been prepared. The phenylurethans of three of these phenols were also prepared.

3. The structures of the phenols have been established.

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[6] Shriner and Fuson, "Systematic Identification of Organic Compounds," John Wiley and Sons, Inc., New York, N. Y., 1940, p. 137.

[7] Bickel and French, THIS JOURNAL, **48**, 747 (1926).

[8] French and Wirtel, *ibid.*, **48**, 1736 (1926).