methoxyphenylthiazole)-4-ethylamine. The further study of this base is being continued with the object of developing a practical synthesis of the bridged thiazole derivative of 3,4-dihydroxyphenylethylamine represented by formula II in this paper.

3. Ten new thiazole derivatives have been described.

NEW HAVEN, CONNECTICUT

[CONTRIBUTION FROM THE SCHOOL OF CHEMISTRY OF THE UNIVERSITY OF MINNESOTA]

STUDIES ON THE POLYMETHYLBENZENES. IV. THE PREPARATION AND PHYSICAL PROPERTIES OF PURE PSEUDOCUMENE[1]

BY LEE IRVIN SMITH AND AXEL P. LUND

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The work reported in this paper is a continuation of a research which has for one of its immediate purposes the separation of the isomeric liquid hydrocarbons which result from the methylation of xylene by the method of Friedel and Crafts.[2] In the previous papers reports were made on the pure tetramethylbenzenes, and on penta- and hexamethylbenzenes. This paper deals with pseudocumene (1,2,4-trimethylbenzene), and reports the preparation and purification, together with the freezing point, refractive index and vapor pressure curve of a very pure sample.

Pseudocumene has been obtained from petroleum,[3] but the commercial source is coal tar.[4] However, pseudocumene obtained in this way is always contaminated with mesitylene, and it is very doubtful whether a specimen of the pure hydrocarbon has ever been obtained from any of these sources.

Synthetic pseudocumene has been made in several ways, but the yields were always low and, in addition, most of the methods are open to the objection that isomeric by-products might result. Thus Jacobsen[5] reports that if phorone is heated with phosphorus pentoxide or zinc chloride, some pseudocumene results, but if concd. sulfuric acid be used, only mesitylene results. The decomposition of camphor by zinc chloride is reported to give pseudocumene[6] but these syntheses do not give pure products, nor good enough yields for purposes of preparation.

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[1] Abstracted from a thesis by Axel P. Lund, presented to the Graduate Faculty of the University of Minnesota, in partial fulfilment of the requirements for the degree of Master of Science.

[2] Smith and co-workers, I, THIS JOURNAL, **51**, 2994 (1929); II, **51**, 3001 (1929); III, **52**, 1998 (1930); also **48**, 1413 (1926).

[3] Engler, *Ber.*, **18**, 2234 (1885); Markownikow, *Ann.*, **234**, 97 (1886).

[4] Jacobsen, *Ber.*, **9**, 256 (1876); *Ann.*, **184**, 179 (1877); Schultz and Herzfeld, *Ber.*, **42**, 3602 (1909).

[5] Jacobsen, *ibid.*, **10**, 855 (1877).

[6] R. Fittig, Köbrich and Jilke, *Ann.*, **145**, 140 (1868); Reuter, *Ber.*, **16**, 626 (1883).

Paul Jannasch, and others[7] have prepared pseudocumene by treating bromoxylenes with methyl iodide and sodium, or by treating dibromotoluenes with the same reagents, but in every case there is question as to the purity of the aromatic bromo compounds, and the yields of pseudocumene were very low.

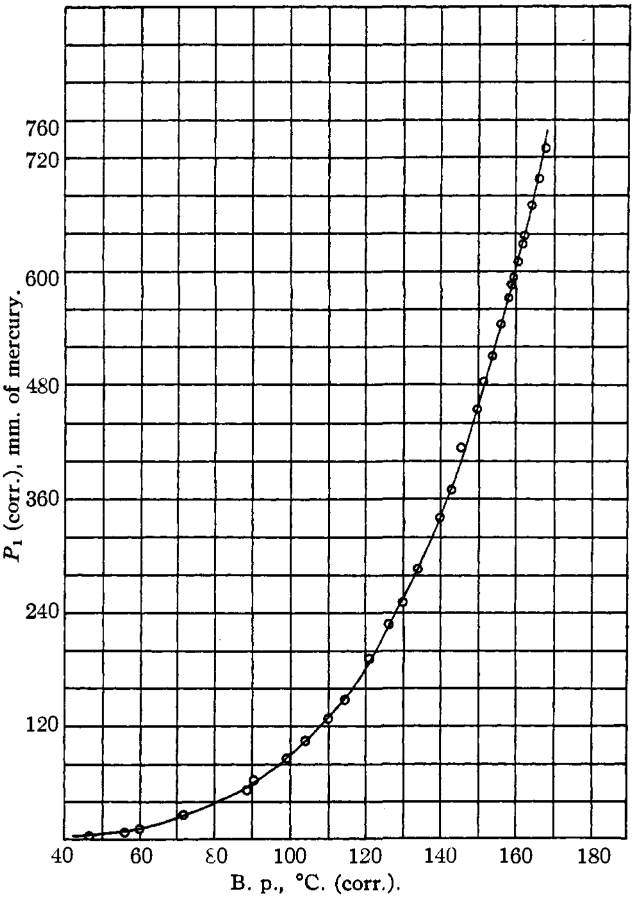

Fig. 1.—Vapor pressure curve for pseudocumene.

While the direct methylation of the xylenes using aluminum chloride and methyl chloride has been used to prepare pseudocumene, such a method always gives a mixture and none of the specimens prepared in this way were pure. This is because the methylation in the presence of aluminum chloride is reversible, and methyl groups are eliminated as well as intro-

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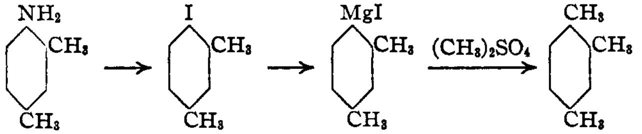
[7] Jannasch, *Ann.*, **176**, 283 (1875); E. and R. Fittig, *ibid.*, **139**, 187 (1866); R. Fittig and Laubinger, *ibid.*, **151**, 258 (1869); R. Fittig and Jannasch, *ibid.*, **151**, 291 (1869); Jannasch, *ibid.*, **176**, 283 (1875).

duced, so that the final result will depend upon many factors; but in every case the product is a mixture of substances, and very little is known about the way in which various factors influence the result. About the only generalization that can be safely made is that ortho methylation apparently occurs in very small amounts: that is, of the trimethylbenzenes formed, very little will be the 1,2,3-isomer, and of the tetramethylbenzenes, the 1,2,3,4-isomer will result in least amount.[8]

The one synthesis in the literature which might be made to give pure pseudocumene in fair yields is that of Haller,[9] who started with pseudocumidine, a solid, which could be obtained in a pure state. This was diazotized, and then reduced to the hydrazine, after which the hydrazine group was eliminated by boiling with a solution of copper sulfate. Haller gives the boiling point of his product as 169–170° (corr.), but does not mention the over-all yield nor the amount of material he prepared. His synthesis was used to prepare pseudocumene in 1919 by Auwers,[10] who gave the boiling point as 169° and n_D^{20} as 1.5046.

All the other samples of pseudocumene which have been used for the determination of physical constants were commercial products, and nothing is known as to their method of preparation.[11]

Preparation of Pseudocumene.—The preparation of pseudocumene for this work involves the following series of reactions



Starting with pure xylidine, the series gives intermediates which are easily purified. No rearrangements are involved, and the only trimethylbenzene which can result from these reactions is pseudocumene. Some xylene is formed, due to the reducing action of the Grignard reagent, but this is easily separated by fractional distillation.[12]

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[8] See papers I, II and III in this series; also Smith and Dobrovolny, THIS JOURNAL, 48, 1420 (1926); Friedel and Crafts, *Ann. chim. phys.*, 1, 449 (1884); Ador and Rilliet, *Ber.*, 11, 1627 (1878); 12, 329 (1879); Jacobsen, *ibid.*, 9, 256 (1876); 10, 1009 (1877); 14, 2624 (1881); 18, 338 (1885).

[9] Haller, *ibid.*, 18, 89 (1885).

[10] Auwers, *Ann.*, 419, 99 (1919).

[11] (a) Auwers and Müller, *Ber.*, 44, 1606 (1911); (b) Landolt and John, *Z. physik. Chem.*, 10, 303 (1892); (c) Brühl, *J. prakt. Chem.*, [2] 50, 142 (1894); (d) Perkin, *J. Chem. Soc.*, 67, 1249 (1896); (e) Woringer, *Z. physik. Chem.*, 34, 263 (1900).

[12] While this paper was being written, the paper of Maxwell and Adams [THIS JOURNAL, 52, 2962 (1930)] appeared, in which these authors prepared pseudocumene from *m*-xylene by bromination, followed by conversion of the bromo-*m*-xylene to pseudocumene through the Grignard reagent. Their yield of pseudocumene, based upon the *m*-xylene, was about 40%, as compared with our over-all yield of about 30%.

Experimental Part

4-Amino-1,3-dimethylbenzene.—This was obtained from the Eastman Kodak Co., and was distilled immediately before using; b. p. 111° at 18 mm. Practically all of the sample showed a constant boiling point.

4-Iodo-1,3-dimethylbenzene.[13]—In a 3-liter round-bottom flask are placed 200 g. of concd. sulfuric acid, 1500 cc. of water and 121 g. (1 mole) of xylidine. The mixture is warmed on the steam-bath until all of the xylidine sulfate dissolves, and is then cooled to 0°, with stirring to produce small crystals. To the cold solution is added a solution of 69 g. of sodium nitrite in 200 cc. of water with stirring and cooling. (The temperature should not be allowed to rise above +5°.) An excess of nitrous acid should be used, and after about 80% of the sodium nitrite is added, the starch–potassium iodide test should be applied. It should be positive for fifteen minutes after an excess of sodium nitrite has been added. When enough sodium nitrite has been supplied, a solution of 250 g. of potassium iodide (30% excess) in 300 cc. of water is gradually run in, with stirring and cooling. The temperature of the mixture is kept at 5–10° for twenty-four hours and then allowed to come to room temperature. The iodo compound settles to the bottom as a black, oily layer. The mixture is allowed to stand for a day at room temperature, and is finally warmed on the steam-bath until effervescence ceases. The mixture is then made strongly alkaline, stirred and the aqueous layer siphoned off. The dark oil is again treated with alkali, after which it is steam distilled. The orange colored oil is separated from the water, dried over calcium chloride and distilled *in vacuo*; b. p. 105–106° at 5 mm.; 108–110° at 10–12 mm.; 124–126° at 28–30 mm. Runs were made in 0.5, 1.0, 1.5 and 2.0 molar quantities, the yields running from 69.0 to 82.7%, with an average yield of about 75% for 1.0 molar quantities. Two important factors which influence the yields very much are the amount of potassium iodide used and the time of the reaction. An excess of about 30% of potassium iodide and very slow raising of the temperature after the potassium iodide has been added give the best yields.[14]

Pseudocumene.—The iodoxylene was converted to pseudocumene using the method already described for the preparation of isodurene.[15] The product is worked up in the same way: the excess dimethyl sulfate is destroyed with alcoholic alkali and, after washing out the alcohol and alkali, the oil is dried over calcium chloride and then warmed with sodium shavings to remove the last traces of halogen compounds. The oil is then filtered from the sodium and distilled *in vacuo* using a long packed column with a double jacket. Grignard reactions were carried out using 0.5 to 3.0 molar quantities, but the yields do not differ very much from the smaller to larger runs. The material from six different runs, totaling $11^3/_8$ moles of iodo compound, was combined and fractionated three times, with the results shown in Table I.

TABLE I

FRACTIONATION OF CRUDE REACTION PRODUCT

Fraction	B. p., °C.	Pressure, mm.	Wt., g.	Yield, %
I *m*-Xylene	Up to 45	16	346	28.5
II Intermediate	47.7–67.2	21–22	18	..
III Pseudocumene	68–68.5	22	503	37
IV Residue in flask	....	...	Very small	..

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[13] See also Hammerich, *Ber.*, 23, 1634 (1890); Willgerodt, *ibid.*, 33, 842 (1900).

[14] It is very interesting in this connection that we were unable to make the corresponding bromo compound from xylidine using the Sandmeyer reaction. The product is chiefly xylenol and the yield of bromo compound is very small.

[15] Smith and MacDougall, THIS JOURNAL, 51, 3003 (1929); Smith, "Organic Syntheses," John Wiley and Sons, Inc., New York, 1931, Vol. XI.

About a third of the material is lost in the synthesis, probably as *m*-xylene which is very difficult to hold in a receiver under vacuum. That Fraction I is *m*-xylene was shown by converting a sample of it to the dinitro compound, m. p. 92–93°, and the trinitro compound melting at 181.5–182°.

In order to get a very pure sample for the determination of physical constants, Fraction III was refractionated, cutting off the first and final fourths and taking only the middle half. Then the process was repeated, using as starting material the middle half from the previous fractionation, and again cutting off the first and final fourths. This gave 125 g. of pseudocumene having a constant boiling point of 68.0° at 22 mm., but all the fractions of the pseudocumene boiled over a range of about 0.5°.

A further attempt to purify the hydrocarbon by making the picrate and recrystallizing this was a failure because the picrate of the substance is too soluble and has too low a melting point to be of any use for purification purposes.

The Vapor Pressure Curve of Pseudocumene.—There is, apparently, only one study on the vapor pressure of pseudocumene in the literature, that of Woringer,[16] and all the data on the vapor pressure of this substance in the literature are copied from Woringer's paper.[17]

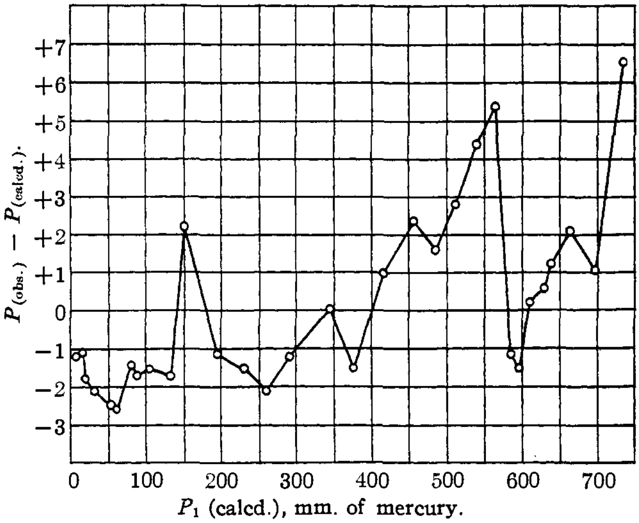

Fig. 2.—Vapor pressure–deviation plot for pseudocumene. $\mathrm{Log}_{10}p = 7.0144 - 1.5014\mu - 0.1447\mu^2$. ($\mu = 1000/T_{\text{abs.}}$)

The method used for determining the vapor pressure curve is a dynamic one, and the apparatus and procedure have already been described.[18] The results are given in the form of tables and curves. The equation

$$\log_{10} p = 7.0144 - 1.5014\mu - 0.1447\mu^2 \text{ (where } \mu = 1000/T)$$

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[16] Woringer, *Z. physik. Chem.*, **34,** 263 (1900).

[17] "International Critical Tables," McGraw-Hill Book Co., Inc., New York, **1928,** Vol. III, p. 225; Spielmann, "The Constituents of Coal Tar," Longmans, Green & Co., New York, **1924,** p. 62.

[18] MacDougall and Smith, This Journal, **52,** 1998 (1930).

fits these results fairly well. For comparison, the calculated and observed vapor pressures are given in the table, and the deviations are shown in the form of a graph. In every case Woringer's boiling points are lower than ours, and in the region from 5 to 100 mm. pressure Woringer's boiling points are too low by as much as 50° in extreme cases. In the region of higher pressures, Woringer's boiling points agree fairly well with ours, but are always too low, approaching ours more closely the higher the pressure.

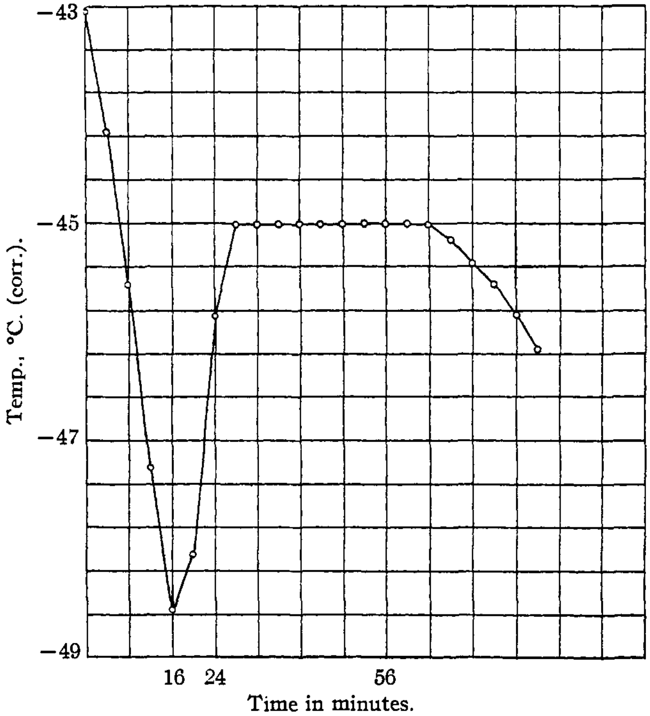

Fig. 3.—Cooling curve, freezing point of pseudocumene.

The boiling point of pseudocumene under 760 mm. pressure is 169.34°, calculated from the vapor pressure equation, and 169.1° by extrapolation of the vapor pressure curve.

The Freezing Point of Pseudocumene.—This was determined essentially as described in connection with previous work.[19] The cooling bath was composed of chlorobenzene (freezing point −45°) to which was added carbon dioxide snow and ether until the bath was at −60°. Once this temperature was reached, it was easy to maintain it by adding small amounts of ether and solid carbon dioxide from time to time. Readings were taken every minute and the results are shown graphically in Fig. 3. The freezing point of pseudocumene is −45.00 ± 0.05° corr.

[19] Smith and MacDougall, This Journal, 51, 3005 (1929).

TABLE II

VAPOR PRESSURE DATA FOR PURE PSEUDOCUMENE

B. p., °C. (corr.)	*P*, obs. (mm.)	*P*, calcd.	Deviation	B. p., °C. (corr.)	*P*, obs. (mm.)	*P*, calcd.	Deviation
47.1	7	8.207	−1.207	143.3	373.7	375.2	−1.5
57.6	13	14.16	−1.16	147.0	417.2	416.2	+1.0
61.6	15.5	17.27	−1.77	150.1	458.2	455.8	+2.4
73.1	28.0	30.09	−2.09	152.1	483.7	482.1	+1.6
89.1	56.0	58.37	−2.37	154.4	516.2	513.4	+2.8
92.0	63.0	65.55	−2.55	156.2	543.7	539.3	+4.4
98.6	83.0	84.70	−1.7	158.1	573.3	567.9	+5.4
99.6	86.5	87.96	−1.46	159.2	583.8	584.9	−1.1
105.0	106.0	107.5	−1.5	159.9	594.3	595.8	−1.5
111.1	132.0	133.7	−1.5	160.9	612.3	612.1	+0.2
115.1	152.5	150.1	+2.4	161.9	628.8	628.2	+0.6
122.6	196.6	197.7	−1.1	162.3	636.3	635.0	+1.3
127.7	231.6	233.1	−1.5	164.3	669.8	667.7	+2.1
130.8	255.1	257.2	−2.1	165.9	698.8	697.6	+1.2
134.9	290.6	291.9	−1.3	167.8	738.8	732.3	+6.5
140.1	341.6	341.5	+0.1				

Refractive Index.—Previous determinations, recorded in the literature, for the refractive index of pseudocumene are Auwers,[10] n_D^{20} 1.5046; Auwers and Müller,[11a] $n_D^{13.9}$ 1.50780; Landoldt and John,[11b] $n_D^{14.7}$ 1.5072; and Brühl,[11c] $n_D^{21.6}$ 1.50441. All our fractions of pseudocumene, after the second distillation, gave the value n_D^{24} 1.5032 (Abbé refractometer).

Summary

1. A new method has been devised for preparing pseudocumene in quantity and fairly cheaply. The method gives a product free from any isomeric by-products.

2. The vapor pressure curve, freezing point and refractive index of a very pure specimen of pseudocumene have been determined.

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