samples for analysis were dried at 105° except 5-*p*-hydroxybenzalcreatinine which was heated at 165° for one hour. The condensation with hydrocinnamaldehyde was carried out in melted acetamide.

TABLE I

ALDEHYDE CONDENSATION PRODUCTS OF CREATININE

Compound, -creatinine	Color	M. p.,[a] °C.	Solvent for crystal-lization	Yield, %
5-*p*-Methoxybenzal-	Yellow	248–249[b]	Water	63
5-*o*-Methoxybenzal-	Cream	241	Water	31
5-*o*-Ethoxybenzal-	Yellow	236[b]	Water	34
5-*p*-Hydroxybenzal-	Yellow	289	Water	32
5-Hydrocinnamal-	Yellow	225–230	Ethanol	25
5-*p*-Methylbenzal-	Yellow	285[b]	Ethanol	28
5-Piperonal-	Yellow	274[b,c]	Water	29
5-*o*-Chlorobenzal-	Yellow	242[b,c]	Pptd. from dil. HCl with NH₃	57

Formula	Nitrogen, % Calcd.	Found	M. p.,[a] °C. of picrate	M. p.,[a] °C. of hydrochloride
$C_{12}H_{13}O_2N_3$	18.18	18.01	244[b]	247–248[b]
$C_{12}H_{13}O_2N_3$	18.18	17.49	255–270[b]	258–259[b]
$C_{13}H_{15}O_2N_3$	17.14	17.01	244–246[b]	214[b]
$C_{11}H_{11}O_2N_3$	19.27	19.23	252–257[b]	...
$C_{13}H_{15}ON_3$	18.29	18.22	221	...
$C_{12}H_{13}ON_3$	19.53	19.45	256[b]	256[b]
$C_{12}H_{11}O_3N_3$	17.14	16.55	255	...
$C_{11}H_{10}ON_3Cl$	17.84	17.31	260	241

[a] Melting points are uncorrected.   [b] Melts with decomposition.   [c] Melting point taken in closed tube.

TABLE II

RESIDUES FROM ALDEHYDE CONDENSATIONS SUGGESTED AS TRIALDEHYDE-DI-CREATININE DERIVATIVES

Aldehyde from which product is derived	Solvent for crystallization	Color
o-Methoxybenzaldehyde	Acetic acid	Yellow
o-Ethoxybenzaldehyde	Nitrobenzene	Red
p-Methylbenzaldehyde	Acetic acid	Yellow
o-Chlorobenzaldehyde	Acetic acid	Yellow
Piperonal	Aniline	Red-orange

M. p.,[a] °C.	Formula	Nitrogen, % Calcd.	Found
292	$C_{32}H_{33}O_5N_6$	14.45	14.62
297	$C_{35}H_{39}O_5N_6$	13.47	13.94
309	$C_{31}H_{32}O_2N_6$	16.14	16.18
270	$C_{29}H_{23}O_2N_6Cl_3$	14.17	14.26
327	$C_{32}H_{26}O_5N_6$	13.50	13.88

[a] Melting points are uncorrected.

The experimental data are summarized in Tables I and II.

We wish to express our appreciation to the Valentine Meat Juice Company for the creatine from which the creatinine used in these experiments was prepared and to the Virginia Academy of Science for a grant with which to purchase chemicals.

Summary

1. *p*-Methoxybenzaldehyde, *o*-methoxybenzaldehyde, *o*-ethoxybenzaldehyde, *p*-hydroxybenzaldehyde, hydrocinnamaldehyde, *p*-methylbenzaldehyde, piperonal and *o*-chlorobenzaldehyde have been condensed with creatinine.

2. The picrates of the above condensation products and the hydrochlorides of all except piperonalcreatinine, *p*-hydroxybenzalcreatinine and hydrocinnamalcreatinine have been prepared and described.

3. The nitrogen content and apparent purity of products isolated from the condensations of creatinine with certain of the above-named aldehydes suggest that two moles of the primary condensation product condense further with one mole of aldehyde.

RICHMOND, VA.   RECEIVED JANUARY 22, 1936

The Reaction between Quinones and Sodium Enolates. IV. Pseudocumoquinone, Sodium Acetoacetic Ester and Sodium Malonic Ester[1]

BY LEE IRVIN SMITH AND C. W. MACMULLEN

Previous papers in this series[2] have dealt with the reaction between a fully substituted quinone, duroquinone and sodium malonic ester. In this case the reaction was unlike any of the other addition reactions of quinones, for the product was a coumarin derivative (I) and one of the methyl groups of the quinone was involved in the reaction. In order to explore the limits of this reaction, it was desired to study the addition of sodium enolates to pseudocumoquinone (trimethylquinone) (II).

This quinone has three methyl groups attached to the nucleus, and therefore offers the possibility of undergoing the same type of reaction with sodium enolates as was shown by duroquinone. In addi-

(1) Abstracted from a thesis by C. W. MacMullen, presented to the Graduate Faculty of the University of Minnesota, in partial fulfilment of the requirements for the degree of Doctor of Philosophy, July, 1935.

(2) (a) Smith and Dobrovolny, THIS JOURNAL, 48, 1693 (1926); (b) Smith, *ibid.*, 56, 472 (1934); (c) Smith and Denyes, *ibid.*, 58, 304 (1936).

I   II
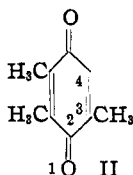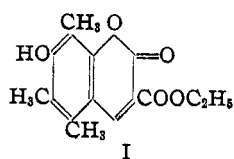
tion, it contains one conjugated system not substituted in the 4-position (II, 1-4) which might react in the usual way.

The literature apparently contains no report of the addition of sodium malonic ester to a halogen-free, mononuclear quinone such as II, with one or more unsubstituted positions. The studies of Stieglitz[3] as well as those of Jackson[4] and his students dealt with chloranil and bromanil; while the studies of Liebermann[5] and his students dealt largely with halogenated indones and naphthoquinones, although α- and β-naphthoquinones were also found to react. In the case of these halogenated quinones, the malonic ester residue apparently replaced one or more of the halogen atoms, but it was not possible to fix the course of the reaction from the structures of the products alone. Both α- and β-naphthoquinone reacted with one molecule of the ester to give the corresponding quinonyl malonic ester and the hydroquinone. Liebermann mentioned that thymoquinone reacted in the same way, but he did not describe any experiments with this quinone or any compounds derived from it.

The reaction between acetoacetic ester and quinone was first studied by v. Pechmann[6] who, however, did not propose any structures for his products. Ikuta,[7] after studying the reaction between acetoacetic ester and chloranil, repeated the work of v. Pechmann and isolated two products from the reaction. Ikuta regarded one of the products as a difurobenzene (III), and the other as a 5-hydroxybenzofuran (IV).

III

IV   V
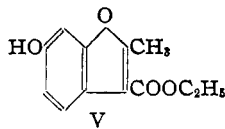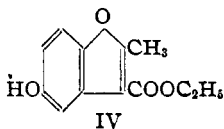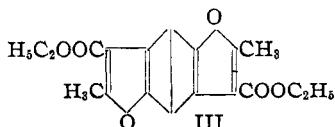
The action of zinc chloride on a solution of toluquinone and acetoacetic ester in acetone was studied by Graebe and Levy,[8] who succeeded in isolating two products, a difurobenzene analogous to the product obtained by Ikuta (III), and a hydroxybenzofuran. Graebe and Liebermann were unable to decide upon the location of the hydroxyl group in the latter and they suggested that Ikuta's product (IV) might actually be the 6-hydroxy derivative (V).

The addition of sodium acetoacetic ester to trimethylquinone in alcohol, produced two substances which could be readily separated by distillation with steam. The volatile compound was 5-hydroxy-2,4,6,7-tetramethylcoumarone (VI), and the non-volatile compound was 5-hydroxy-4,6,7-trimethylisocoumaranone (VII).

VI, R = H   VII, R = H
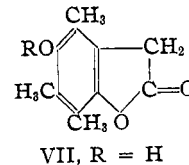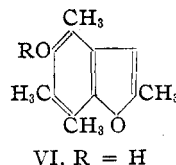
The addition of sodium malonic ester to trimethylquinone in alcohol gave but one substance, the isocoumaranone VII. No compound of the coumarin series, corresponding to I, was obtained from either of these reactions, but since the best yields of the coumarin had been obtained from duroquinone by operating in the absence of alcohol,[2a] sodium acetoacetic ester was added to II in benzene. The product was resinous material, from which the coumarone VI was isolated. The isocoumaranone VII was undoubtedly formed also, but it could not be isolated from the reaction product in sufficient quantity for purification.

The formation of two products in the acetoacetic ester reaction, one of which was the sole product of the malonic ester addition, and the entire absence of any product comparable to the coumarin I, can be interpreted simply and logically as resulting from 1,4-addition of the reagent to the open conjugated system in II followed by ring closure and the usual cleavages of β-keto esters and malonic esters. The quinone and acetoacetic ester would give the intermediate VIII, which by loss of alcohol and the "acid" cleavage, would give VII; and by enolization, followed by loss of water and the "ketone" cleavage, would

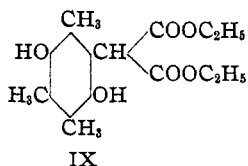(3) Stieglitz, *Am. Chem. J.*, **13**, 38 (1891).

(4) Jackson, *ibid.*, **17**, 597 (1895).
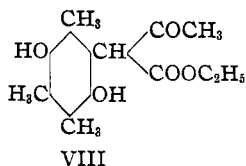
(5) (a) Liebermann, *Ber.*, **31**, 2906 (1898); **32**, 264, 916 (1899); **33**, 566 (1900); (b) Michel, *ibid.*, **33**, 2402 (1900); (c) Hirsch, *ibid.*, **33**, 2412 (1900); (d) Lanser and Wiedermann, *ibid.*, **33**, 2418 (1900).

(6) Von Pechmann, *ibid.*, **21**, 3005 (1888).

(7) Ikuta, *J. prakt. Chem.*, [2] **45**, 65 (1892).

(8) Graebe and Levy, *Ann.*, **283**, 251 (1894).

VIII

IX

give VI. Similarly, from malonic ester the intermediate IX would result, which could undergo ring closure and cleavage in one way only, leading to VII.

The substance VII had the composition $C_{11}H_{12}O_3$. It was readily soluble in dilute alkali, gave a negative iodoform test, but reduced permanganate solution. It failed to form a phenylhydrazone or an oxime. Its alkaline solution reacted with methyl sulfate to give 3,6-dimethoxy-2,4,5-trimethylphenylacetic acid (X), which was synthesized by an independent method, and finally the isocoumaranone VII itself was synthesized from 3,6-dinitro-2,4,5-trimethylphenylacetic acid (XI) by reduction to the amino oxindole

X

XI

XII
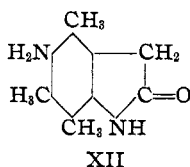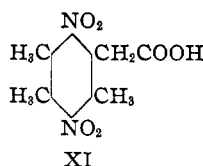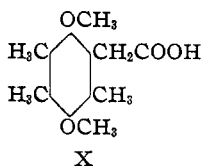
XII, which was converted to the isocoumaranone VII via the barium salt of the diaminophenylacetic acid according to the method of Marschalk.[9]

The substance VI had the composition $C_{12}H_{14}O_2$. It was not an aldehyde or a ketone since it failed to react with phenylhydrazine, hydroxylamine, sodium bisulfite or Tollens' reagent. It was readily attacked by permanganate, as is characteristic of coumarones. The presence of the hydroxyl group was shown by the formation of a benzoate (VI, R = C_6H_5CO) and a monomethyl ether (VI, R = CH_3), but the action of the alkali gave no products derived by opening the hetero ring. Although VI was not synthesized, it was felt that the chemical properties and mode of formation, together with the proven structure of VII, left no doubt as to the structure of VI.

(9) Marschalk, *Ber.*, **45**, 582 (1912).

Experimental Part

Addition of Acetoacetic Ester to Pseudocumoquinone[10]

(A) In Alcohol.—Sodium acetoacetic ester was prepared by adding sodium ethoxide (0.1 mole) (from sodium (2.3 g.) and 100 cc. of absolute alcohol) to acetoacetic ester (15 cc., 0.12 mole) in absolute alcohol (25 cc.). A solution of pseudocumoquinone (15 g., 0.1 mole) in absolute alcohol (85 cc.) was slowly (1.75 hours) dropped into the solution of sodium acetoacetic ester. The red reaction mixture, after standing overnight, was poured onto ice (1 kg.) and hydrochloric acid (40 cc.). The sticky, brown solid, which soon became light colored and granular, was filtered while ice was still present in the mixture. The solid was then distilled with steam. The distillate contained 4 g. of white solid (VI). The hot liquid remaining in the distilling flask was filtered from the resinous material (11.5 g.) and the filtrate, when cooled, deposited 1 g. of yellow solid (VII). The resin was refluxed for six hours with glacial acetic acid (60 cc.), water (50 cc.) and zinc (20 g.). The hot solution, decanted from the zinc, deposited 7 g. of yellow solid (VII) when cooled. Approximately the same results were obtained when the ester and quinone were dissolved in alcohol and sodium ethoxide added slowly to the solution.

(B) In Benzene.—Powdered sodium (1 g.) was covered with dry benzene (80 cc., thiophene free) and acetoacetic ester (6 cc.) slowly added. The mixture was warmed and shaken thoroughly until all the sodium reacted. After cooling, pseudocumoquinone (4.8 g.) was added and the mixture allowed to stand with occasional heating (total thirty hours) for two weeks. After decomposition with hydrochloric acid, the benzene layer was separated and worked up as described under A. The product was chiefly VI, although a small amount of impure VII was also obtained. The resinous material formed in this experiment was not investigated.

Addition of Malonic Ester to Pseudocumoquinone.— The sodium derivative of the ester was added to the quinone in alcohol as described for the addition of acetoacetic ester. No product volatile with steam was obtained; the residue after steam distillation consisted of an orange solid which after crystallization from alcohol was light yellow and melted at 196–198°. Mixed with the isocoumaranone (m. p. 197–198°) obtained by the addition of acetoacetic ester, the melting point was 195–197°. When this product was methylated it gave 3,6-dimethoxy-2,4,5-trimethylphenylacetic acid, the crude acid melting at 150–151°. When mixed with a specimen of the acid prepared from the acetoacetic ester product (m. p. 154–157°), the substance melted at 151–152°. The sole product of the action of malonic ester on pseudocumoquinone was therefore the isocoumaranone VII.

5-Hydroxy-2,4,6,7-tetramethylcoumarone (VI) crystallized from dilute alcohol as a white solid which melted at 138–139°. The substance gave no reaction with phenylhydrazine, hydroxylamine, or sodium bisulfite; it reduced permanganate rapidly, but did not react with Tollens' reagent or with bromine in carbon tetrachloride.

Anal. Calcd. for $C_{12}H_{14}O_2$: C, 75.74; H, 7.42. Found: C, 75.8, 75.9; H, 7.4, 7.3.

(10) For the preparation of this quinone see ref. 2b.

CHART I

SYNTHESIS OF 2,4,5-TRIMETHYLPHENYL ACETIC ACID
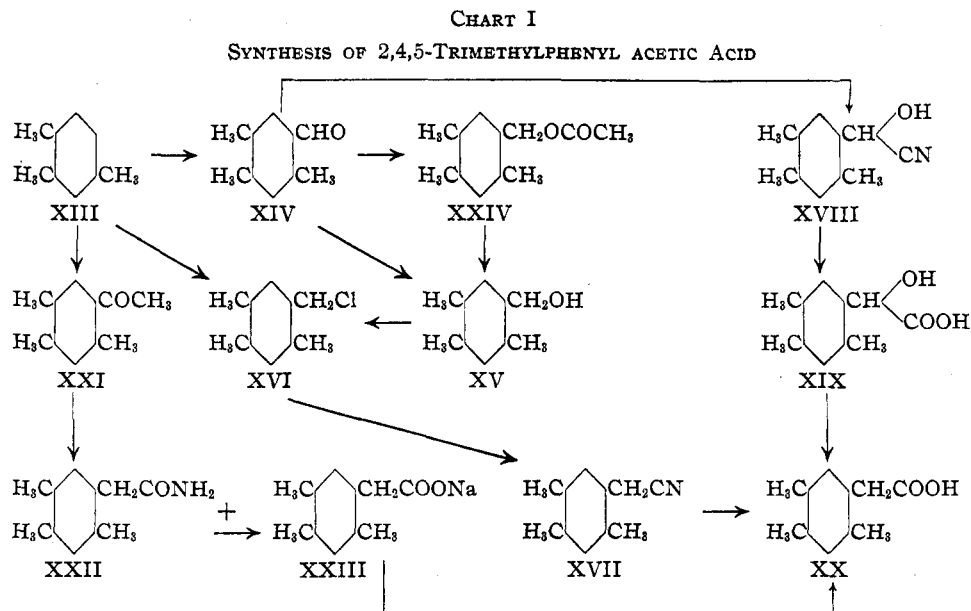
5-Methoxy-2,4,6,7-tetramethylcoumarone (VI, R = CH₃).—The coumarone (3 g.) and methyl sulfate (18.9 g.) were dissolved in methanol (20 cc.) and a solution of potassium hydroxide (18 g.) in methanol (90 cc.) was slowly added. The mixture was distilled with steam, and the product isolated from the distillate. It crystallized from dilute methanol as a white solid which melted at 60–61°.

Anal. Calcd. for $C_{13}H_{16}O_2$: C, 76.42; H, 7.90. Found: C, 76.26; H, 7.71.

5-Benzoyloxy-2,4,6,7-tetramethylcoumarone (VI, R = C₆H₅CO) was prepared from the coumarone by means of the Schotten–Baumann reaction. The product was recrystallized from a mixture of chloroform and ethyl alcohol. It was white and melted at 145–145.5°.

Anal. Calcd. for $C_{19}H_{18}O_3$: C, 77.51; H, 6.17. Found: C, 77.20; H, 6.18.

5-Hydroxy-4,6,7-trimethylisocoumaranone (VII, R = H).—The crude yellow solid, non-volatile with steam, melted at 197–198°. On standing, it turned orange and finally red, accompanied by a drop in the melting point. It was best purified by refluxing it for a short time with zinc and acetic acid, followed by crystallization from alcohol, when it was obtained as colorless needles, melting at 197–198° to a red liquid. The substance dissolved in hot water to give a yellow solution, and it was readily soluble in dilute alkali (red solution), concd. sulfuric acid, alcohol and ether. No phenylhydrazone or oxime was formed, and the iodoform test was negative, but the substance reduced permanganate. Ammonolysis was not successful.

Anal. Calcd. for $C_{11}H_{12}O_3$: C, 68.71; H, 6.30; mol. wt., 192. Found: C, 68.63, 68.50; H, 6.23, 6.47; mol. wt. (Rast), 200, 205.

Methylation: 3,6-Dimethoxy-2,4,5-trimethylphenylacetic Acid (X).—A solution of the isocoumaranone (0.7 g.) in methanol (5 cc.) and dimethyl sulfate (7 cc.) was heated to boiling and potassium hydroxide (6 g.) in hot methanol

(30 cc.) was slowly added. After refluxing for an hour, the solution was cooled, acidified with hydrochloric acid, and diluted with water. The white precipitate, removed and crystallized from dilute alcohol, melted at 158–159°.

Anal. Calcd. for $C_{13}H_{18}O_4$: C, 65.51; H, 7.62; OCH₃ (two), 26.05; neut. eq., 238. Found: C, 65.50; H, 7.66; OCH₃, 26.08; neut. eq., 245.

Synthesis of 2,4,5-Trimethylphenylacetic Acid (XX).—The synthesis of VII necessitated the use of (XX) as an intermediate. This acid was made in 1910 by Willgerodt[11] by the action of yellow ammonium sulfide upon 5-aceto-pseudocumene. Since, however, the mechanism of this reaction is not known, it was felt that the structure of the acid made this way would not be certain, and therefore the acid was synthesized by two other methods. All the syntheses gave the same acid and Willgerodt's acid was therefore 2,4,5-trimethylphenylacetic acid (m. p. 128–129°), although the melting point reported by him (118°) was low. The routes to the acid are shown in Chart I.

Durylic aldehyde (XIV) was synthesized from pseudocumene (XIII) (40 g.), and zinc cyanide (65 g.) in benzene (200 cc.) by the action of gaseous hydrochloric acid, according to the method of Adams.[12] The product (28.6 g., 58%) was white, boiled at 115–118° under 7 mm., and melted at 38–40°.

2,4,5-Trimethylbenzyl Acetate (XXIV).—Reduction of the aldehyde (XIV) (51.4 g.) in acetic acid (150 cc.) and water (50 cc.) by refluxing with zinc (36 g.) for fifteen hours gave a liquid, b. p. 141–150° under 9 mm., which was chiefly the acetate (XXIV) although analysis showed it to contain small amounts of the alcohol XV.

Anal. Calcd. for $C_{12}H_{16}O_2$: C, 74.95; H, 8.39. Found: C, 76.27; H, 8.43.

(11) Willgerodt, *J. prakt. Chem.*, [2] **80**, 185, 193 (1909); *ibid.*, **81**, 388 (1910).

(12) Adams and Levine, THIS JOURNAL, **45**, 2373 (1923); Adams and Montgomery, *ibid.*, **46**, 1518 (1924).

2,4,5-Trimethylbenzyl Alcohol (XV).—The crude acetate (XXIV) (39.6 g.) was refluxed for four hours with sodium hydroxide (80 g.), alcohol (200 cc.) and water (30 cc.). The product, after crystallization from alcohol, was a white solid which melted at 83–83.5°.[13]

Anal. Calcd. for $C_{10}H_{14}O$: C, 79.94; H, 9.39. Found: C, 79.85; H, 9.15.

2,4,5-Trimethylbenzyl Chloride (XVI).—The alcohol XV, refluxed with concd. hydrochloric acid for five hours, gave the chloride, a liquid which boiled at 110° under 5 mm. The chloride was also made by the direct chloromethylation of pseudocumene according to the method of von Braun and Nelles.[14] Fractionation of the crude product from 126 g. of pseudocumene gave 70.3 g. (70%) of a fraction boiling at 111–116° under 6 mm.

Anal. Calcd. for $C_{10}H_{13}Cl$: C, 71.19; H, 7.77. Found: (sample prepared from the alcohol) C, 72.01; H, 7.85; (sample prepared from the hydrocarbon) C, 70.61; H, 7.74.

2,4,5-Trimethylbenzyl Cyanide (XVII).—The chloride (17.1 g.) was dissolved in alcohol (170 cc.) and the solution added slowly to a hot solution of sodium cyanide (7.4 g.) in water (10 cc.). After the vigorous reaction subsided, the mixture was refluxed for five hours. The product was a liquid which boiled at 133–137° under 4 mm., m. p. 9–10°. The yield was 13.8 g. (85%).

Anal. Calcd. for $C_{11}H_{13}N$: C, 82.96; H, 8.23. Found: C, 83.13; H, 8.28.

2,4,5-Trimethylphenylacetic Acid (XX).—The cyanide (13 g.) was heated on the steambath for two and a half hours with 50% sulfuric acid (160 cc.), followed by gentle refluxing for forty-five minutes. The crude product was extracted with sodium carbonate, the carbonate solution extracted with ether, and the acid isolated from the alkaline solution. The m. p. of the crude product was 116–118°.

2,4,5-Trimethylmandelic Acid (XIX).—This was made from durylic aldehyde according to the procedure of Corson, Dodge, Harris and Yeaw[15] for the preparation of mandelic acid. The product (9 g. from 35 g. of the aldehyde), recrystallized from benzene, melted at 133–135°.

Anal. Calcd. for $C_{11}H_{14}O_3$: C, 68.00; H, 7.27. Found: C, 68.33; H, 7.20.

2,4,5-Trimethylphenylacetic Acid (XX).—The mandelic acid XIX (9.7 g.), acetic acid (50 cc.), red phosphorus (3 g.) and 45% hydriodic acid (5 cc.) were refluxed in an all-glass apparatus for four hours. The hot mixture was filtered and the filtrate poured into water (100 cc.) containing sodium bisulfite (2 g.). The acid, crystallized from water, formed white needles which melted at 128–129°.

Anal. Calcd. for $C_{11}H_{14}O_2$: C, 74.11; H, 7.92. Found: C, 74.28; H, 7.53.

(13) Kromer [*Ber.*, **24**, 2411 (1891)] described this substance as a yellow solid, m. p. 168°.

(14) Von Braun and Nelles, *Ber.*, **67**, 1094 (1934).

(15) "Organic Syntheses," Coll. Vol. I, John Wiley and Sons, Inc., New York, 1932, p. 329.

Synthesis by Willgerodt's Method.—5-Acetopseudocumene (XXI) (2 g.) and filtered ammonium polysulfide (10 cc.) were heated in a sealed tube to 207–213° for six and one-half hours. The reaction product was extracted with ether and the ether evaporated. The residue, a brown oil, was a mixture of the acid and the amide. It was refluxed with alcohol (30 g.) and potassium hydroxide (10 g.) until no more ammonia was evolved (six hours). The alcohol was boiled off, the cooled solution extracted twice with ether and then acidified. The crude (yellow) acid was dissolved in carbonate, boiled with norite, filtered and the filtrate extracted with ether. The aqueous layer, when acidified, gave a white precipitate which was recrystallized from water. The melting point was 123–124°.

Anal. Calcd. for $C_{11}H_{14}O_2$: C, 74.11; H, 7.92. Found: C, 74.15; H, 7.87. Specimens of this acid, prepared by any of the three methods used, showed no depression in melting point when mixed. The acid usually melted at 123–125°, but when recrystallized several times from water, the m. p. was 128–129°.

Synthesis of the Isocoumaranone (VII) and of 3,6-Di-

CHART II

SYNTHESIS OF VII AND OF X
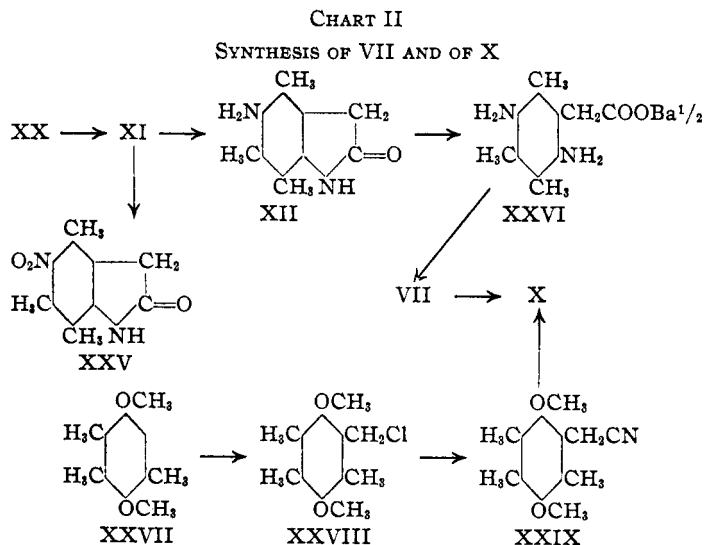
methoxy-2,4,5-trimethylphenylacetic Acid (X).—The routes to these two substances are shown in Chart II.

3,6-Dinitro-2,4,5-trimethylphenylacetic Acid (XI).—A solution of the acid XX (3 g.) in chloroform (20 cc.) was floated onto concd. sulfuric acid (20 cc.). Fuming nitric acid (5 g., d. 1.52) was added a drop at a time, with cooling and stirring. Stirring was continued at 0° for thirty minutes, and then at room temperature for thirty minutes. The layers were separated and the sulfuric acid solution poured onto ice. The chloroform layer was filtered and the filtrate extracted with carbonate. The precipitates from the acid layer and from the chloroform were added to the carbonate extraction, the mixture warmed and filtered. The orange filtrate was acidified and the product recrystallized from alcohol. It was white, melted at 203–203.5°, and weighed 2.1 g. (45%).

Anal. Calcd. for $C_{11}H_{12}O_6N_2$: C, 49.23; H, 4.51. Found: C, 49.57, 49.56; H, 4.57, 4.29.

Reduction to XXV and XII.—Reduction of the dinitro acid by stannous chloride was unsuccessful, as it was impossible to isolate the product from the reaction mixture. Catalytic hydrogenation (pressure 40 lb.) of the dinitro acid (3.4 g.) in alcohol (150 cc.) in the presence of a platinum oxide catalyst (0.1 g.), followed by filtration of the warm solution gave unchanged material (insoluble in warm alcohol) and **5-nitro-4,6,7-trimethyloxindole (XXV)** which crystallized from the filtrate. The substance crystallized from alcohol as a yellow solid, insoluble in acid but soluble in alkali. Analysis indicated the reduction of one nitro group and the loss of water.

Anal. Calcd. for $C_{11}H_{12}O_3N_2$: C, 59.97; H, 5.50. Found: C, 60.32; H, 5.62.

Reduction of the dinitro acid (8 g.) in ethyl alcohol (75 cc.) with Raney catalyst (1 g.) at 80° for two and one-half hours and under an initial pressure of 1300 lb. gave **5-amino-4,6,7-trimethyloxindole (XII).** The contents of the bomb was poured into water (200 cc.), the mixture was heated and filtered while hot. The filtrate deposited pink needles (4 g., 71%) which melted at 260–261° to a red liquid. Recrystallization from dilute alcohol removed some of the color, but the substance was never obtained perfectly colorless. Recrystallization did not change the melting point. The substance was soluble in dilute hydrochloric acid, and analysis indicated reduction of both nitro groups accompanied by loss of water.

Anal. Calcd. for $C_{11}H_{14}ON_2$: C, 69.43; H, 7.42. Found: C, 69.78; H, 7.48.

5-Hydroxy-4,6,7-trimethylisocoumaranone (VII).—The amino oxindole (XII) (1 g.), barium hydroxide (4 g.) and water (40 cc.) were heated in a sealed tube at 160° for four and a half hours. The barium salt of the diamino acid (XXVI) precipitated out. It was not characterized. Sodium nitrite (1 g.) was added to the cooled (0°) suspension of the barium salt and the mixture was slowly run into a cold solution of sulfuric acid (5 cc.) in water (100 cc.). Barium sulfate precipitated at once, and the solution, momentarily green, changed to yellow. After standing for one hour at 0°, the mixture was warmed on the steam-bath for two hours. The hot orange solution was filtered and the filtrate, on cooling, deposited a yellow solid. The substance, removed and crystallized from dilute alcohol, was yellow and melted at 176–183°. When treated with zinc and acetic acid, as described before, the substance became white and melted at 195–196°. A mixture of this with the isocoumaranone VII (m. p. 190–192°) prepared from pseudocumoquinone melted at 193.5–194.5°. The two substances were therefore identical.

3,6 - Dimethoxy - 2,4,5 - trimethylbenzyl Chloride (XXVIII).—3,6-Dimethoxypseudocumene (XXVII) (15.4 g.),[16] concd. hydrochloric acid (80 g.) and formalin (16 g.) were stirred at 70° for eight hours while a stream of dry hydrogen chloride was passed through. The reaction mixture was diluted with water, extracted with ether and the ether layer thoroughly washed. Evaporation of the ether left a brown oil (14.4 g., 74%) which solidified on cooling. Fractionation of this oil gave 11.8 g. (60%) of product boiling at 134–135° under 3.5 mm. Recrystalliza-

(16) For preparation, see ref. 2b, p. 473.

tion from ether–petroleum ether gave a white solid which melted at 63–63.5°. The substance gave an immediate precipitate with alcoholic silver nitrate.

Anal. Calcd. for $C_{12}H_{17}O_2Cl$: C, 62.99; H, 7.50. Found: C, 62.86; H, 7.55.

3,6-Dimethoxy-2,4,5-trimethylbenzyl Cyanide (XXIX).—A solution of the above chloride (11.8 g.) in alcohol (120 cc.) was added slowly to a hot solution of sodium cyanide (4 g.) in water (5.5 cc.). After the vigorous reaction subsided, the mixture was warmed on the steam-bath for eight hours and then filtered while still hot. The alcohol was distilled from the filtrate, the residual oil taken up in ether and thoroughly washed with water. The ether was removed and the product fractioned. The main fraction, which boiled at 150–160° under 3 mm., solidified to a yellow solid (11 g., 80%). Crystallization from ether–petroleum ether followed by recrystallization from alcohol gave a white solid which melted at 90–91°.

Anal. Calcd. for $C_{13}H_{17}O_3N$: C, 71.19; H, 7.82; OCH_3 (two), 28.31. Found: C, 71.19; H, 7.74; OCH_3, 28.43.

3,6-Dimethoxy-2,4,5-trimethylphenylacetic Acid (X).—The cyanide (11 g.), dissolved in acetic acid (15 cc.) was warmed on the steam-bath for forty-five minutes with water (15 cc.) and sulfuric acid (15 cc.). The reaction mixture, poured onto ice, gave a white, waxy precipitate melting at 229–231° after recrystallization from dilute acetic acid. The substance was insoluble in dilute alkalies, alcohol, acetone and petroleum ether, and was undoubtedly the amide although it could not be obtained pure enough for concordant analyses because of the unchanged cyanide in it. This substance was warmed on the steam-bath with 50% sulfuric acid for one and one-quarter hours, then poured into ice water. The precipitate was removed, warmed with sodium carbonate solution, filtered and the filtrate acidified. The white solid, recrystallized from dilute ethyl alcohol, melted at 155.5–157°. When mixed with a specimen of the dimethoxy acid (m. p. 158–159°) prepared by methylating the isocoumaranone VII, the melting point was unchanged. The two products were therefore identical.

Summary

1. The addition of sodium acetoacetic ester to trimethylquinone gives two products, 5-hydroxy-2,4,6,7-tetramethylcoumarone and 5-hydroxy-4,6,7-trimethylisocoumaranone. The addition of sodium malonic ester to this quinone gives but one product, the same hydroxyisocoumaranone.

2. These products are formed by the primary addition of the reagents to the conjugated system which carried no substituent in the β-position. The primary addition is followed by the usual cleavages of these reagents, and by ring closure.

3. The structure of the isocoumaranone was proved by synthesis; that of the coumarone follows by analogy.

4. No coumarin derivative is obtained in this

reaction; hence the unsubstituted conjugated system is the only one which reacts.

5. The structure of Willgerodt's 2,4,5-tri-

methylphenylacetic acid was proved by two independent syntheses.

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[CONTRIBUTION FROM THE RESEARCH LABORATORIES OF THE ETHYL GASOLINE CORPORATION]

The Methyl Nonanes

BY GEORGE CALINGAERT AND HAROLD SOROOS

In the course of a study on the correlation of the physical properties of the alkanes[1] it was found that considerable uncertainty exists regarding the properties of the alkanes above C_8 with one methyl group in the side chain. In order partly to fill this lacuna and also to enlarge the scope of usefulness of the correlation plot described in the above reference the four isomeric methylnonanes have been prepared and purified, and some of their physical properties have been determined.

Preparations

The conventional Grignard method of synthesis was used as before.[2] In the present work the carbinols were dehydrated and hydrogenated simultaneously by treatment with hydrogen under 200 atmospheres pressure at 250° in the presence of 4% of Raney nickel catalyst[3] in accordance with the procedure outlined by Adkins and Wojcik,[4] using the autoclave previously described.[5] Under the conditions applied, this reaction was observed to stop before completion, due, apparently, to the separation of water. In the case of 2-methylnonane, the reaction was interrupted at that point, which accounts for the low yield. In the other three cases, when hydrogen absorption ceased, the autoclave was cooled, the contents removed, and after separation of the water the partially hydrogenated material was hydrogenated further over a fresh batch of catalyst. The materials used, the products obtained, and the yields are listed in Table I.

The crude alkanes were treated with 98% sulfuric acid, washed, dried, refluxed over sodium-potassium alloy and finally fractionated carefully through a column packed with crushed carborundum. The final yields and the physical properties

of the purified compounds are given in Table II, where the physical properties of n-decane are included for comparison.

Discussion

The physical properties of the 2- and 3-methyl isomers align themselves in relation to those of n-decane in accordance with the predictions based on the lower homologs of the series.[6]

No reliable information is available from the literature to make possible an accurate prediction of the physical properties of the 4- and 5-methyl isomers.[1] On the other hand, the values reported above for the density of 4- and 5-methylnonane are shown on the plot of reference.[1] They indicate that the data reported in the literature for 4-methylheptane[7] and 4-methyloctane[8] are probably inaccurate, and that the true values must lie close to 0.705 for 4-methylheptane and 0.721 for 4-methyloctane.

The data in Table II indicate that a shift of the methyl group from the 3-position toward the center of the molecule: (a) progressively lowers the boiling point, but with a decreasing increment, (b) decreases the index of refraction slightly, the increment becoming almost imperceptible after the 4-isomer, (c) decreases the density, except that the 5-methyl isomer shows a slight increase in density, probably caused by the increased symmetry of the molecule.

It is evident that as the length of the chain increases, the effect of the shift of a methyl group becomes less and less perceptible. Only those properties, such as melting point, which are affected by symmetry, still show sharp differences. It seems probable, therefore, that above C_{10} the identification of branched chain alkanes can no longer be based on the measurement of the common physical properties.

(1) George Calingaert and J. W. Hladky, THIS JOURNAL, **58**, 153 (1936).

(2) Graham Edgar, George Calingaert and R. E. Marker, *ibid.*, **51**, 1483 (1929).

(3) U. S. Patent 1,628,190 (1927).

(4) H. Adkins and B. Wojcik, *ibid.*, **55**, 1293 (1933).

(5) George Calingaert and F. J. Dykstra, *Ind. Eng. Chem., Anal. Ed.*, **6**, 383 (1934).

(6) Graham Edgar and George Calingaert, THIS JOURNAL, **51**, 1540 (1929); also ref. 1.

(7) d^{20}_4 0.7169, L. Clarke, *ibid.*, **33**, 520 (1911).

(8) d^{15}_{15} 0.7320, or d^{20}_4 0.7274, L. Clarke, *ibid.*, **34**, 683 (1912).