method exploited by Baltzly and Buck[7] gives by the debenzylation process 5-methylaminouracil (I) in quantitative yield.

Experimental

The method of preparation and isolation of the substituted 5-aminouracils is illustrated by a few examples. Other experimental details for all the products are summarized in Table I.

5-Butylaminouracil (IV).—A mixture of 5 g. (0.026 M) of 5-bromouracil and 7 g. (0.1 M) of n-butylamine was refluxed for 2 hours on a steam-bath. The bromouracil gradually dissolved and a white flocculent precipitate slowly formed. After cooling 50 cc. of water was added to the reaction mixture and the pH was adjusted to 6–7 by addition of hydrochloric acid. The white insoluble product was collected by filtration, washed with much cold water, and after drying weighed 5 g. (100%). When recrystallized from methanol it melted at 286–288° (dec.). For analysis it was best purified by recrystallization from methanol-ether mixtures as its hydrochloride (see Table I).

5-(N-Morpholino)-uracil (X).—After refluxing in a metal-bath at 140–150° for 1 hour a mixture of 9.5 g. (0.05 M) of 5-bromouracil and 20 g. (0.23 M) of morpholine gave on cooling and diluting with cold water 10 g. (100%) of X. Recrystallized from hot water this yielded 7.5 g. (75%) of fluffy white needles; m.p. > 310°.

5-Benzylmethylaminouracil (VII).—A mixture of 10 g. (0.052 M) of 5-bromouracil and 24 g. (0.2 M) of benzylmethylamine was heated for 5 minutes at 180–190° in a metal-bath. A violent reaction set in as the boiling point of the amine was approached. After cooling the solid cake was broken up and washed out with 6 N hydrochloric acid. Next morning the white insoluble product was collected by filtration, washed with 6 N hydrochloric acid, then with ethanol and ether. The yield of VII was 12.5 g. (90%) and when recrystallized from methanol it melted at 242–243°.

5-Methylaminouracil (I) from VII.—A suspension of 2.7 g. (0.01 M) of VII in 70 cc. of methanol was shaken with palladized charcoal and hydrogen in the usual way.[7] The hydrogen uptake was rapid and 0.01 M had been absorbed within about 6 minutes. After removal of the catalyst and concentration of the methanol filtrate the addition of ether precipitated 1.8 g. (100%) of I; m.p. 242–243°.

Acknowledgment.—The author is grateful to Mr. Samuel W. Blackman for the microanalytical results included.

Tuckahoe 7, New York Received September 15, 1950

---

(7) R. Baltzly and J. S. Buck, This Journal, **65**, 1984 (1943).

[Contribution from the Chemical Laboratories of General Mills, Inc.]

1,4-Addition Reactions. V. The Synthesis of Substituted Cyclohexenes and Cyclohexanes[1]

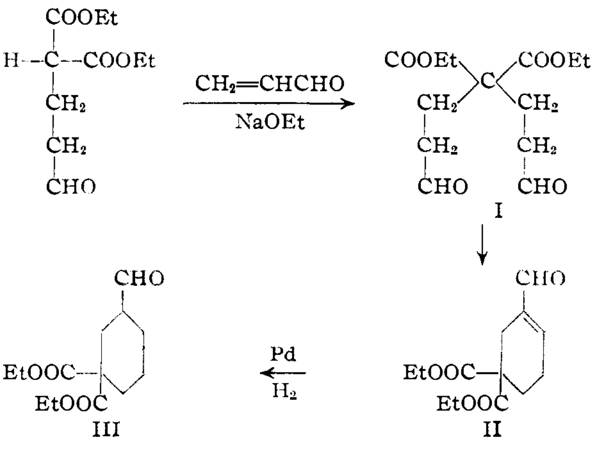
By Owen A. Moe, Donald T. Warner and Marjorie Iwen Buckley

The stepwise 1,4-addition of ethyl malonate and ethyl cyanoacetate to 2 moles of α,β-unsaturated aldehydes has been studied. The reaction between γ,γ-dicarbethoxybutyraldehyde yielded small quantities of the dialdehydo compound (γ,γ-dicarbethoxypimelic dialdehyde); however, the principal product was 1-formyl-5,5-dicarbethoxy-1-cyclohexene. Similarly, the reaction between γ-carbethoxy-γ-cyanobutyraldehyde and acrolein and the reaction between γ,γ-dicarbethoxy-α-methylbutyraldehyde and methacrolein yielded cyclic type products. These reactions constitute convenient preparations of several cyclohexene and cyclohexane aldehydes.

The 1,4-addition of malonate systems and cyclic imides to aliphatic α,β-unsaturated aldehydes has been well established,[2,3,4,5] and the utility of the resulting aldehydo compounds in the synthesis of amino acids has been demonstrated.[4,6,7]

In connection with some earlier work involving the addition of ethyl malonate to acrolein,[3] it was observed that a considerable quantity of a viscous residue remained when the aldehydo compound, namely, γ,γ-dicarbethoxybutyraldehyde, was separated from the crude reaction mixture by distillation under reduced pressure. At that time it was considered plausible that this residue consisted primarily of the di-addition product. However, an extensive investigation[8] of this residue has demonstrated the absence of aldehydo groups. The present paper reports the results of a study concerned with the synthesis of some di-addition products.

The 1,4-addition of γ,γ-dicarbethoxybutyraldehyde to acrolein proceeded to yield the dialdehydo compound I which was characterized as the bis-2,4-dinitrophenylhydrazone. In subsequent experiments, the principal product was compound II which was characterized as the 2,4-dinitrophenylhydrazone. It should be noted that the compounds containing the structural features represented by I possess all the prerequisites demanded for a successful aldol type reaction. Hence, cyclic products such as the cyclohexene type represented by II must be considered most probable.



The reaction between γ,γ-dicarbethoxy-α-methylbutyraldehyde and methacrolein appeared attractive for experimental investigation since the in-

---

(1) Paper No. 108, Journal Series, General Mills, Inc., Research Dept.

(2) O. A. Moe and D. T. Warner, This Journal, **70**, 2763 (1948).

(3) D. T. Warner and O. A. Moe, *ibid.*, **70**, 3470 (1948).

(4) O. A. Moe and D. T. Warner, *ibid.*, **71**, 1251 (1949).

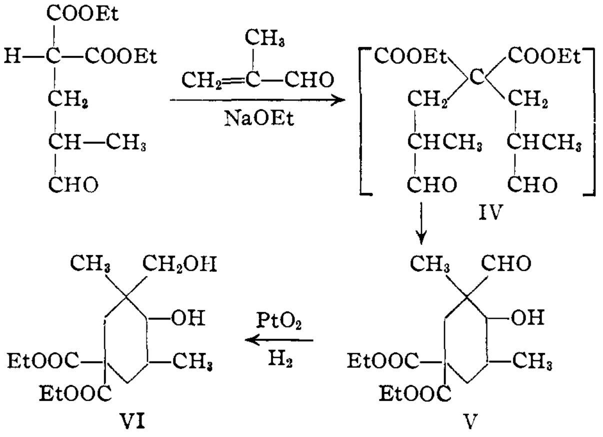
(5) D. T. Warner and O. A. Moe, *ibid.*, **71**, 2586 (1949).

(6) D. T. Warner and O. A. Moe, *ibid.*, **70**, 2765 (1948).

(7) D. T. Warner and O. A. Moe, *ibid.*, **70**, 3918 (1948).

(8) The results of this investigation will be described in a later paper.

termediate dialdehydo compound IV would have available only one α-hydrogen atom per aldehydo carbonyl.



It was found that this reaction proceeded to yield a product V which contained both an aldehydo group and a hydroxyl group, since it readily formed a 2,4-dinitrophenylhydrazone and a 3,5-dinitrobenzoate.

The 1,4-addition of γ-carbethoxy-γ-cyanobutyraldehyde to acrolein yielded 1-formyl-5-carbethoxy-5-cyano-1-cyclohexene VII which was readily reduced to the corresponding cyclohexane derivative VIII.

Experimental[9]

Preparation of γ,γ-Dicarbethoxypimelic Dialdehyde I.—The γ,γ-dicarbethoxybutyraldehyde (142.4 g.) was dissolved in 250 cc. of absolute ethanol. After cooling to 0° the catalyst (0.15 g. sodium in 10 cc. of absolute ethanol) was added. The acrolein (40 g.) was added dropwise and the reaction temperature was not permitted to exceed 5°. After standing at 5° for 16 hours, the reaction mixture was neutralized with 0.5 g. of glacial acetic acid and the ethanol was removed *in vacuo*. The residual oil was dissolved in benzene (325 cc.) and washed four times with 150-cc. portions of water. After drying over anhydrous sodium sulfate, the benzene was removed *in vacuo*. The residual oil was distilled and a low boiling forerun was discarded. The first fraction (27.5 g.) was collected at 142–147° at 0.8 mm., $n^{25}\text{D}$ 1.4546. The main fraction (46.5 g.) was collected at 147–151° at 0.8–1.0 mm., $n^{25}\text{D}$ 1.4554. The next fraction (21.6 g.) was collected mostly at 151–153° at 1.0–1.3 mm., and some high boiling material, 168–182° at 1.8–2.5 mm., was collected in this same fraction, $n^{25}\text{D}$ 1.4650. The main fraction (46.5 g.) was redistilled and 11.5 g. was collected at 142° at 0.3 mm., $n^{25}\text{D}$ 1.4700. A portion of this latter product was used to prepare the bis-2,4-dinitrophenylhydrazone which melted at 182.5–183.5° after crystallization from ethyl acetate.

Anal. Calcd. for $C_{25}H_{28}O_{12}N_8$: C, 47.46; H, 4.46; N, 17.72. Found: C, 47.22; H, 4.41; N, 17.90.

The first fraction (27.5 g.) was dissolved in 100 cc. of absolute ethanol and 0.8 g. of 5% palladium-on-charcoal was added. Attempted reduction at 33 pounds initial pressure of hydrogen was unsuccessful, indicating the virtual absence of carbon-to-carbon unsaturation. However, when ethyl cyanoacetate (25 g.), glacial acetic acid (2.5 cc.) and piperidine (0.8 g.) were added and hydrogenation was resumed,[10] a rapid uptake of hydrogen was noted and 80% of the theoretical amount of hydrogen (on the basis of two aldehyde groups) was consumed. No attempt was made to characterize this complex simultaneous condensation–reduction product.

Synthesis of 1-Formyl-5,5-dicarbethoxy-1-cyclohexene (II).—The γ,γ-dicarbethoxybutyraldehyde (216 g.) was dissolved in benzene (500 cc.). The catalyst (0.1 g. of sodium in 10 cc. of absolute ethanol) was added and the resulting solution was cooled to 5°. Acrolein (56 g.) was added dropwise over a period of 90 minutes and the temperature was maintained at 8° by continued cooling. An additional quantity of catalyst (0.2 g. of sodium) was added. After stirring for an additional 2.5 hours, the reaction mixture was acidified with the requisite quantity of glacial acetic acid. The benzene solution was washed with water and after drying, the benzene was removed *in vacuo*. The residual oil was distilled at approximately 3 mm. and after three more distillations (removing the low boiling foreruns) 55 g. of product was collected at 124–130° at 0.7 mm., $n^{25}\text{D}$ 1.4772. A middle fraction collected at 126–127° at 0.7 mm., $n^{25}\text{D}$ 1.4772 was analyzed.

Anal. Calcd. for $C_{13}H_{18}O_5$: C, 61.41; H, 7.09. Found: C, 61.18; H, 7.39.

The 2,4-dinitrophenylhydrazone was prepared in a conventional manner and after purification by crystallization from ethyl acetate it melted at 162–163°.

Anal. Calcd. for $C_{19}H_{22}O_8N_4$: C, 52.53; H, 5.07; N, 12.90. Found: C, 52.90; H, 5.35; N, 13.13.

Reduction of Compound II.—The above cyclohexene derivative (6.0 g.) was dissolved in 50 cc. of absolute ethanol and 0.5 g. of palladium-on-charcoal was added. The reduction was carried out at an initial pressure of 34 pounds of hydrogen. After the reduction was complete, the catalyst was removed by filtration and the alcoholic filtrate was used directly in the preparation of the derivative. The 2,4-dinitrophenylhydrazone of 1-formyl-5,5-dicarbethoxycyclohexane melted at 141.5–142° after purification by crystallization from ethyl acetate.

Anal. Calcd. for $C_{19}H_{24}O_8N_4$: C, 52.3; H, 5.5; N, 12.84. Found: C, 52.4; H, 5.7; N, 12.97.

Synthesis of 1-Formyl-1,3-dimethyl-2-hydroxy-5,5-dicarbethoxycyclohexane (V).—The α-methyl-γ,γ-dicarbethoxybutyraldehyde (37 g.) was dissolved in 38 cc. of absolute ethanol containing 0.03 g. of sodium and the resulting solution was cooled to 5°. Methacrolein (11 g.) was added dropwise with stirring and the reaction temperature was maintained below 10°. After stirring for 3.5 hours, the reaction mixture was neutralized and the ethanol was removed *in vacuo*. The residual oil was distilled, and distillate was collected up to 160° at 1.0 mm. Redistillation yielded 6 g. of product collected at 145° at 0.3 mm., $n^{25}\text{D}$ 1.4700. The 2,4-dinitrophenylhydrazone prepared in the conventional manner melted at 156–157° after purification.

Anal. Calcd. for $C_{21}H_{28}O_7N_4$: C, 52.5; H, 5.8; N, 11.7. Found: C, 52.3; H, 5.6; N, 11.8.

The 3,5-dinitrobenzoate was prepared in the conventional manner and melted at 175–176° after crystallization from ethanol.

Anal. Calcd. for $C_{22}H_{26}O_{11}N_2$: C, 53.44; H, 5.26; N, 5.67. Found: C, 53.54; H, 5.27; N, 5.90.

An attempt to reduce this hydroxy aldehyde with palladium-on-charcoal yielded only the original product, indicating no carbon-to-carbon unsaturation. However, when the reduction was carried out with platinum oxide catalyst, at 36 pounds hydrogen, almost the theoretical quantity (1 mole) of hydrogen was consumed. After removing the catalyst by filtration, the filtrate was concentrated *in vacuo* and the resulting compound (1-hydroxymethyl-1,3-dimethyl-2-hydroxy-5,5-dicarbethoxycyclohexane) was obtained as a gummy solid which proved very difficult to crystallize. However, it was readily characterized as the bis-3,5-dinitrobenzoate which melted at 180.5–181.5° after purification by crystallization from ethanol.

Anal. Calcd. for $C_{29}H_{30}O_{16}N_4$: C, 50.43; H, 4.35; N, 8.12. Found: C, 50.59; H, 4.36; N, 8.31.

Synthesis of 1-Formyl-5-carbethoxy-5-cyano-1-cyclohexene (VII).—This cyclohexene derivative was prepared from γ-carbethoxy-γ-cyanobutyraldehyde (29.5 g.) and acrolein (10.5 g.) employing benzene (80 cc.) as the solvent and sodium ethoxide (0.014 g. sodium) as the catalyst. Approximately 15% yield of product was collected at 142–144° at 1.2 mm., $n^{30}\text{D}$ 1.4698. This material was not purified further but was used directly for the preparation of the 2,4-dinitrophenylhydrazone which melted at 209–210° after purification by crystallization from ethyl acetate.

---

[9] "Microanalyses by James R. Kerns."

[10] E. R. Alexander and A. C. Cope, THIS JOURNAL, 66, 886 (1944).

Anal. Calcd. for $C_{17}H_{17}O_6N_5$: C, 52.72; H, 4.39; N, 18.10. Found: C, 52.66; H, 14.43; N, 18.22.

This same product VII could be obtained in very low yield when ethyl cyanoacetate was treated with two molar equivalents of acrolein under similar reaction conditions.

The low pressure reduction of compound VII to 1-formyl-5-carbethoxy-5-cyanocyclohexane (VIII) proceeded smoothly in the presence of 5% palladium-on-charcoal when the previously described conditions were employed. Compound VIII was also identified as the 2,4-dinitrophenylhydrazone which melted at 125–126°.

Anal. Calcd. for $C_{17}H_{19}O_6N_5$: C, 52.44; H, 4.88; N, 17.99. Found: C, 52.30; H, 5.06; N, 18.23.

Minneapolis 13, Minn. Received August 17, 1950

[Contribution from the Noyes Chemical Laboratory, University of Illinois]

Polyalkylene Sulfides. V. The Rate of Formation in Emulsion[1]

By C. S. Marvel and A. H. Markhart, Jr.[2]

The rate of disappearance of mercaptan groups in the emulsion polymerization of diolefins and dimercaptans has been found to be very rapid; approximately 90% in 5 minutes. However, many hours are required for the polymer to attain its maximum molecular weight.

Previous papers of this series[3–6] have described the preparation and properties of a number of polymers obtained by the reaction of diolefins and dimercaptans. In order to determine the conditions for the formation of higher molecular weight products, it appeared advisable to follow the reaction quantitatively. This paper presents the results of a study of the over-all rate of the reaction between diolefins and dimercaptans in a redox-activated emulsion system.

Experimental

The reaction was followed in two ways: first, by determining the rate of disappearance of mercaptan from the emulsion and, secondly, by the rate of growth of polymer molecules as determined by inherent viscosity measurements.

Rate of Mercaptan Disappearance.—An emulsion of hexamethylenedithiol was prepared by tumbling overnight in a nitrogen atmosphere 1.39 g. of this compound in 60 ml. of a 1% solution of MP-189-EF[7] buffered at *p*H 3.5. An aliquot of this emulsion was analyzed for thiol by the Kolthoff–Harris[8] amperometric titration procedure described below. Fifty milliliters of this emulsion was transferred to a 4-oz., nitrogen-filled wide-mouth screw-cap bottle. One milliliter of activator solution was added and a small vial (16 × 25 mm.) containing an equivalent quantity of diolefin dropped in. The bottle was immediately capped and shaken. At various time intervals, the bottle was opened and a slow stream of nitrogen introduced while an aliquot was removed by pipet for analysis. Due to the short time intervals between sampling during the first part of the reaction, the bottle was shaken by hand in air for the first 15 minutes; the remainder of the run was carried out by tumbling in a 30° bath. An alternative sampling technique employing a hypodermic syringe and bottles fitted with self-sealing liners was found to give less accurate aliquots, and in the case of certain thiols, severe attack of the liners was encountered. The persulfate catalyst itself was found to have but a very slight effect upon the determination of the mercaptan concentration.

Rate of Polymer Growth.—The polymerization was carried out in essentially the same manner as described above but with four times as much material. At the specified time intervals 10-ml. aliquots of the emulsion were removed by pipet and coagulated with an alum–hydrochloric acid solution. The coagulated polymer was collected by filtration, washed with water and methanol and air-dried. The dry powder was dissolved in 15 ml. of chloroform, the solution filtered and poured slowly into 150 ml. of methanol. The samples were collected and dried in a vacuum desiccator prior to viscosity determination.

Inherent Viscosity Determinations.—Polymer samples (0.200 g.) were dissolved in 50 ml. of chloroform and the viscosity of these solutions measured in an Ostwald–Fenske type viscometer at 25.0°.[9]

Monomers.—Biallyl (1,5-hexadiene), dimethylbiallyl (2,5-dimethyl-1,5-hexadiene) and hexamethylenedithiol were prepared by standard procedures.[5] Ethanedithiol and bis-(2-mercaptoethyl) sulfide were gifts from the Thiokol Corporation. All monomers were redistilled before use.

Amperometric Titrations.—The procedure followed was that of Kolthoff and Harris[8] in which the mercaptan is titrated with silver nitrate using a rotating platinum wire electrode. The titrations were carried out in ammoniacal solution prepared as follows: 100 ml. of 95% ethanol was placed in a 250-ml. beaker. Approximately 0.4 g. of ammonium nitrate was dissolved in the alcohol and 1.7 ml. of concentrated ammonium hydroxide added. The mercaptan sample was then placed in this solution and titrated with 0.005 *N* silver nitrate. The points obtained near the end-point did not lie on the straight line of the volume of reagent *versus* current graph. The points obtained at currents above 10 microamperes were in general very reliable and found to lie on a straight line.

Activator.—A solution of 2.150 g. of ammonium persulfate, 1.108 g. of sodium bisulfite and 0.110 g. of cupric sulfate pentahydrate was prepared from reagent grade materials and diluted to 100 ml. Aliquots of this solution were employed as activators, 1 ml. per 50 ml. of emulsion. The solutions were made up within 5 minutes of each run.

Results and Discussion

The data for the rate of disappearance of mercaptan in the reactions of hexamethylenedithiol with biallyl and dimethylbiallyl are given in Table I and Fig. 1.

The great speed of this type of reaction is clearly shown. Visual evidence of the rapidity of the polymerization is given by the fact that even a 45-second sample, when injected into ethanol for titration, precipitated a product already insoluble in alcohol. Also, within the first few minutes of reaction the emulsion changes from a milky-white opaque mixture to an opalescent, semi-transparent latex. This is indicative of the disappearance of monomer droplets and the formation of polymer–

---

[1] This investigation was carried out under the sponsorship of the Office of Rubber Reserve, Reconstruction Finance Corporation, in connection with the U. S. Government Synthetic Rubber Program.

[2] Research Department, Monsanto Chemical Company, Everett, Massachusetts.

[3] C. S. Marvel and R. R. Chambers, This Journal, **70**, 993 (1948).

[4] C. S. Marvel and P. H. Aldrich, *ibid.*, **72**, 1978 (1950).

[5] C. S. Marvel and H. E. Baumgarten, *J. Pol. Sci.*, in press.

[6] C. S. Marvel and G. Nowlin, This Journal, **72**, 5026 (1950).

[7] MP-189-EF is an electrolyte free emulsifier which consists essentially of mixed alkanesulfonic acids. We are indebted to Dr. Stanley Detrich of Jackson Laboratory, E. I. du Pont de Nemours and Company, for this material.

[8] I. M. Kolthoff and W. E. Harris, *Ind. Eng. Chem.*, *Anal. Ed.*, **18**, 161 (1946).

[9] L. C. Cragg, *J. Coll. Sci.*, **1**, 261 (1946).