arise from sodium exchange reactions between benzene and two amylsodium molecules.

Phthalic acid is formed in these processes as a result of sodium benzoate being present during addition of amyl chloride to sodium in benzene solution.

If sodium benzoate is added after formation of phenylsodium the yield of phthalic acid is suppressed and that of triphenylcarbinol is increased.

Nickel as a catalyst causes a considerable increase in yield of butylmalonic acid, a slight increase for phthalic acid and no change in the quantity of dimethylmalonic acid.

The sodium metal can be activated by addition of a small amount of amyl alcohol. The total yield of acids and the proportion of caproic acid is thereby increased.

CAMBRIDGE, MASS. RECEIVED JUNE 3, 1938

---

[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF MOUNT HOLYOKE COLLEGE]

# Bromo Ethers Derived from Hydantoins Having Terminal Ethylene Double Bonds in the C-5-Position

BY DOROTHY A. HAHN, MARGARET J. MCLEAN AND HELEN T. MURPHY[1]

The addition of bromine to each of two geometric isomers of ethyl N-3-methyl-C-5-benzalhydantoin-N-1-acetate, m. p. 50.5–51.5° and 121–122°, respectively, has been reported.[2] It was stated at that time that a molar quantity of bromine was decolorized as rapidly as added to a solution of either unsaturated hydantoin in carbon tetrachloride and that no evolution of hydrobromic acid took place until after the solution had been heated. In separating the product the carbon tetrachloride was replaced gradually by absolute alcohol and under these conditions a white crystalline compound, m. p. 113–113.5°, was precipitated which on analysis was found to contain one molecule of alcohol. The latter was obviously not present in the form of alcohol of crystallization since it could not be removed even by heating in a high vacuum. The formation of this compound was assumed tentatively to take place in the following way

$$C_2H_5OOCCH_2NCON(CH_3)COC{=}CHC_6H_5 \xrightarrow{Br_2}$$
$$C_2H_5OOCCH_2NCON(CH_3)COCBrCHBrC_6H_5$$

the latter compound then losing hydrobromic acid and adding ethanol to form

$$C_2H_5OOCCH_2NCON(CH_3)COC{=}CBrC_6H_5C_2H_5OH$$

This interpretation of the reaction was based not only upon the results of analysis and the fact that dense fumes of hydrobromic acid had been evolved during the process of heating, but also upon references in the literature which established the formation of unsaturated monobromo derivatives following the addition of bromine to unsaturated hydantoins possessing analogous configurations.[3]

In repeating this experiment it was discovered that although both modifications of ethyl N-3-methyl-C-5-benzalhydantoin-N-1-acetate when treated in this way gave the same compound, m. p. 113–113.5°, a second and more soluble product, m. p. 92–94°, isomeric with the first was also formed in both cases. On the assumption that this represented a geometric modification of the higher melting compound, it was examined spectrographically since it was known that different types of unsaturated hydantoins could be identified readily, and that even isomers could be distinguished one from the other by means of their absorption curves.[4] The results of this investigation were very surprising since while the absorption curves of the two products indicated isomers, they also showed clearly that both belonged to the class of *saturated* and not unsaturated hydantoin derivatives.[5] This discovery led to a consideration of possible molecular configurations for compounds having the above composition that would account for the existence of isomeric saturated hydantoins. And since, due to the presence of two asymmetric carbon atoms, stereo

---

(1) The preparation of N-1,N-3-dimethyl-C-5-benzalhydantoin and its derivatives together with the investigation of their respective absorption spectra must be credited to Miss Helen T. Murphy, an honor student at Mount Holyoke College. The spectrographic work was carried out under the direction of Dr. Hildegard Stücklen, Assistant Professor of Physical Chemistry, to whom grateful acknowledgment is due.

(2) Litzinger, THIS JOURNAL, **56**, 676 (1934).

(3) Wheeler, Hoffman and Johnson, *J. Biol. Chem.*, **10**, 154 (1911); Wheeler and Hoffman, *Am. Chem. J.*, **45**, 375–6 (1911); Johnson and Hoffman, *ibid.*, **47**, 20 (1912).

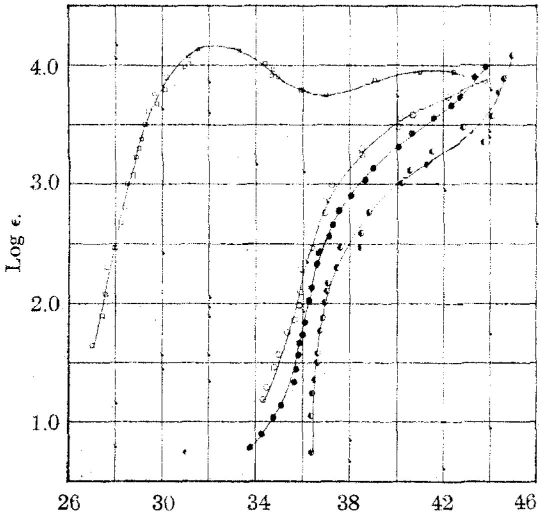
(4) Seikel, THIS JOURNAL, **59**, 436 (1937).

(5) (a) Hahn and Evans, *ibid.*, **50**, 809 (1928); (b) Hahn and Dyer, *ibid.*, **52**, 2505 (1930); Seikel, unpublished work.

modifications were to be expected[6] in the case of a molecule having the following arrangement of atoms

$$C_2H_5OOCCH_2\overline{NCON(CH_3)CO\underset{*}{C}}(OC_2H_5)\underset{*}{C}HBrC_6H_5$$

the two isomers in question were finally assumed to represent, respectively, racemic modifications of this type.



$1/\lambda \times 10^{-3}$ cm.$^{-1}$.

Fig. 1.—□-□-□ N-1,N-3-dimethyl-C-5-benzalhydantoin, $CH_3\overline{NCON(CH_3)COC}{=}CHC_6H_5$,; N-1,N-3-dimethyl-C-5, 5-ethoxy-bromobenzylhydantoin, $CH_3\overline{NCON(CH_3)COC}(OC_2H_5)CHBrC_6H_5$; ○-○-○ isomer, m. p. 141–143°; ●-●-● isomer, m. p. 119.5–121.5°; ◐-◐-◐ N-1,N-3-dimethyl-C-5-benzylhydantoin, $CH_3\overline{NCON(CH_3)COC}HCH_2C_6H_5$.

Recently the behavior of N-1,N-3-dimethyl-C-5-benzalhydantoin, $CH_3\overline{NCON(CH_3)COC}{=}CHC_6H_5$, has been investigated under conditions closely analogous to those which have just been described. Although only one of the two geometric isomers of this substance which are theoretically possible has as yet been isolated (p. 817),[5a] this reacts with bromine to form two isomeric compounds, m. p. 141–143° and 119.5–121.5°, which correspond in composition to the formula, $CH_3\overline{NCON(CH_3)CO\underset{*}{C}}(OC_2H_5)\underset{*}{C}HBrC_6H_5$. These isomers again have been assumed to represent different racemic mixtures, respectively, since such an interpretation is in agreement with the results of analysis and also with the character of the absorption curves of the two compounds. The latter are not only closely analogous to those of the two isomeric ethoxybromo derivatives of ethyl N-3-methyl-C-5-benzalhydantoin-N-1-acetate[7] but both pairs of curves show a marked similarity to that of N-1,N-3-dimethyl-C-5-benzylhydantoin,[8] which can be prepared directly by reducing the corresponding unsaturated compound. On the other hand, they differ radically from the curve of N-1,N-3-dimethyl-C-5-benzalhydantoin.[9]

Due to the fact that the dibromo addition products, the formation of which precedes the formation of both of the above pairs of isomeric ethoxybromo derivatives, are extremely soluble and also very unstable compounds they have not as yet been isolated. It has been observed, however, that the corresponding addition products which are formed when C-5-benzalhydantoin and N-3-methyl-C-5-benzalhydantoin are treated, respectively, in carbon tetrachloride with molar quantities of bromine, are almost insoluble in neutral solvents. An attempt, therefore, is being made to prepare these compounds in pure condition, although they also are very unstable and are difficult to separate completely from the unacted upon unsaturated hydantoins from which they are obtained, since these too are relatively insoluble substances. Even at this stage of the investigation, however, it seems probable from a preliminary study of these products that the same general relationships can be shown to exist between unsaturated hydantoins of this type and their respective dibromo, alkoxybromo and oxybromo derivatives that have been reported recently to maintain in the case of 2,4-diketotetrahydropyrimidines and their corresponding derivatives.[10] This investigation is well under way and will be reported later in detail.

## Experimental

**Ethyl N-3-Methyl-C-5,5-ethoxy-bromobenzylhydantoin-N-1-acetate,** $C_2H_5OOCCH_2\overline{NCON(CH_3)COC}(OC_2H_5)CHBrC_6H_5$, exists in two isomeric modifications, m. p.

---

[6] Hahn and Seikel, THIS JOURNAL, **58**, 647 (1936).

[7] The spectra of ethyl N-3-methyl-C-5-benzalhydantoin-N-1-acetate and its derivatives were examined several years ago by Dr. Margaret K. Seikel (unpublished work). Since the absorption curves of these compounds are almost identical with those of the corresponding derivatives of N-1,N-3-dimethyl-C-5-benzalhydantoin, it has seemed more confusing than helpful to try to represent both sets in the same figure.

[8] *Cf.* ref. 5a, p. 817. This same compound is also formed when each of the two isomeric ethoxybromo derivatives of N-1,N-3-dimethyl-C-5-benzalhydantoin is reduced under the action of hydrogen iodide and red phosphorus.

[9] Compare the four curves in the accompanying figure.

[10] Johnson and Sprague, THIS JOURNAL, **59**, 2436 (1937).

113–113.5° and 92–94°, both of which are formed when either of the two geometric isomers of ethyl N-3-methyl-C-5-benzalhydantoin-N-1-acetate is treated with bromine under conditions which have already been described.[2] The lower melting and more soluble product was not isolated from the reaction mixture, however, until later when oily residues deposited from filtrates from the isomer, m. p. 113–113.5°, were examined. It was finally obtained by a process of fractional crystallization and when pure separated from concentrated alcohol solutions in the form of well-defined colorless prisms, which suffered no loss in weight when heated at 70°.

*Anal.* Calcd. for $C_{15}H_{15}O_4N_2Br\cdot C_2H_5OH$: N, 6.78; Br, 19.35. Found: N, 6.96, 7.05; Br, 19.88, 20.05.

It is interesting to note that in repeating these experiments and using "seed" to induce crystallization, 10.0 g. of the unsaturated ester, m. p. 50.5–51.5°, gave 6.2 g., m. p. 110–112°, as a first precipitate and 3.1 g., m. p. 80–84°, on concentrating the filtrate; while 10.0 g. of the unsaturated ester, m. p. 121–122°, gave 3.3 g., m. p. 110–112°, as a first precipitate and 6.1 g., m. p. 80–84°, on concentrating the filtrate.

**N-1,N-3-dimethyl-C-5,5-ethoxy-bromobenzylhydantoin,** $CH_3\overline{NCON(CH_3)COC}(OC_2H_5)CHBrC_6H_5$, exists in two isomeric modifications, m. p. 141–143° and 119.5–121.5°, both of which were formed under the following conditions. Bromine,[11] dissolved in chloroform (3.8 g. in 38 cc.), was added rapidly at room temperatures to a colorless solution of N-1,N-3-dimethyl-C-5-benzalhydantoin (p. 817)[5a] in the same solvent (5.0 g. in 15 cc.) until a permanent color remained after shaking. No hydrobromic acid was evolved during this process, which occupied only a few minutes, but when the solution was heated dense fumes of the mineral acid were given off. After the solution had been concentrated to a volume of 25 cc., an equal quantity of absolute alcohol was added and the mixture evaporated rapidly over a steam-bath to 25 cc. This process was repeated 5 or 6 times or until the odor of chloroform was no longer noticeable. The boiling solution (50 cc.) was then set aside to crystallize. The first precipitate, when filtered, washed with absolute alcohol and dried, weighed 4.22 g., m. p. 137–139°. A second precipitate, which was obtained by concentrating the filtrate and wash alcohol to 20 cc., consisted of 2.6 g., m. p. 103–106°. Small additional amounts of both products were obtained from the filtrate from the second precipitate, the combined weights of all representing a yield of more than 90% of the theoretical as calculated on the basis of the above formula. So far as could be observed there was no reason for suspecting the presence of any other substances in the reaction mixture. The two products were purified by recrystallization from absolute alcohol, in which the second is much the more soluble. Both separated from their boiling solutions, on cooling, in the form of large transparent hexagonal prisms or plates, which showed no loss in weight on heating.

*Anal.* Calcd. for $C_{14}H_{17}O_3N_2Br$: C, 49.28; H, 5.02; Br, 23.42. Found: (m. p. 141–143°) C, 49.41, 49.60; H, 5.01, 4.96; Br, 23.97, 23.86; (m. p. 119.5–121.5) C, 49.76, 49.58; H, 5.01, 5.26; Br, 23.47, 23.52.

Both compounds when heated for one hour at 110° with hydrogen iodide and red phosphorus were transformed into N-1,N-3-dimethyl-C-5-benzylhydantoin,[8] which was identified by comparison with an analyzed specimen.

The absorption curves of these two isomers, together with curves of the unsaturated hydantoin (p. 817)[5a] from which they were obtained and the corresponding saturated hydantoin[8] which resulted from their reduction, are represented in the accompanying figure. The spectrographic measurements were made by the Henri method[12] using a Hilger E2 quartz spectrograph. Each compound was dissolved in absolute alcohol which had been freed from all traces of benzene by fractional distillation with a Fenske column (3.5 × 1.5 cm.). The source of light was a copper-silver spark and Eastman No. 40 photographic plates were used except for the region below 2400 Å., when "Ultraviolet Spectrographic" plates were used.

## Summary

N-1,N-3-dimethyl-C-5-benzaldehydantoin, when treated in chloroform solution with a molar quantity of bromine, gives an addition product which loses hydrobromic acid on heating and when the chloroform is replaced by absolute alcohol, is subsequently transformed into an ethoxybromo derivative. The latter exists in two isomeric modifications, both of which yield N-1,N-3-dimethyl-C-5-benzylhydantoin when heated with hydrogen iodide and red phosphorus.

The absorption curves of the two isomers, on comparison with those of N-1,N-3-dimethyl-C-5-benzylhydantoin and other saturated hydantoins of the same general type, indicate that both represent saturated compounds. Moreover, these two curves closely resemble those of the two isomeric ethoxybromo derivatives of ethyl N-3-methyl-C-5-benzalhydantoin-N-1-acetate which were obtained from the latter by means of similar transformations.

SOUTH HADLEY, MASS. RECEIVED JUNE 10, 1938

---

[11] The calculated molar quantity of bromine equals 3.69 g.

[12] Henri, "Études de Photochemie," Gauthier-Villars, Paris, 1919, p. 5; *cf.* E. P. Carr and G. F. Walter, *J. Chem. Phys.*, **4**, 756 (1936).