

Structure and Reactivity of Organic Ions in Gas-Phase Radiolysis. VI. The Formation Process of the $C_7H_7^+$ Ion from Ethylbenzene and the Reaction with Dimethylamine

Sir:

In the preceding communication,¹ we have reported that in the gas-phase radiolysis of toluene, one-third of the $C_7H_7^+$ ion which reacts with toluene forming the methyl-diphenylmethanes (MDPM) is produced *via* a scrambling path. The process seemed to proceed through a symmetrical cycloheptatriene-like intermediate proposed by Meyerson² and also by Harrison,³ supported recently by Howe and McLafferty⁴ in mass spectrometric investigations. However, there are still uncertainties concerning the structure and formation process of the $C_7H_7^+$ ion, which has been attributed to be a tropylium ion rather than a benzyl ion in the area of mass spectrometry.⁵ The questions have been raised whether such a less electrophilic tropylium ion contributes to the MDPM formation if produced in the γ -radiolysis of toluene vapor, and also whether the initially formed benzyl ion undergoes hydrogen scrambling, possibly *via* a ring expansion.

In order to get some insight in these problems, we investigated the reaction of the $C_7H_7^+$ ion with dimethylamine which has higher basicity than that of toluene and would be expected to react with tropylium ion,⁶ using ethylbenzene and ethylbenzene- α - d_2 for a scrambling study. Since it has been well established that only the original methyl group of ethylbenzene is lost by electron impact,² the single isotopic species, $C_7H_5D_2^+$, is expected to take part in the following ion-molecule reactions. This simplification is favorable for the present discussion.

Gaseous mixtures of ethylbenzene and dimethylamine were irradiated with ^{60}Co γ -rays to a dose of 3.9×10^{18} eV in a 100-ml Pyrex cell at room temperature. The formation of *N,N*-dimethylbenzylamine⁷ and a small amount of an unknown product⁸ was newly observed by the addition of dimethylamine, along with products such as benzene, toluene, and ethyl-diphenylmethane (EDPM) formed from the radiolysis of pure ethylbenzene, as reported previously.⁹ However, *N,N*-dimethyltropyliumamine, which would be expected to be formed by the reaction of tropylium ion with dimethylamine, was not detected among the reaction products.

(1) Y. Yamamoto, S. Takamuku, and H. Sakurai, *J. Amer. Chem. Soc.*, **94**, 661 (1972).

(2) P. N. Rylander, S. Meyerson, and H. M. Grubb, *ibid.*, **79**, 842 (1957).

(3) F. Meyer and A. G. Harrison, *ibid.*, **86**, 4757 (1964).

(4) I. Howe and F. W. McLafferty, *ibid.*, **93**, 99 (1971).

(5) H. M. Grubb and S. Meyerson in "Mass Spectrometry of Organic Ions," F. W. McLafferty, Ed., Academic Press, New York, N. Y., 1963, Chapter 10.

(6) It has been reported that tropylium ion reacts with dimethylamine forming *N,N*-dimethyltropyliumamine in the liquid phase (W. von E. Doering and L. H. Knox, *J. Amer. Chem. Soc.*, **79**, 352 (1957)).

(7) *N,N*-Dimethylbenzylamine was identified by a comparison of glc, nmr, and mass spectra with those of an authentic sample.

(8) This product could not be identified because of the remarkable low yield. However, of interest is the structure since it was a common product in the γ -radiolysis of toluene, xylenes, and cycloheptatriene in the presence of dimethylamine and was not inhibited by a radical scavenger.

(9) The isomer distribution of EDPM was 6.1% ortho, 83.7% meta, and 10.2% para at a pressure of 4 mm of ethylbenzene (Y. Yamamoto, S. Takamuku, and H. Sakurai, *Bull. Chem. Soc. Jap.*, **44**, 574 (1971)).

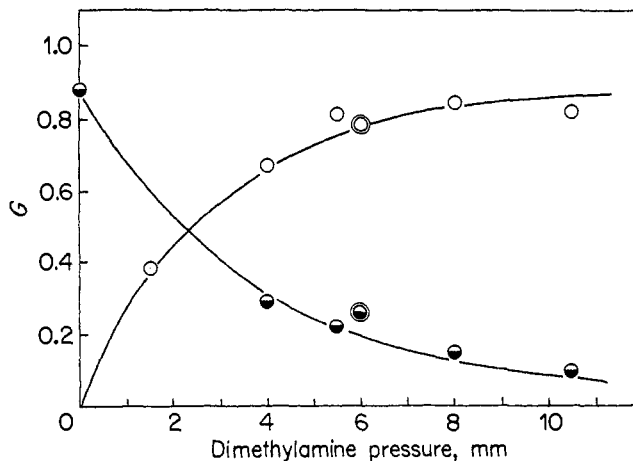
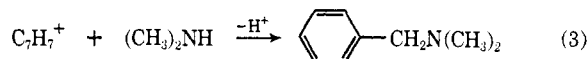
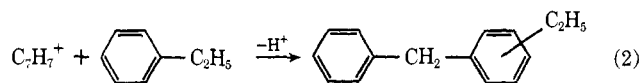
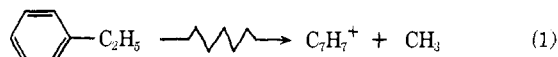


Figure 1. Variations of the yields of ethyldiphenylmethanes (EDPM, \bullet) and *N,N*-dimethylbenzylamine (\circ) as a function of the dimethylamine pressure in the radiolysis of ethylbenzene vapor (4 mm); \ominus , \odot , 10 mol % of oxygen was added.

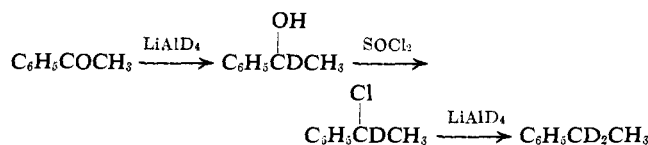
Figure 1 shows the yields of *N,N*-dimethylbenzylamine and EDPM formed from ethylbenzene irradiated in the presence of varying amounts of dimethylamine. The yields were not affected by the addition of oxygen. Since the increase in the yield of *N,N*-dimethylbenzylamine corresponds well to the decrease in the yields of EDPM (Figure 1), it may be concluded that the same $C_7H_7^+$ ion is a common precursor for both products as shown in eq 1-3.¹⁰



In order to clarify the formation process of the $C_7H_7^+$ ion, ethylbenzene- α - d_2 ¹¹ was irradiated in a 6-l. Pyrex cell at room temperature. *N,N*-Dimethylbenzylamine and EDPM produced in the presence and absence of dimethylamine, respectively, were isolated by a preparative gas chromatograph, and submitted to mass and nmr spectrometry.¹² The result obtained from the comparison of the observed mass spectra of these prod-

(10) In the γ -radiolysis of mixtures of toluene and dimethylamine, a quite similar relationship to that of ethylbenzene (Figure 1) in the yields of MDPM's and *N,N*-dimethylbenzylamine was observed. Furthermore, *N,N*-dimethylbenzylamine was a common product in the radiolysis of gaseous mixtures of dimethylamine with hydrocarbon such as cycloheptatriene, norbornadiene, and xylene isomers, which are known to produce a $C_7H_7^+$ ion in abundance under electron impact. These results are also additional evidence supporting eq 1-3.

(11) Ethylbenzene- α - d_2 was prepared as follows



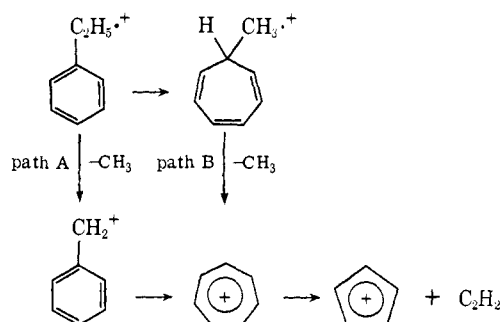
Isotopic purity of the ethylbenzene- α - d_2 purified by preparative glc was found to be better than 99% by nmr analysis.

(12) Since the yield was very low, the product isolated in a trap was washed by a solvent (CCl_4) for nmr measurement and then the solution was submitted for gas chromatography-mass spectrometry combination (Hitachi RMU-4) after the nmr measurement using CAT (Hitachi Perkin-Elmer R-20 spectrometer).

ucts with that of the authentic sample¹³ is that the active species for both products is a common $C_7H_5D_2^+$ ion formed by a preferential loss of β -methyl from the original molecular ion without involving isotopic mixing between β -methyl and benzyl groups.

The methylene protium atom, however, was not detected for the nmr analysis of *N,N*-dimethylbenzylamine formed by the radiolysis of a mixture of ethylbenzene- α - d_2 (2.2 mm) and dimethylamine (3.8 mm). However, in EDPM produced from ethylbenzene- α - d_2 (5 mm) small amounts of methylene protium atom were observed and the ratio of the methylene and phenyl protium atoms of EDPM was determined to be 0.024, suggesting the occurrence of a $\sim 15\%$ scrambling path. If the $C_7H_5D_2^+$ ion reacted after complete scrambling as proposed in mass spectrometry, the H_{CH_2}/H_{Ph} ratio would be 0.189. The present observation shows sharp contrast with the mass spectrometry of ethylbenzene in which the $C_7H_7^+$ ion formed by a loss of β -methyl can be satisfactorily represented as a tropylium ion structure. The elucidation is evidenced by the fact that all hydrogens of the $C_7H_7^+$ ion completely lose the positional identity and become equivalent in the further degradation process to the $C_5H_5^+$ ion. Scheme I has been proposed as a possible pathway from

Scheme I



the mass spectrometric investigations.¹⁴ Though it has not been established whether path A or path B is preferable, structural information on the nondecomposing $C_7H_7^+$ ion, which comprises about 90% of the total $C_7H_7^+$ ion in ethylbenzene,¹⁵ is not obtained by the mass spectrometry. On the other hand, the present results clearly demonstrate that the nondecomposing $C_7H_7^+$ ion is predominantly an unscrambled benzyl ion produced *via* path A which reacts rapidly with dimethylamine. Since the $C_7H_7^+$ ion reacts less rapidly with ethylbenzene, hydrogen scrambling may come to compete with the EDPM formation. The reactivity ratio of the $C_7H_7^+$ ion with dimethylamine and ethylbenzene, k_3/k_2 , was calculated to be 2.7 from data shown in Figure 1.

In the radiolysis of toluene vapor a scrambling path such as path B contributed appreciably to the MDPM formation (31–33%).¹ The reason why the toluene and ethylbenzene ions behave differently is obscure, but seems to correlate with the lifetime of the molecular ion as suggested by Howe and McLafferty.⁴ The ethyl-

(13) The mass spectra of *N,N*-dimethylbenzylamine formed by the radiolysis of a mixture of ethylbenzene- α - d_2 and dimethylamine agreed closely with that of *N,N*-dimethylbenzylamine- α - d_2 prepared by a reduction of *N,N*-dimethylbenzamide with $LiAlD_4$.

(14) P. Brown, *Org. Mass Spectrom.*, **2**, 1317 (1969).

(15) E. Stenhagen, S. Abrahamsson, and F. W. McLafferty, Ed., "Atlas of Mass Spectral Data," Vol. 1, Interscience, New York, N. Y., 1969.

benzene ion is probably more short-lived than the toluene ion¹⁶ since the β C–C bond fission in the former occurs with greater facility; therefore the scrambling path cannot compete with the direct dissociation path. The benzyl ion thus formed is also short-lived in the presence of ethylbenzene and dimethylamine which are reactive to the ion; consequently the further reactions of the benzyl ion may proceed without involving hydrogen scrambling to a considerable extent.

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(16) The greater $M^+ : C_7H_7^+$ intensity ratio in the spectrum of toluene (0.74) than in those of ethylbenzene (0.32) may mean that the ethylbenzene ion decomposes more rapidly to $C_7H_7^+$ ion than toluene ion does (ref 15).

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A Facile Synthesis of Quinine and Related Cinchona Alkaloids

Sir:

There has been a remarkable resurgence of interest within the past few years^{1–3} in developing new synthetic routes to the Cinchona alkaloids, culminating in several ingenious total syntheses of quinine (**10a**) and quinidine (**11a**) by Uskoković² and Gates.³ Albeit by different routes, both groups prepared the olefin **8a** ($R_3 = H$) which served as the immediate precursor to a mixture of desoxyquinine and desoxyquinidine (**9a**) by intramolecular Michael addition of the piperidine nitrogen to the conjugated vinyl grouping. Subsequent base-catalyzed hydroxylation gave a mixture of quinine (**10a**) and quinidine (**11a**), along with smaller amounts of epiquinine and epiquinidine.

We have recently described⁹ a new procedure for the direct introduction of alkyl and alkenyl groups into heterocyclic nuclei involving nucleophilic displacement of a suitable leaving group on the heterocycle by a Wittig reagent to provide a new heterocyclic ylide which subsequently can be either hydrolyzed (to give an alkyl-substituted heterocycle) or treated with a carbonyl compound (to give an alkenyl-substituted heterocycle). We now describe the application of this new synthetic method to the direct conversion of 4-chloro-6-methoxyquinoline (**3**) to a mixture of desoxyquinine and desoxy-

(1) M. Uskoković, J. Gutzwiller, and T. Henderson, *J. Amer. Chem. Soc.*, **92**, 203 (1970).

(2) J. Gutzwiller and M. Uskoković, *ibid.*, **92**, 204 (1970).

(3) M. Gates, B. Sugavanam, and W. L. Schreiber, *ibid.*, **92**, 205 (1970).

(4) D. L. Coffen and T. E. McEntee, Jr., *Chem. Commun.*, 539 (1971).

(5) M. Uskoković, C. Reese, H. L. Lee, G. Grethe, and J. Gutzwiller, *J. Amer. Chem. Soc.*, **93**, 5902 (1971).

(6) G. Grethe, H. L. Lee, T. Mitt, and M. Uskoković, *ibid.*, **93**, 5904 (1971).

(7) R. L. Augustine and S. F. Wanat, *Syn. Commun.*, **1**, 241 (1971).

(8) D. R. Bender and D. L. Coffen, *J. Heterocycl. Chem.*, **8**, 937 (1971).

(9) E. C. Taylor and S. F. Martin, *J. Amer. Chem. Soc.*, **94**, 2874 (1972).