Uskoković has described an alternative synthetic approach to the Cinchona alkaloids involving the construction of the epoxide **12** which, when subjected to reductive debenzoylation, underwent intramolecular, nucleophilic ring opening of the epoxide to give quinine and quinidine directly.[2] In view of the general success of the phosphorus ylide approach for the functionalization of heterocycles with alkyl and alkenyl groups, we have examined the possible utility of sulfur ylides for the direct introduction of epoxy substituents into heterocyclic nuclei.[10] The potential applicability of this approach to the synthesis of the Cinchona alkaloids is illustrated by the following reactions. Thus, 4-methylsulfonylquinoline (**14**) was treated with 2 equiv of diphenylmethylenesulfurane (**13**) in 1,2-dimethoxyethane at $-30°$ to give the sulfur ylide **15** which, without isolation, was treated with **2**. The *N*-acetylamino epoxide **16c** (R_3 = $COCH_3$) thus formed was hydrolyzed directly to **16c** (R_3 = H) which underwent spontaneous, intramolecular cyclization to a mixture of *rac-erythro*-rubanol (**10c**, **11c**) (12%), *rac-threo*-rubanol (<1%), and approximately 9% of products arising from solvolysis of the intermediate amino epoxide **16c** (R_3 = H). It should be noted that the entire sequence of reactions commencing with 4-methylsulfonylquinoline and terminating with **10c** and **11c** was executed without the isolation of a single intermediate.

Similarly, ylide **15** was treated directly with **1** to give the *N*-acetylamino epoxide **16d** (R_3 = $COCH_3$). Hydrolytic removal of the *N*-acetyl group *in situ* to **16d** (R_3 = H) was followed by intramolecular cyclization to provide a mixture of cinchonidine (**10d**) (10%) and cinchonine (**11d**) (8%).[11] Unfortunately, 4-methylsulfonyl-6-methoxyquinoline proved to be unreactive toward diphenylmethylenesulfurane, but we are currently investigating the possible utilization of other, more stable ylides in an attempt to extend the above concepts to a one-step synthesis of quinine and quinidine.

Acknowledgment. We are deeply grateful to Dr. Milan Uskoković of Hoffmann-La Roche for many stimulating discussions and a generous gift of *N*-benzoylmeroquinene.

(10) E. C. Taylor, M. L. Chittenden, and S. F. Martin, manuscript in preparation.

(11) Small amounts of epicinchonine and epicinchonidine (<2%) and some 12% of solvolysis products arising from the intermediate amino-epoxide **16d** (R_3 = H) were also formed in this reaction sequence.

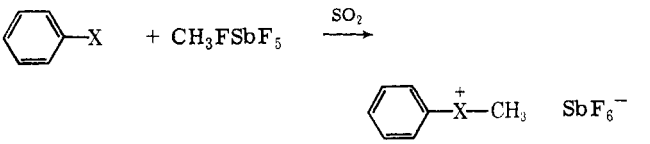
(12) NIH Predoctoral Fellow, 1969–1972.

Edward C. Taylor,* Stephen F. Martin[12]
Department of Chemistry, Princeton University
Princeton, New Jersey 08540
Received June 16, 1972

Onium Ions. III.[1] Alkylarylhalonium Ions

Sir:

Diphenylhalonium ions have been known for many years.[2,3] We have more recently reported the preparation of dialkylhalonium ions and suggested their possible importance in Friedel–Crafts alkylation reactions.[1,4] The possibility that alkylarylhalonium ions could also play a role in Friedel–Crafts reactions has led us to an investigation of the existence of these ions. When a SO_2 solution of iodobenzene is added to a SO_2 solution of the CH_3F–SbF_5 complex[5] (methyl fluoroantimonate) at $-78°$, a clear slightly colored solution results. The pmr spectrum of this solution at $-80°$ shows in addition to the excess methyl fluoroantimonate a methyl singlet at δ 3.80 and a multiplet aromatic region (7.7–8.3) with a peak area ratio of 3:5. The aromatic signals show the same coupling pattern as that of iodobenzene in SO_2 but are deshielded by approximately 0.5 ppm. The fluorine-19 nmr spectrum of the solution shows only a very broad absorption centered around ϕ 112 (from CF_3CCl_3) which is characteristic of the SbF_6^- counterion. We suggest that the species that accounts for the nmr data is the methylphenyliodonium ion, $CH_3I^+C_6H_5$ (**1-I**). When bromobenzene and other aryl bromides or iodides are added in the same manner to methyl fluoroantimonate in SO_2, analogous spectra are obtained indicating the formation of the corresponding methylarylhalonium ions (**1-X**).



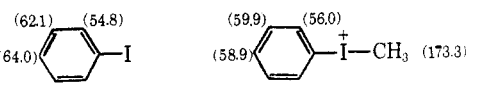
1-X

X = Br or I

Likewise, the reaction of aryl bromides and iodides with ethyl fluoroantimonate[5] in SO_2 results in the formation of ethylarylhalonium ions.

The pmr data of the alkylarylhalonium ions studied are summarized in Table I. The pmr chemical shifts of the methyl and ethyl protons are in good agreement with those reported for dialkylhalonium ions.[4]

The cmr chemical shift of the methyl carbon in the methylphenyliodonium ion, **1-I**, occurs at $\delta_{^{13}C}$ 173.3 (from CS_2) which agrees with that reported for the dimethyliodonium ion ($\delta_{^{13}C}$ 184.3).[4b] The C-1 chemical shift occurs at $\delta_{^{13}C}$ 87.4 compared to 97.0 in iodobenzene.[6] The ^{13}C chemical shifts of $C_{2,6}$, $C_{3,4}$, and C_6 in ion **1-I** are not appreciably different from the analogous carbons in iodobenzene. This indicates that there is not any appreciable charge delocalization due to resonance into the aromatic ring in the methylphenyliodonium ion.



The reaction of chlorobenzene and fluorobenzene, respectively (with methylfluoroantimonate), in SO_2 does not result in the formation of alkylarylhalonium ions **1-Cl** or **1-F** but instead sulfinylmethylation occurs exclusively at the para position forming the corresponding methyl sulfinylates. Methyl fluoroantimonate is apparently methylating SO_2 and the aromatic rings of

(1) Parts I and II are considered, respectively: G. A. Olah and J. R. DeMember, *J. Amer. Chem. Soc.*, **91**, 2113 (1969); **92**, 718 (1970).

(2) A. N. Nesmeyanov, L. G. Makarova, and T. P. Tolstaya, *Tetrahedron*, **1**, 145 (1957), and references given therein.

(3) I. Masson and E. Race, *J. Chem. Soc.*, 1718 (1937).

(4) G. A. Olah and J. R. DeMember, *J. Amer. Chem. Soc.*, **92**, 2562 (1970).

(5) G. A. Olah, J. R. DeMember, and R. H. Schlosberg, *ibid.*, **91**, 2112 (1969); G. A. Olah, J. R. DeMember, R. H. Schlosberg, and Y. Halpern, *ibid.*, **94**, 156 (1972).

(6) P. C. Lauterbur, *J. Chem. Phys.*, **38**, 1406 (1963).

Table I. Nmr Parameters of Alkylarylhalonium Ions[a]

Ion	CH_3X^+–	CH_3	$-CH_2-$	CH_3CX^+	Aromatic	^{19}F[b]
$C_6H_5-Br^+-CH_3$	4.45				7.5–7.9	
$C_6H_5-I^+-CH_3$	3.80				7.7–8.3	
$4\text{-}FC_6H_4-I^+-CH_3$	3.80				7.0–8.1	103.4
$4\text{-}FC_6H_4-Br^+-CH_3$	4.40				7.3–8.1	103.7
$4\text{-}CH_3C_6H_4-I^+-CH_3$	3.75	2.40			7.3–8.0	
$4\text{-}CH_3C_6H_4-Br^+-CH_3$	4.35	2.40			7.4–7.9	
$C_6H_5-I^+-C_2H_5$			4.70	1.95	7.6–8.1	
$4\text{-}FC_6H_4-I^+-C_2H_5$			4.75	1.92	7.2–8.2	104.2
$C_6H_5-Br^+-C_2H_5$			5.30	1.90	7.7–8.2	
$4\text{-}FC_6H_4-Br^+-C_2H_5$			5.35	1.90	7.3–8.1	104.1

[a] Proton chemical shifts are from TMS in external capillary tube. Spectra were recorded at −70° in SO_2 solution at 60 MHz. Relative peak areas were in agreement with expectation. [b] Fluorine chemical shifts are from CF_3CCl_3 in external capillary tube. The chemical shifts of 4-fluorobromobenzene and 4-fluoroiodobenzene in SO_2 solution are 114.8 and 113.9 ppm, respectively.

fluorobenzene and chlorobenzene are more reactive toward the resulting $^+SO_2CH_3$ than the unshared electron pairs on halogen. The fluorine atom in any case is too electronegative to form a fluoronium ion. When chlorobenzene is added to methyl fluoroantimonate in SO_2ClF, sulfinylmethylation does not occur while methylation occurs on the aromatic ring to give chlorotoluenes and chloroxylenes.

All of the methylarylhalonium ions observed are stable to −20° as shown by pmr. When a SO_2 solution of the methylphenylbromonium ion **1**-Br is heated in a sealed tube to 0°, decomposition readily occurs to give a mixture of bromoxylenes. The n → π methyl rearrangement is irreversible indicating that the C-methylated products are thermodynamically more stable once formed. The SO_2 solution of the methylphenyliodonium ion **1**-I is considerable more stable. However, after 15 hr at room temperature in a sealed tube, rearrangement had occurred. Rearrangement of the ethylphenylbromonium ion **2**-Br occurs readily at −70° to give C-methylated products.

These results indicate the possibility that alkylarylhalonium ions may play an important role in Friedel–Crafts alkylation of halobenzenes. The fact that alkylarylhalonium ions can alkylate aromatics in an intermolecular reaction is demonstrated by the reaction of the methylphenylbromonium ion **1**-Br with benzene at −78° to give toluene and xylenes. Furthermore, in the presence of excess bromobenzene, the methylphenylbromonium ion is unstable even at −78° due to reaction with the excess bromobenzene to give bromotoluenes and bromoxylenes. The strong ability to alkylate aromatics is an explanation for the fact that bromoxylenes and not bromotoluenes are formed in the decomposition of ion **1**-Br. Any bromotoluenes that are formed under these conditions would be immediately alkylated by the excess methylphenylbromonium ion to give bromoxylenes.

Alkylarylhalonium ions were shown to be good general alkylating agents not only for π, but also for n bases. Dimethyl ether, for example, when added to a SO_2 solution of the methylphenylbromonium ion **1**-Br is methylated to the trimethyloxonium ion, trimethylamine is methylated to the tetramethylammonium ion, and methyl bromide is methylated to the dimethylbromonium ion. The fact that **1**-Br reacts with methyl bromide to give dimethylbromonium ion irreversibly shows that methyl bromide has a greater affinity for the incipient methyl cation than bromobenzene.

The fact that one gets increasing amounts of the ortho alkylated isomer going through the series from fluorobenzene to iodobenzene in Friedel–Crafts alkylations has been generally explained by an intramolecular rearrangement of the intermediate alkylarylhalonium ions. However, if alkylarylhalonium ions are involved in alkylation reactions, the present results indicate that the preferred reaction pathway would proceed *via* an intermolecular methyl transfer and not an intramolecular rearrangement. Nevertheless the results do not discount the fact that Friedel–Crafts reactions carried out under the usual conditions may proceed by direct attack of the alkyl halide–Lewis acid complex on the aromatic ring.

Acknowledgment. Support of this work by grants from the National Science Foundation and the Petroleum Research Fund, administered by the American Chemical Society, is gratefully acknowledged.

(7) Postdoctoral Research Associate.

George A. Olah,* Earl G. Melby[7]
Department of Chemistry, Case-Western Reserve University
Cleveland, Ohio 44106
Received March 13, 1972

Strong Conformational Consequences of Hyperconjugation

Sir:

It is in ionic species that hyperconjugation comes to the fore.[1–4] We show here that in the cations $XCH_2-CH_2^+$ or anions $XCH_2-CH_2^-$ there may be large barriers to internal rotation due to hyperconjugation. *If X is more electronegative than H, then the cation will prefer conformation B, while the anion favors A. If X is less electronegative than H, then the cation favors A while the anion prefers B.*[5] The magnitude of these preferences

(1) The molecular orbital representation of hyperconjugation was introduced by R. S. Mulliken, *J. Chem. Phys.*, **1**, 492 (1933); **3**, 520 (1935); **7**, 339 (1939).

(2) Proceedings of the Conference on Hyperconjugation, *Tetrahedron*, **5**, 105 (1959).

(3) M. J. S. Dewar and H. M. Schmeising, *ibid.*, **6**, 166 (1959); M. J. S. Dewar, "Hyperconjugation," Ronald Press, New York, N. Y., 1962.

(4) For reviews of anionic fluorine hyperconjugation, see (a) D. Holtz, *Progr. Phys. Org. Chem.*, **8**, 1 (1971), and (b) W. A. Sheppard and C. M. Sharts, "Organic Fluorine Chemistry," W. A. Benjamin, New York, N. Y., 1969, p 18 ff.

(5) Idealized geometries, locally tetrahedral at XCH_2, trigonal planar at CH_2, are here assumed also for the anion. Distortions from these are discussed below.