Tetrahedron Letters No.1, pp. 13 - 16, 1971. Pergamon Press. Printed in Great Britain.

HALOGEN PARTICIPATION IN THE PROTONATION OF 5-HALO-EPOXIDES WITH TRIFLUOROACETIC ACID.

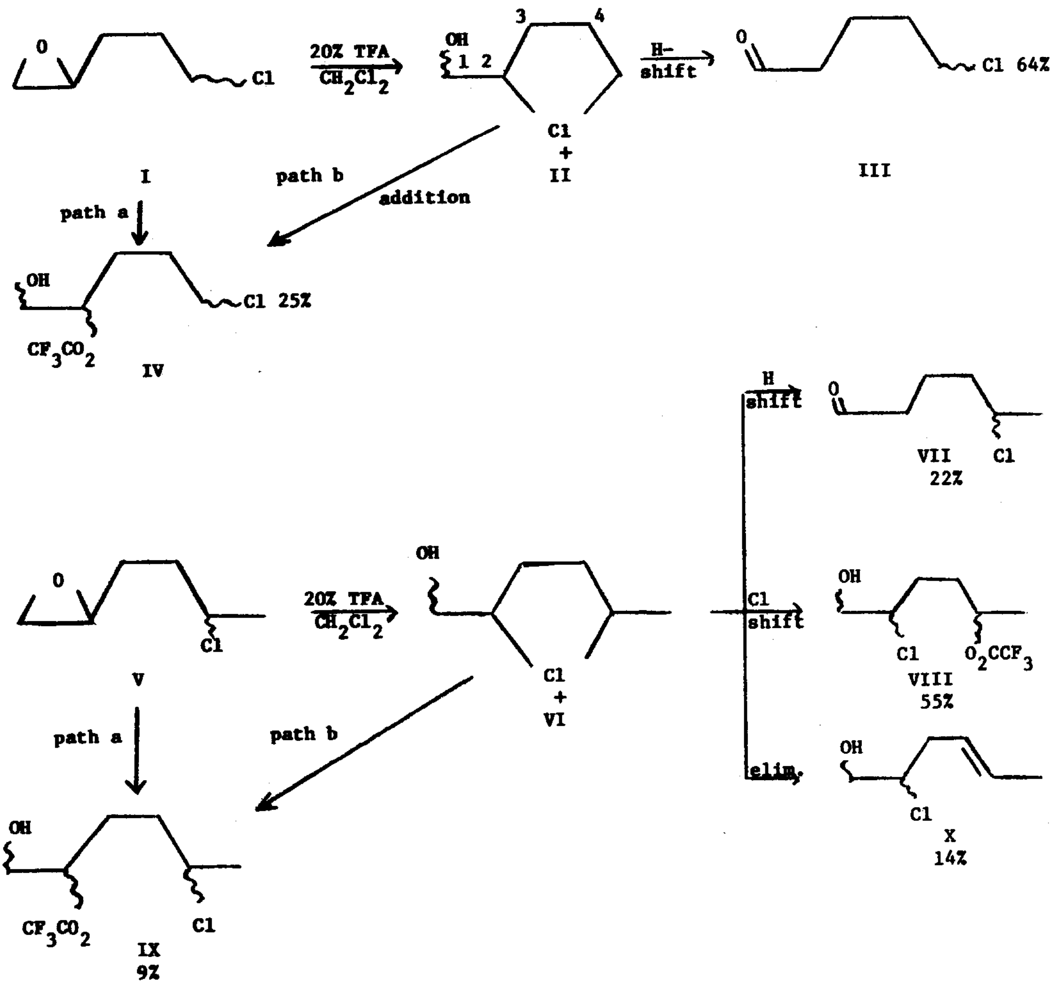
Paul E. Peterson, Joseph M. Indelicato, and Benedict R. Bonazza
Department of Chemistry, St. Louis University
St. Louis, Missouri 63156

(Received in USA 17 November 1970; received in UK for publication 30 November 1970)

By analogy with previous examples of solvolytic reactions proceeding via 5-membered ring halonium ion intermediates,[1,2] the epoxide I (Figure 1) may be envisioned to react via the halonium ion II. The ion II may be seen to be primary-secondary, a type which has been found to open with S_N1 character at the secondary carbon.[1,2,3] This reaction mode could lead to the secondary trifluoroacetate IV. We wished to see whether the inductive hydroxyl substituent might alter the reaction path, possibly to give opening at the primary carbon which would result in a product of 1,4-halogen shift (cf. ref 4). Similar considerations apply to reaction of the epoxide V via the di-secondary chloronium ion VI.

When the chloroepoxide (I) was added to 20% trifluoroacetic acid in methylene chloride the aldehyde III (64%) and the secondary trifluoroacetate IV (∿ 25%) were formed, in addition to a minor unidentified component, which was not the envisioned 1,4-halogen shifted product from ring opening at the primary position. The epoxide V gave aldehyde VII (22%) and, significantly, the halogen shifted product VIII, (55%), indicating the anticipated intermediacy of chloronium ion VI. Minor products X and IX also were formed (Scheme I). The various alcohols were isolated as the trifluoroacetate esters, formed by slow subsequent esterification. Components were separated by preparative gas chromatography and identified

Figure 1


O
Cl
20% TFA
CH_2Cl_2
OH
1 2
3
4
Cl
+
II
H-
shift
O
Cl 64%
III
I
path a
path b
addition
OH
Cl 25%
CF_3CO_2
IV
H
shift
O
VII
Cl
22%
O
Cl
V
20% TFA
CH_2Cl_2
OH
Cl
+
VI
Cl
shift
OH
Cl
O_2CCF_3
VIII
55%
path a
path b
elim.
OH
Cl
X
14%
OH
CF_3CO_2
Cl
IX
9%

by nmr at 100 MHz except for the aldehydes, whose 2,4-dinitrophenylhydrazones also were analyzed for C and H.

Significantly 1-hexene oxide formed no aldehyde (<2%) under the reaction conditions. This finding strongly suggests that aldehyde formation is a characteristic reaction of hydroxychloronium ions. Accordingly 1,4-chlorine participation, is the predominant reaction path for epoxides I and V, although normal epoxide opening, path a, may compete. Our data do not rule out the alternative (thought to be less likely) that IV and IX also arise from halonium ion intermediates (path b). The increased percent of reaction of V via a halonium ion, assuming path a is followed, is about that which would be expected from the moderately greater participation tendency of secondary chlorine, compared to primary.[2] Our results indicate that inductive destabilization by the hydroxyl group does not lead to "primary opening" of the chloronium ion II, since hydrogen shift to give aldehyde is a process having almost as low an activation energy as "secondary opening", as is apparent from the reactions of the ion VI. Tendencies for neighboring group participation have been shown to vary widely among reactants capable of serving as formally analogous carbonium ion sources.[5] The present study suggests that epoxide opening shows a higher participation tendency than cyclopropane opening.[5] Assuming path a is followed, the extent of participation resembles that found in additions to alkenes[6] and alkynes[7] and is less than that found for tosylate solvolyses.[2] These results are noteworthy in view of the interest in cyclization of squalene epoxide and related compounds to steroid precursors.[8]

REFERENCES

1. P. E. Peterson and J. F. Coffey, Tetrahedron Letters, 3131 (1968).
2. P. E. Peterson, R. J. Bopp, D. M. Chevli, E. L. Curran, D. E. Dillard, and R. J. Kamat, J. Amer. Chem. Soc., 89, 5902 (1967).
3. G. A. Olah and P. E. Peterson, ibid., 90, 4675 (1968).
4. P. E. Peterson, P. R. Clifford, and F. J. Slama, ibid., 92, 2840 (1970).
5. P. E. Peterson and G. F. Thompson, J. Org. Chem., 33, 398 (1968).
6. P. E. Peterson, C. Casey, E. V. P. Tao, A. Agtarap, and G. Thompson, J. Am. Chem. Soc., 87, 5163 (1965).
7. P. E. Peterson, R. J. Bopp, and M. M. Ajo, ibid., 92, 2834 (1970).
8. E. E. Van Tamelin, Accounts of Chemical Research, 1, 111 (1968).