CHEMISTRY LETTERS, pp. 1505-1508, 1981.

A NOVEL METHOD FOR THE SYNTHESIS OF 2,2,2-TRIBROMOETHANOLS FROM ALDEHYDES AND CARBONTETRABROMIDE IN THE PRESENCE OF STANNOUS FLUORIDE ———A SYNTHESIS OF DIACETYL-D-ERYTHRONOLACTONE———

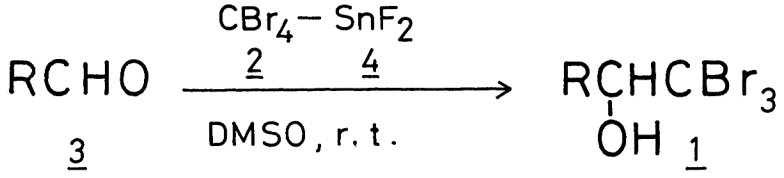
Teruaki MUKAIYAMA, Masahiko YAMAGUCHI, and Jun-ichi KATO
Department of Chemistry, Faculty of Science,
The University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113

In the presence of stannous fluoride, 2,2,2-tribromoethanols are conveniently prepared from aldehydes and carbontetrabromide under a mild reaction condition. The reaction is efficiently applied to the synthesis of 2,3-diacetyl-D-erythronolactone starting from 2,3-O-isopropylidene-D-glyceraldehyde.

During our continuous investigations on the exploration of new synthetic reactions by using low valent tin compounds, stannous halides were found to be a useful reagent. Thus, homoallylalcohols[1] and α,β-epoxyphenylketones[2] were synthesized in good yields by the reaction of carbonyl compounds with organotin(IV) compounds, formed in situ by the oxidative addition of stannous halide to organic compounds such as allyl iodide and α,α-dibromophenyl ketones.

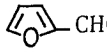
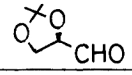
We now wish to report a convenient method for the preparation of 2,2,2-tribromoethanols(1) from carbontetrabromide(2) and aldehydes(3) in the presence of stannous fluoride(4), and an application of the procedure to the stereoselective synthesis of (2R,3R)-2,3-diacetoxydihydro-2(3H)-furanone(2,3-diacetyl-D-erythronolactone(5).

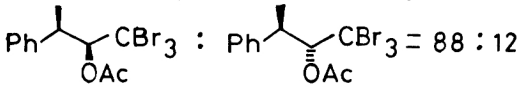
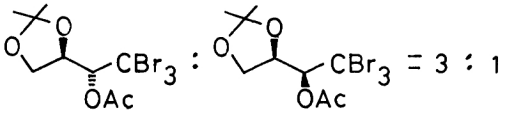
In the first place, the reaction conditions for the synthesis of a 2,2,2-tribromoethanols(1) was investigated in detail in order to examine the behavior of the unstable intermediate, tribromomethyltin(IV) compound(6).[3] And it was found that the followings were required to obtain 1 in good yield; 1) the use of a slight excess of 2 over 4; 2) the addition of several portions of solid stannous fluoride(4) to the solution of 2 and 3; 3) the use of dimethyl sulfoxide(DMSO) as the solvent. Based on these preliminary experiments various aldehydes(3) are transformed to the corresponding 2,2,2-tribromoethanols(1) in good yields under mild reaction conditions as shown in the Scheme I and Table.



Scheme I

Table The Synthesis of 2,2,2-Tribromoethanols[1].

entry	3	Yield (%) of 1	mp (bp)[2]
1	PhCHO	78[7]	76-77°C (n-hexane recryst.)
2		80	(140 °C/0.5 mmHg)
3	$PhCH_2CH_2CHO$	73[7]	(180 °C/0.4 mmHg)
4	$n\text{-}C_8H_{17}CHO$	58	(180 °C/0.3 mmHg)
5	PhCH=CHCHO	72	81-81.5 °C (n-hexane recryst.)[3]
6	PhCOCHO	46	(180 °C/0.3 mmHg)
7		54[5]	53-54 °C (n-hexane recryst.)[4]
8		61[6),7]	(110 °C/0.2 mmHg)

1) All the products gave satisfactory NMR and IR spectra, and are positive to Beilstein's test.
2) By bulb to bulb distillation.
3) This compound showd a rather higher melting point than reported in referece 4).
4) The melting point of the major isomer.
5) 
To determined the configuration by NMR according to the reference 4) the product was acetylated with Ac_2O-Pyridine.
6) The yield of the acetylated product as a mixture of isomers. See text.

7) Satisfactory elemental analyses were obtained for these compounds (C,H,Br).

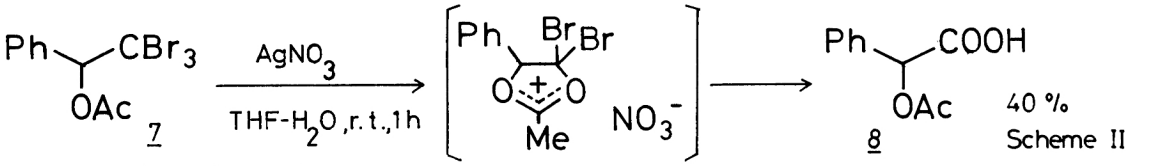
A typical procedure is described for the preparation of 1-furyl-2,2,2-tribromoethanol: Under an argon atmosphere, to a mixture of carbontetrabromide (2, 497 mg, 1.5 mmol) and furaldehyde (48 mg, 0.5 mmol) in DMSO (2 ml) was added a solid stannous fluoride (4, 79 mg, 0.5 mmol), and the solution was stirred for 5 min. Then another portion of 4 (79 mg, 0.5 mmol) was added, and the stirring was continued for further 5 min. The mixture was diluted with methylene chloride and 2N HCl. After 30 min's stirring, the precipitated tin(IV) oxide was removed by filtration, and organic materials were extracted with methylene chloride. The extracts were dried over $MgSO_4$ and the solvents were removed under reduced pressure. 1-Furyl-2,2,2-tribromoethanol (139 mg, 80%) was isolated by thin layer chromatography on silica gel. Bp 140 °C/0.5 mmHg (by bulb to bulb distillation). NMR($CDCl_3$) δ 3.70 (1H, s), 5.17 (1H, s), 6.30 (1H, dd, J=1,3 Hz), 6.57 (1H, d, J=3 Hz), 7.30 (1H, d, J=1 Hz). IR (neat) 3400, 600, 560 cm^{-1}.

The results show several synthetic utilities of the reaction: 1) In the cases of cinnamyl aldehyde and phenylglyoxal, the reaction proceeds selectively at

aldehyde group without effecting other functional groups (entry 5,6): 2) A rather high 1,2-asymmetric induction according to the Felkin's model[5] occurs in the cases of aldehydes with an asymmetric center at the α-carbon of the carbonyl group (entry 7,8).

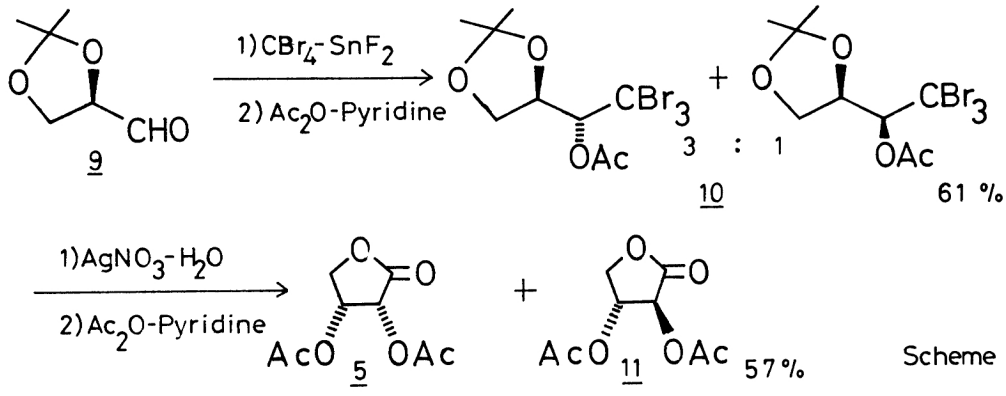
Concerning the synthesis of 2,2,2-tribromoethanol derivative(I) staring from carbonyl compounds, a few methods are reported using bromoform and several kinds of bases, such as tin amide[4], lithium amide[6], and potassium salts.[7] The present method, utilizing carbontetrabromide(2) and stannous fluoride(4) would provide a convenient method for the preparation of 1 under non-basic conditions.

The alcohols(1) thus obtained are useful synthetic intermediates, and may be converted to α-hydroxycarboxylic acids by hydrolysis. As it was reported in a literature[7] that the base treatment of 1 affords α-bromocarboxylic acid via a rearrangement of the dibromoepoxide, we examined a non-basic hydrolysis by use of a silver(I) salt. But, when 1-phenyl-2,2,2-tribromoethanol, prepared from benzaldehyde, was treated with silver(I) nitrate, the expected mandelic acid was not obtained at all probably because of the instability of the cationic intermediate.[8] Then, in order to stabilize the cationic species by neighboring group participation as shown in Scheme II, the corresponding acetate(7) was treated with silver(I) nitrate in aqueous tetrahydrofuran (THF), and now α-acetoxyphenylacetic acid(8) was obtained in moderate yield.



Scheme II

Next, based on this new method for the synthesis of the α-acetoxycarboxylic acids from aldehydes by one carbon homologation, we tried the synthesis of the D-erythronolactone derivative(5) starting from 1,2-O-isopropylidene-D-glyceraldehyde(9).[9] Aldehyde(9) was allowed to react with 2 in the presence of 4 according to the procedure previously described. The resulted adduct, without isolation, was acetylated to afford 2,2-dimethyl-4-(1-acetoxy-2,2,2-tribromoethyl)-1,3-dioxolane (10, 61%)[10] as a mixture of two diastereomers in 3 : 1 ratio. The configuration of the major isomer was expected to be (2R, 3R) by assuming the Felkin's model[5] in the transition state, and it was proved by converting 10 to the lactone(5) according to the following procedure. The acetate(10) was treated



Scheme III

with excess silver(I) nitrate for 1 h at r.t., and, after the solvent was evaporated, the residue was mixed with Ac_2O-pyridine to afford the diastereomixture of the lactone (5, 11, 57%). The isolation of the major isomer(5) was perfomed by the distillation, which seemed to effect the decomposition of the minor isomer(11) (Scheme III). ^1H-, ^{13}C-NMR, IR spectra and optical rotation of the product(5)[11] agreed well with that of the authentic sample prepared by the acetylation of D-erythronolactone.[12]

Several methods for the synthesis of D-erythronolactone by degradation of D-ribose[12] and D-glucose[13] have been known. Different from these processes, the present synthesis is achieved by the employment of a new stereoselective one carbon homologation reaction to form 2,2,2-tribromoethanol(1), a precursor to α-acetoxy-carboxylic acid. Utilization of this novel compound(1) to various synthetic purpose is now in progress.

References

1) T. Mukaiyama, T. Harada, and S. Shoda, Chem. Lett., 1980, 1507.
2) S. Shoda and T. Mukaiyama, Chem. Lett., 1981, 723.
3) When carbontetrabromide(2) and stannous fluoride(4) are mixed in DMSO, immediate generation of heat occurs. No reaction, however, proceeds if an aldehyde is added to the mixture after the solution is cooled. It is presumed that the organotin(IV)compound(6) is unstable, and immediately decomposes under the present reaction conditions.
4) C. Furet, C. Servens, and M. Pereyre, J. Organometal. Chem., 102, 423 (1975).
5) M. Chérest, H. Felkin, and N. Prudent, Tetrahedron Lett., 1968, 2199.
6) H. Taguchi, H. Yamamoto, and H. Nozaki, Bull. Chem. Soc. Jpn., 50, 1588 (1977).
7) W. Reeve and R. Tsuk, J. Org. Chem., 45, 5214 (1980); Ya. G. Bal'on and M. D. Shul'man, Ukr. Khim. Zh., 42, 1215 (1976) (Chem. Abstr., 86, 89299a (1977).); J. W. Howard, J. Am. Chem. Soc., 52, 5059 (1930).
8) It is presumed that β-elimination occurs before water molecule attacks at the cationic center.
9) Our recent investigations on the synthesis of sugar derivatives starting from 1,2-O-isopropylideneglyceraldehyde are; M. Yamaguchi and T. Mukaiyama, Chem. Lett., 1981, 1005; T. Harada and T. Mukaiyama, Chem. Lett., 1981, 1109.
10) Bp 110 °C/0.2 mmHg (by bulb to bulb distillation). $[\alpha]_D^{27}$=+18°(c 2.0, $CHCl_3$). NMR($CDCl_3$) 1.33(6H, s), 2.20(3H,s), 4.0-4.2(2H, m), 4.6-4.9(1H, m), 5.40(0.25 H, d, J=5 Hz), 5.80(0.75 H, d, J=2 Hz). IR(neat) 1760, 600, 560 cm^{-1}.
11) V. C. Jelinek and F. W. Upson, J. Am. Chem. Soc., 60, 355 (1938). Bp 130 °C/ 0.4 mmHg (by bulb to bulb distillation). $[\alpha]_D^{24}$=-61°(c 2.3, $CHCl_3$). H-NMR($CDCl_3$) δ 2.13(6H, s), 4.43 (2H, s), 5.57 (2H, s). ^{13}C-NMR($CDCl_3$) δ 20.2, 20.5, 67.2, 69.2, 69.7, 169.3, 169.8, 170.5. IR(neat) 1730-1820 cm^{-1} (broad).
12) E. Hardegger, K. Kreis, and H. El. Khadem, Helv. Chim. Acta, 34, 2343 (1951).
13) For examples; A. S. Perlin and C. Brice, Can. J. Chem., 33, 1216 (1955); P. A. J. Gorin and A. S. Perlin, Can. J. Chem., 34, 693 (1956); R. Barker and D. L. MacDonald, J. Am. Chem. Soc., 82, 2301 (1960); D. L. Mitchell, Can. J. Chem., 41, 214 (1963).

(Received August 31, 1981)