Derivatization of Keto Fatty Acids: V. Synthesis and Characterization of 1,3-Dioxolanes

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ABSTRACT

The synthesis of substituted 1,3-dioxolanes from oxo fatty acid esters using 1,2-propanediol is described. This reagent, besides forming dioxolanes, also converts the methyl ester to the 2′-hydroxy propyl ester. Methyl 10-oxoundecanoate gives 2′-hydroxy propyl 10-(2″-methyl ethylene dioxolane) undecanoate (Ia, 75%) as a mjaor product. Methyl 9-oxooctadecanoate reacts similarly and yields 2′-hydroxy propyl 9-(2″-methyl ethylene dioxolane) octadecanoate (IIb, 60%), along with the minor products (IIa, IIc). Methyl 2-oxooctadecanoate, after prolonged refluxing, affords only 2′-hydroxy propyl 2-(2″-methyl ethylene dioxolane) octadecanoate (IIIa) in 70% yield. Structures of each reaction product were established on the basis of elemental analysis, IR, NMR and a study of mass spectrometry.

INTRODUCTION

Dioxolanation has been used both as a method for the protection of oxo function (2) and for the preparation of a variety of compounds showing industrial (3) and pharmaceutical potential (4). Recently a number of dioxolanes have been identified as insecticides, fungicides and germicides (5-7). A few dioxolanes have been used as flavoring materials (8) and also in perfumes (9). However, there has been no literature on dioxolanation of fatty compounds, except one report from our laboratory which describes the successful preparation of a terminal 1,3-dioxolane from the methyl 10,11-epoxyundecanoate (10). In continuation of our work on the derivatization of fatty acids, an attempt has been made to prepare dioxolanes from oxo esters and 1,2-propanediol using paratoluene sulphonic acid (p-TSA) and benzene as catalyst and solvent, respectively.

EXPERIMENTAL PROCEDURES

All chemical procedures, chromatographic and spectroscopic details as well as preparation of methyl 10-oxoundecanoate (I), 9-oxooctadecanoate (II, from isoricinoleic acid) and 2-oxooctadecanoate (III) are described in our earlier report (11).

General Procedure of Reaction of 1,2-Propanediol with Ketones

1,2-Propanediol (10 mL) and dry benzene (100 mL) were refluxed in a Dean Stark apparatus for 1 hr in order to remove traces of water. To this solution, ketone (I, II, III, 10 mmole) was added, followed by p-toluenesulphonic acid (100 mg). The contents were refluxed until complete conversion of reactants was noted by TLC (2 hr for I, 16 hr for II, 20 hr for III). The solvent was evaporated under reduced pressure and the residue extracted with diethyl ether. The ethereal solution was washed with aqueous $NaHCO_3$, dried over (Na_2SO_4) and the solvent evaporated. The products were separated by silica gel column chromatography using petroleum ether with the increasing proportion of diethyl ether as eluate. Ia: (Viscous oil, 75%) (Found: C, 64.49; H, 10.15. Calcd. for $C_{17}H_{32}O_5$: C, 64.53; H, 10.18%). Ib: (mp.56-57 C, 20%)(Found: C, 65,10; H, 10.11. Calcd. for $C_{14}H_{26}O_4$; C, 65.09; H, 10.12%). IIa: (Viscous oil, 15%) (Found: C, 71.4; H, 11.45. Calcd. for $C_{22}H_{42}O_4$: C, 71.31; H, 11.41%). IIb: (Viscous oil, 60%) (Found: C, 69.55; H, 11.2. Calcd. for $C_{24}H_{46}O_5$: C, 69.53; H, 11.17%). IIc: (mp. 76-77 C, 20%) (Found: C, 70.81; H, 11.32. Calcd. for $C_{21}H_{40}O_4$: C, 70.75; H, 11.30%). IIIa: (Oil, 70%) (Found: C, 69.59; H, 11.21. Calcd. for $C_{24}H_{46}O_5$: C, 69.53; H, 11.17%).

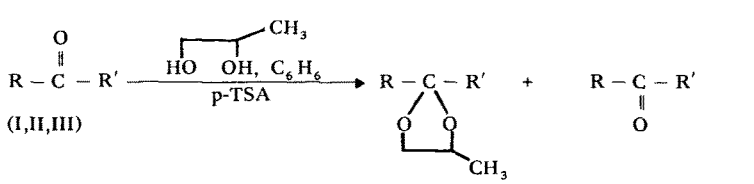
RESULTS AND DISCUSSION

Dioxolanation was carried out according to the procedure described by Williams et al. (12). (Scheme 1).

Reaction of excess of 1,2-propanediol with I, II and III in the presence of a catalytic amount of p-TSA gave a quantitative yield of the corresponding 2′-hydroxy propyl ester of the 2″-methyl dioxolane (Ia, IIb, IIIa). In addition, the terminal and internal oxo esters (I, II) also yielded the corresponding 2′-hydroxy propyl ester of the oxo acids, 2′-hydroxy propyl 10-oxoundecanoate (Ib) and 2′-hydroxy propyl 9-oxooctadecanoate (IIc) as minor products. Methyl 9-(2″-methyl ethylene dioxolane) octadecanoate (IIa) also was obtained in the case of II.

IR spectra of these dioxolanes showed strong bands

SCHEME 1



(I,Ia,Ib): R = CH_3
(I): R′ = $(CH_2)_8-COOCH_3$
(Ia,Ib): R′ = $(CH_2)_8-CO_2CH_2CH(CH_3)$
(II,IIa,IIb,IIc): R = $CH_3-(CH_2)_8$
(II, IIa): R′ = $(CH_2)_7-COOCH_3$
(IIb,IIc): R′ = $(CH_2)_7-CO_2CH_2-CH(CH_3)$
(III,IIIa): R = CH_3 $(CH_2)_{15}$; (III) R′ = CO_2CH_3;
(IIIa): R′ = $CO_2CH_2-CH(OH)CH_3$.

TABLE 1

Compound	IR (cm^{-1})	NMR (δ)	Mass, m/z (source, intensity)
Ia	3470(-OH), 1740 (Ester), 1170, 1100, 1050(C-O)	3.96(m, 4H), 3.5(m, 2H), 2.75(br.m,-OH), 2.25 (t, 2H), 1.23(br.s,CH_2-chain and CH_3-C-), 1.15(m, 2 X CH_3).	316(M^+, absent), 301(M-CH_3, 5.2), 299(M-OH,1), 283(301-H_2O, 0.5), 241(M-$C_3H_7O_2$, 10), 183 (M-$C_6H_{13}O_3$, 14.8), 118(McLafferty, 1), 113 ($C_6H_9O_2$, 6), 101(α-Cleavage, 100), 71(113-C_3H_6, 8), 59(C_3H_7O, 16.3), 45(59-CH_2, 6.5), 43(CH_3CO^+, 63.4).
Ib	3440,1730,1695 (CH_3COCH_2-), 1160,1065,1010.	3.9(d, 2H), 3.55(m, 1H), 2.55(br.m,-OH), 2.3 (m, 4H), 2.08(s, CH_3-CO), 1.25, 1.15(d, CH_3).	258(M^+, 1), 243(M-CH_3, 2.5), 241(M-OH, 15.3), 201(M-C_3H_5O, 46), 183(M-$C_3H_7O_2$, 100), 118(6), 59(McLafferty+1, 38), 58(McLafferty, 58), 45(22), 43(>100).
IIa	1735,1160,1090, 1010.	3.96(m, 2H), 3.58 (s, $COOCH_3$), 3.45 (m, 1H), 2.22(m, 2H), 1.25, 1.15(d, CH_3), 0.9 (t, CH_3).	370(M^+, absent), 371(M+1, 0.4), 339(M-OCH_3, >100), 243(α-Cleavage,>100), 213(α-Cleavage, >100), 113(43), 74(McLafferty, 7.6), 71(83), 55(100), 43(99).
IIb	3450,1730,1175, 1090.	3.95(m, 4H), 3.5(m, 2H), 2.3(m, C_2-CH_2 and -OH), 1.25, 1.15(m, 2 X CH_3-), 0.9(t, CH_3-).	414(M^+, absent), 397(M-OH, 0.6), 339 (M-$C_3H_7O_2$, 10.5), 287(M-C_9H_{19}, 70), 213 (α-Cleavage, 100), 118(6), 113(22.5), 71(22.5), 59(20), 45(6), 43(31).
IIc	3280,1730,1695, 1175,1105,1080, 1030.	3.95(m, 2H), 3.5(m, 1H), 2.48(s, -OH), 2.3(m, 6H), 1.25, 1.15(d, CH_3-), 0.9 (t, CH_3-).	
IIIa	3440,1735,1170, 1115,1070.	3.95(m, 4H), 3.5(m, 2H), 2.2-2.4(br.m, C_2-CH_2- and -OH), 1.3, 1.15(m, 2 X CH_3-), 0.9(t, CH_3-).	414(M^+, absent), 386(M-28, 0.3), 311 (α-Cleavage, 8.3), 283(311-C_2H_4, 13), 269(283-CH_2, 4), 271(269+2H, 8.3), 243 (271-C_2H_4, 22), 225($C_{16}H_{33}$, 26.5), 211 (225-CH_2, 14), 113(10.3), 103(M-311, 15), 71(29), 59(100), 45(10.6), 43(50).

(1010-1175 cm^{-1}) for the ether grouping, suggestive of the incorporation of the dioxolane ring in to the fatty acid chain. The replacement of methoxy by 2′-hydroxy propoxy was evident from the strong band (3280-3440 cm^{-1}) attributable to hydroxyl function. However NMR spectra were more informative and gave direct evidence of the replacement of methoxy by 2′-hydroxy propoxy in the cases of Ia, IIb, IIIa. The spectra of these compounds were void of the strong methyl ester signal. Incorporation of the dioxolane ring in Ia, IIa, IIb and IIIa was established more firmly by NMR chemical shifts and integrations of methyl, methylene and methine protons of the ring as well as of 2′-hydroxy propyl grouping where present. The downfield appearance of the methylene protons ($\delta \sim 3.9$) in relation to the methine proton ($\delta \sim 3.5$) of the ring and 2′-hydroxy propyl grouping was suggestive of the shielding nature of the methyl group directly attached to a secondary carbon atom. The methyl protons appeared at δ 1.2-1.0.

The mass fragmentation pattern of mono-alkyl substituted terminal 1,3-dioxolane has been studied (13). However, scanning of the literature reveals no MS data on fatty dioxolanes except one from our laboratory (10). In the present study, the dioxolane compounds give a common characteristic fragmentation pattern through α-cleavages to ring. Molecular ion peak is not present. The parent ion peak usually is due to M-OH, M-H_2O, M-CH_3 or M+1. Some common ions which are considered to arise due to ring are at m/z 113 ($C_6H_9O_2$), 71, 59, 45 and 43.

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