Derivatization of Keto Fatty Acids: II. Synthesis of Long-Chain Enolacetates

S.F. SIDDIQI, FASIH AHMAD, M.S. SIDDIQI and **S.M. OSMAN**, Section of Oils and Fats, Department of Chemistry, Aligarh Muslim University, Aligarh-202 001, India

ABSTRACT

Long-chain enolacetates were prepared by refluxing the keto fatty acids with acetic anhydride and *p*-toluene sulfonic acid (p-TSA). 10-Oxoundecanoic and 2-oxohexadecanoic acids gave mainly 10-acetoxy-10-undecenoic and 2-acetoxy-2-hexadecenoic acids, respectively. On the other hand, 12-oxooctadecanoic acid on similar treatment was assumed to yield an isomeric mixture of 12-acetoxy-12(11)-octadecenoic acids. The structure of the individual reaction products were established by spectral studies.

INTRODUCTION

In the recent past, preparation of vinyl fatty derivatives in oil-based industries has assumed importance because of their potential application in plastics (1, 2). Monosubstituted ethylenic structures such as vinyl fatty esters at one time were commercially important in the synthesis of polymers and adducts (3). Another type of vinyl structure can be formed from keto fatty acids in which the keto group forms carbanions or enolate ions which can be trapped in the acylated or metalated form. If the enolate ions are allowed to react with acetic anhydride, a rapid formation of enolacetates occurs. It was apparent from a survey of the literature that a number of methods are available for the synthesis of enolacetates (4–6). Bedoukian (7) has developed an easy and general method for the preparation of enolacetates, using acetic anhydride and *p*-TSA. In view of the potential importance of enolacetates, the present work was undertaken to prepare chain-substituted, enolacetate derivatives of keto fatty acids.

EXPERIMENTAL PROCEDURES

All the melting points are uncorrected. Infrared (IR) spectra were obtained with Perkin-Elmer 621 spectrophotometer (liquid film or in 1% solution in CCl_4). Nuclear magnetic resonance (NMR) spectra were run in $CDCl_3$ on a Varian A60 spectrometer with TMS as internal standard. Chemical shifts were measured in ppm (δ). All NMR spectra gave signals for ester methyl at δ 3.6; and intense signal at δ 1.2–1.4 for chain methylene. Thin layer chromatographic (TLC) plates (20 × 5 cm) were coated with a layer of Silica Gel G (0.25 mm thickness) and a mixture of petroleum ether/ether/acetic acid (80:20:1, v/v) was normally used as the developing solvent. Components on the TLC plates were visualized by charring the sprayed plates with a 20% aqueous solution of perchloric acid.

10-Oxoundecanoic acid (mp 58–59 C), 12-oxooctadecanoic acid (mp 82–82.5 C) and 2-oxohexadecanoic acid (mp 68 C) were prepared as discussed in an earlier communication (8).

Methyl esters were prepared from diazomethane as well as by acid-catalyzed esterification of fatty acids in absolute methanol.

Each reaction product as methyl ester was chromatographed over a column of Silica Gel (20 g). Elution with a mixture of petroleum ether/ether (85:15, v/v) gave the corresponding enolacetate in each case except in 10-oxoundecanoic acid where enolacetate was obtained in the mixture of petroleum ether/ether (95:5, v/v).

Methyl 11-acetoxy-10-ketoundecanoate obtained in the lead tetraacetate oxidation of methyl 10-acetoxy-10-undecenoate, was eluted in the mixture of petroleum ether/ether (85:15, v/v).

Preparation of Enolacetate from 10-Oxoundecanoic Acid

10-Oxoundecanoic acid (**I**; 2 g; 0.01 mol) was added to a mixture of acetic anhydride (3.7 mL; 0.04 mol), *p*-TSA (0.05 g) and refluxed for 4 hr at 120 C. The reaction mixture was poured into water and extracted with ether. The ethereal layer was washed several times with water and sodium bicarbonate (5%) and then dried over anhydrous sodium sulfate. Evaporation of the solvent yielded an oily product (1.9 g) which on column chromatographic purification as methyl ester gave 60% yield of product **II**. (Found: C, 65.1; H, 9.6. Calcd. for $C_{14}H_{24}O_4$: C, 65.62; H, 9.37%). IR (neat) 1180, 1605 and 1740 cm^{-1}. NMR ($CDCl_3$) δ 3.68 (2H,S, $CH_2=C(OAc)-$); 2.45–2.22 (3H,t); 2.01 (3H,S, $CH_2=C(OCOCH_3)-$).

Lead Tetraacetate (LTA) Oxidation of Methyl 10-Acetoxy-10-Undecenoate (II)

Methyl 10-acetoxy-10-undecenoate (**II**; 1 g; 0.004 mol) was refluxed with equimolar amount of LTA (1.77 g) in 50 mL acetic acid at 100 C for 2 hr. The reaction mixture was diluted with water and organic materials were extracted with ether. The ethereal solution was washed with 10% solution of sodium bicarbonate until neutral and dried over anhydrous sodium sulfate. Evaporation of solvent gave an oily product which on column chromatographic purification gave 50% yield of product **III**. (Found: C, 61.21; H, 9.12. Calcd. for $C_{14}H_{24}O_5$: C, 61.76; H, 8.82%). IR (neat) 1110, 1720, 1740 and 1745 cm^{-1}. NMR ($CDCl_3$) δ 4.65 (3H,S, $-CH_2(OAc)-$), 2.5 (4H,m), 2.12 (3H,S, $-CH_2(OCOCH_3)$).

Preparation of Enolacetate from 2-Oxohexadecanoic Acid

2-Oxohexadecanoic acid (**IV**; 2 g; 0.008 mol) was refluxed with acetic anhydride (3 mL; 0.032 mol) and *p*-TSA (0.04 g) for 48 hr as described earlier. After usual work up, a product (1.8 g) was obtained which on chromatographic purification as methyl ester gave 50% yield of product **V**. (Found: C, 68.9; H, 10.20. Calcd. for $C_{19}H_{34}O_5$: C, 69.93; H, 10.42%). IR (neat) 1200, 1660, 1730 and 1770 cm^{-1}. NMR ($CDCl_3$) δ 6.5 (1H,t,$-CH=C(OAc)-$); 3.76 (3H,S); 2.2 (3H,S, $-CH=C(OCOCH_3)$), 2.1 (2H,m); 0.9 (3H,t).

Preparation of Enolacetate from 12-Oxooctadecanoic Acid

12-Oxooctdecanoic acid (**VI**; 2 g; 0.007 mol) was refluxed with acetic anhydride (2.6 mL; 0.028 mol) and *p*-TSA (0.035 g) for 4 hr. The reaction mixture was worked up as described above. The reaction product (1.85 g) on column chromatographic purification as methyl ester yielded 60% of product **VII**. (Found: C, 71.82; H, 10.91. Calcd. for $C_{21}H_{38}O_5$: C, 71.19; H, 10.73%). IR (neat) 1210, 1610, 1720 and 1740 cm^{-1}. NMR ($CDCl_3$) δ 5.5 (1H,t, $-\underset{\text{OAc}}{\underline{C}H}=\underset{\text{OCOCH}_3}{\underline{C}}-$); 2.42-2.34 (t); 2.11 (3H,s, $=\underline{C}-$).

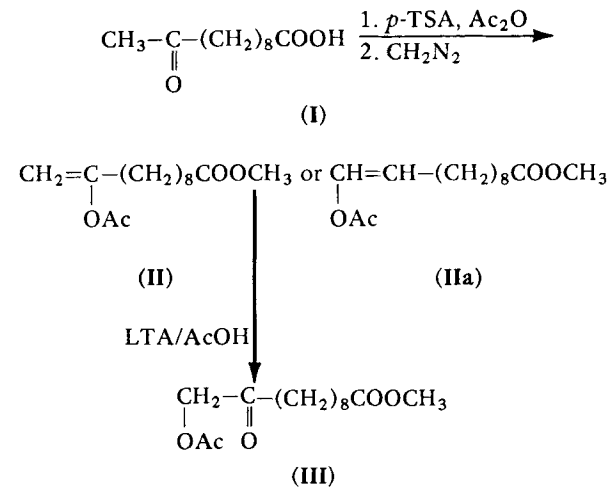
RESULTS AND DISCUSSION

The present work is an extension of our earlier work on derivatization of keto fatty acids. Three keto fatty acids, 10-oxoundecanoic, 2-oxohexadecanoic and 12-oxooctadecanoic were chosen for enolization, because of oxo group location at penultimate, alpha and internal carbon atoms.

In general, each mole of keto fatty acid was refluxed with 4 mol equivalents of acetic anhydride and 5 g of *p*-TSA under nitrogen atmosphere. 10-Oxoundecanoic acid after 4 hr refluxing was worked up, and TLC of the reaction product showed a major component above the starting material along with some other minor products. Column chromatographic purification gave 60% yield of enolacetate (**II**). Elemental analysis of the product corresponded to the formula $C_{14}H_{24}O_4$. The IR spectrum showed a characteristic intense band at 1605 cm^{-1} for substituted double bond and NMR spectrum gave the most characteristic signal for two terminal vinyl protons at δ 3.68 as a sharp singlet. Theoretically, two isomeric enolacetates (**II** and **IIa**) are expected from the reaction. IR values are compatible with both structures. However, NMR spectrum gave specific signal (δ 3.68), which clearly suggested the product as methyl 10-acetoxy-10-undecenoate (**II**) rather than the methyl 10-acetoxy-9-undecenoate (**IIa**). The latter would have given a triplet for vinyl protons and a singlet for terminal methyl protons.

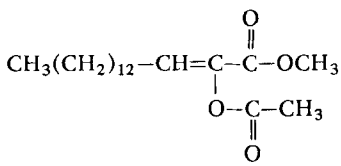
Out of the two possible isomers, only one isomer was obtained. The competitive rate of formulation of only one isomer may be due to the facile removal of less hindered proton which would lead to the formation of a less substituted enolacetate. The complete absence or nonformation of other products at this stage can not be ruled out. It is possible that the other isomer could have been formed in very small quantities which escaped detection. However, the present evidence suggests that the reaction is basically regioselective.

The structure of enolacetate (**II**) was further established by its lead tetraacetate (LTA) oxidation. The LTA oxidation of enolacetates are reported (9) to give α-ketoacetates. The LTA oxidation of **II** in acetic acid gave a single product **III**. Its elemental analysis corresponds to the formula $C_{14}H_{24}O_5$. The IR spectrum showed a complete absence of vinyl unsaturation and gave indication for the presence of keto and acetate groupings. The structure, methyl 11-acetoxy-10-oxoundecanoate (**III**) was confirmed on the basis of the shift of the NMR signal for terminal methylene protons to δ 4.65 (2H,S). Thus the formation of oxoacetate **III** from the LTA oxidation of enolacetate (**II**) supports its structure as methyl 10-acetoxy-10-undecenoate (**II**). The overall reaction sequence is given in Scheme 1.



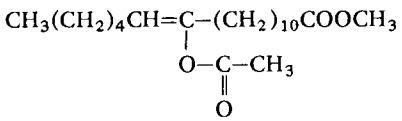
SCHEME 1

Reaction of 10-oxoundecanoic acid gave mainly a single product. It was expected that 2-oxo acid would also give a single product because there is only one alpha position available which contains hydrogen. 2-Oxohexadecanoic acid (**IV**) was similarly refluxed with acetic anhydride and *p*-TSA. TLC monitoring showed that the maximum conversion of the original ketone was achieved after 48 hr of refluxing. TLC of the reaction product after work up showed one major and two minor products. Column chromatographic purification finally gave a TLC homogeneous product (**V**) in 50% yield. Elemental analysis of the compound (**V**) corresponded to the formula $C_{19}H_{34}O_4$. The presence of enolacetate grouping in the molecule is quite clear by IR spectrum, which showed bands at 1770 and 1660 cm^{-1} for vinyl acetate and vinyl unsaturation, respectively. The appearance of a vinyl proton as a triplet at δ 6.5 in NMR further established its structure as **V**.

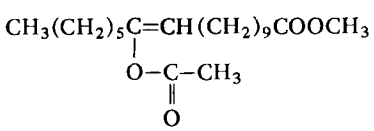


(**V**)

A similar reaction product of 12-oxooctadecanoic acid (**VI**) on TLC plate showed a major product (**VII**) which was isolated by column chromatography. The characteristic IR bands at 1610, 1210 cm^{-1} and NMR signal at δ 5.5 are compatible with isomeric enolacetate, methyl 2-acetoxy-12(11)-octadecenoates (**VIIa** and **VIIb**).



(**VIIa**)



(**VIIb**)

TLC of the product **VII**, in different solvents showed a single spot, however, the product **VII** can be assumed to be a mixture of products **VIIa** and **VIIb**. In 12-oxooctadecanoate, the keto group is midchain and provides approximately equal opportunity for enolization on either side of the keto function.

ACKNOWLEDGMENTS

The authors thank W. Rahman for providing necessary facilities, and CSIR and United States Department of Agriculture, ARS, New Delhi (PL-480 Research Project) for financial aid.

REFERENCES

1. Uzzan, A., Rev. Fr. Corps Gras 7:135 (1960).
2. Calderon, R., H.P. Dupy, E.R. McCall, R.T. O'Connor and L.A. Goldblatt, JAOCS 37:132 (1960).
3. Teeter, H.M., JAOCS 40:143 (1963).
4. Hancu, V., Chem. Ber. 42:1052 (1909).
5. Gwynn, B.H., and E.F. Degering, J. Am. Chem. Soc. 64:2216 (1942).
6. Fahey, R.C., and D.J. Lee, Ibid. 90:2124 (1968).
7. Bedoukian, P.Z., Ibid. 67:1430 (1945).
8. Nasirullah, F. Ahmad, S.M. Osman and W. Pimlott, JAOCS 59:411 (1982).
9. Sung Moon and H. Bohm, J. Org. Chem. 37:4338 (1972).

[Received July 14, 1982]

Cyclopropenoid Fatty Acids in Seed Oils of *Urena repanda* and *Thespesia lampas*

M.S. AHMAD, JR., M.U. AHMAD, A. RAUF, S.M. OSMAN,[1] Department of Chemistry, Aligarh Muslim University, Aligarh-202001, India, and **J.A. BALLANTINE,** Department of Chemistry, University College of Swansea, SA2 8PP, United Kingdom

ABSTRACT

Seed oils of *Urena repanda* and *Thespesia lampas* (Malvaceae) were found to contain malvalic (2.6, 0.6%) and sterculic (1.1, 2.1%) acids, respectively, besides the normal fatty acids. Cooccurrence of these two acids were established by gas chromatographic analysis of silver nitrate/methanol-treated methyl esters using *Sterculia foetida* esters as a reference standard.

INTRODUCTION

Publications on cyclopropenoid fatty acids (CPFA) are abundant but their characterization and estimation are relatively unexplored. The present paper describes the fatty acids composition of *Urena repanda* and *Thespesia lampas*.

EXPERIMENTAL PROCEDURES

The experimental procedure has already been detailed (1).

RESULTS AND DISCUSSION

The analytical values of oils and seeds is given in Table I (2). The gas chromatographic (GC) data of the two oils showed the presence of 3.7% and 2.7% by weight of CPFA, in addition to the conventional fatty acids (Table II). The GC data were found to be in close agreement with those obtained by the method of HBr titration (3).

TABLE I

Analytical Data on *U. repanda* and *T. lampas* Seeds and Oils

	U. repanda	T. lampas
Seeds		
Oil content (%)	8.0	8.6
Protein content (%)	24.4	25.0
Moisture (%)	9.6	9.4
Seed oils		
Iodine value (Wijs)	134.6	108.3
Saponification value	163.6	188.3
Refractive index, nD^{40}	1.4859	1.4820
Halphen test	Positive	Positive
HBr equiv.	3.5	2.4

TABLE II

Component Methyl Esters (% wt) Derived from *U. repanda*, *T. lampas* and *S. foetida* Seed Oils

Fatty Acids	RRT	*U. repanda*	*T. lampas*	*S. foetida*
Lauric	0.17	2.3	–	–
Myristic	0.23	0.2	0.2	–
Myristoleic	0.41	1.9	–	–
Palmitic	0.47	28.7	18.4	26.0
Palmitoleic	0.75	0.3	–	1.0
Stearic	0.89	8.1	0.6	3.4
Oleic	1.00	16.5	14.5	9.4
Linoleic	1.20	37.9	63.6	1.3
Linolenic	1.38	0.4	–	0.6
Malvalic				
(ether deriv.)	2.31	1.8	0.5	6.5
Ketone deriv.	4.20	0.8	0.1	0.6
		2.6	0.6	7.1
Sterculic				
(ether deriv)	3.18	0.9	1.8	48.8
Ketone deriv	5.74	0.2	0.3	2.4
		1.1	2.1	51.2

ACKNOWLEDGMENTS

The CSIR (New Delhi) for Research Fellowships and in part by a grant from USDA under PL-480.

REFERENCES

1. Ahmad, M.S., Jr., M.U. Ahmad, S.M. Osman, and J.A. Ballantine, Chem. Phys. Lipids 25:29(1979).
2. Official and Tentative Methods of the American Oil Chemists' Society, Vol. 1 AOCS (Champaign, IL, 1973).
3. Harris, J.A., F.C. Magne, and E.L. Skau, JAOCS 40:718 (1963).

[Received December 11, 1981]

[1] To whom correspondence should be addressed.