Pergamon

Tetrahedron 55 (1999) 13741–13748

TETRAHEDRON

Acetoxylation of β-Lactams with Lead(IV) Acetate[1]

Le Thanh Giang, József Fetter,* Mária Kajtár-Peredy,[a] Károly Lempert and Gábor Czira [b]

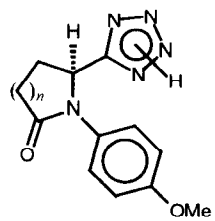
Department of Organic Chemistry, Technical University Budapest, H-1521 Budapest, Hungary
[a]Institute of Chemistry, Chemical Research Center, Hungarian Academy of Sciences, H-1525 Budapest, Hungary
[b] Gedeon Richter Chemical Works, Ltd., H-1475 Budapest 10, Hungary

Received 8 March 1999; revised 6 September 1999; accepted 23 September 1999

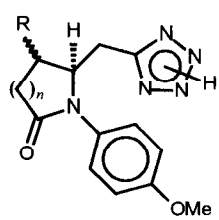
Abstract: 1-(4-Methoxyphenyl)azetidin-2-ones **5a-5g** were acetoxylated by lead(IV) acetate to afford the corresponding compounds **6a**, **6b**, **6c'** and **6d-6g**. In the **d** series elimination products **9** and **10** were also formed. Ring homologue **7a** afforded the hydroxylated derivative **8'a**.

Keywords: Azetidin-2-ones; Pyrrolidin-2-ones; Oxidative Acetoxylation

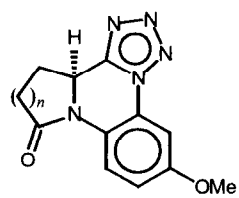
In the preceding paper[2] the oxidative cyclization of some 1-(4-methoxyphenyl)-4-(tetrazol-5-yl)- and -4-(tetrazol-5-ylmethyl)-azetidin-2-ones and their γ- and δ-lactam analogues (**1**, **2**) with lead(IV) acetate (LTA) to afford compounds of types **3** and **4**, respectively, has been described. These novel transformations were thought to be the result of neighbouring group participation by the tetrazol-5-yl and tetrazol-5-ylmethyl groups at position 4, 5 and 6, respectively and, consequently, the diversion of the reaction from its "normal" course experienced with lactams lacking these substituents. Since, much to our surprise, the reaction of such azetidin--2-ones with LTA has so far not been studied, a study of the reaction with LTA of a series of known and new 1-(4-methoxyphenyl)azetidin-2-ones (**5a-5h**) carrying no tetrazol-5-yl or tetrazol-5-ylmethyl groups in position 4, as well as of their ring homologues **7a** and **7c** has been undertaken. The reactions were carried out by refluxing mixtures of the substrates with 3-5 equivalents of LTA in dry dioxane. Compounds **5a**, **5b**, **5e**, **5f**, and



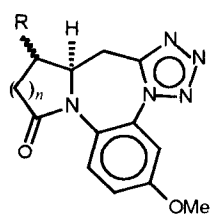
1:[3] $n = 0, 1$



2:[3] $n = 0, 2$



3:[3] $n = 0, 1$

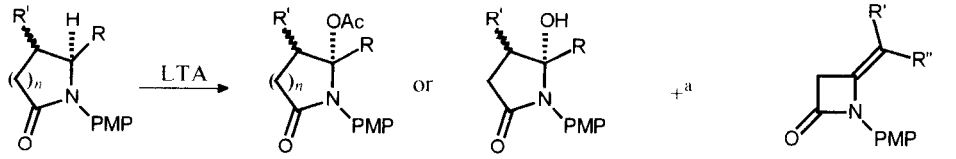


4:[3] $n = 0, 2$

0040-4020/99/$ - see front matter
PII: S0040-4020(99)00857-1

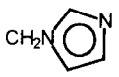
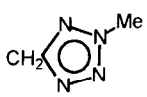
5g afforded with LTA the corresponding 4-acetoxy derivatives **6**[a] in variable yields. In the **c** series acetoxylation was accompanied by acetolysis of the methylsulfonyloxy group, resulting in the formation of compound **6c'** rather than **6c**. In the **d** series, in addition to acetoxylation product **6d**, the two diastereoisomeric elimination products **9** and **10** were obtained. The stereochemistry of the two

Scheme 1



5 (n = 0), **7** (n = 1) **6** (n = 0), **8** (n = 1) **8'** **9**: R' = H, R" = CN (*Z*) **10**: R' = CN, R" = H (*E*)

(PMP = 4- methoxyphenyl, PhthN = phthalimido)

5-8	a	b	c	c'	d	e	f	g	h
R	CO_2Et	CN	CH_2OSO_2Me	CH_2OH	CH_2CN			Ph	Ph
R'	H	H	H	H	H	H	H	PhthN, *cis*	PhthN, *trans*

Substrate	Products and yields
5a	**6a** (78%)
5b	**6b** (73%)
5c	**6c'** (58%)
3d	**6d** (16%) + **9** (25%) + **10**[c] (14%)
5e[b]	**6e** (22%)
5f	**6f** (60%)
5g[b]	**6g** (90%)
5h[b]	decomposition
7a[b]	**8'a** (80%)

[a] From **5d**.

[b] For the preparation of these compounds, see Experimental.

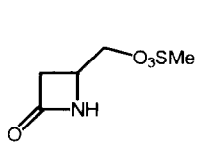
[c] Crude product, contaminated by compounds **6d** and **9**.

diastereoisomers was deduced from their d-NOE spectra. The isomeric structures, containing C-3 - C-4 endocyclic double bonds, were ruled out by the ^{13}C n.m.r. spectra for both diastreoisomers. The behaviour of compound **5f** was striking. While its analogue **2** (n = 0, R= H) (Scheme 2) carrying an *N-un*substituted tetrazole ring had been found [2] to undergo cyclization to compound **4** (R=H, n=0) when treated with LTA, compound **5f** was acetoxylated under the same conditions. (For an attempt to explain this discrepancy, see below.) In contrast to compound **5g** (which afforded a single stereoisomer of type **6**, contaminated by some unchanged starting **5g**), its *trans* isomer **5h** slowly decomposed rather than being acetoxylated when treated with LTA under the same conditions. The stereochemistry of the product arising from **5g** could not be derived unequivocally by NOE studies. However, assuming that the planar C-4 atom of cation **18g** (Scheme 1) will be attacked by the acetate anion at the less hindered face, *i.e. trans* to the 3-phthalimido group, it follows that the

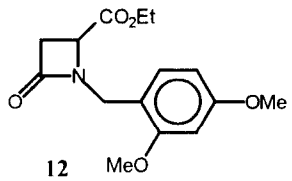
product probably possesses structure **6g** with the phenyl and phthalimido groups occupying the *cis* position with respect to each other.

LTA oxidation of the ring homologue **7a** of compound **5a** afforded, instead of the expected compound **8a**, hydroxy analogue **8'a**, presumably formed by hydrolysis of acetoxy derivative **8a** during work-up. In contrast, compound **7c** was decomposed, rather than acetoxylated by LTA.

The presence of the *N*-(4-methoxyphenyl) groups in the substrates appears to be necessary for the acetoxylations by LTA to occur, since neither compound **11** nor **12**[10] underwent acetoxylation when treated with LTA.

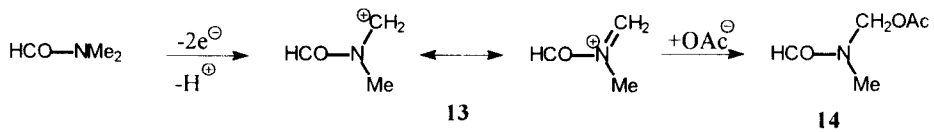


11



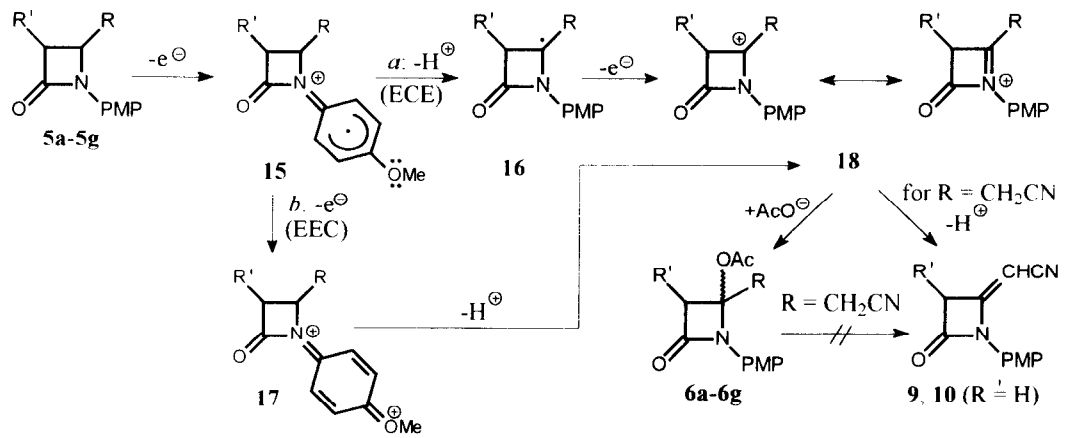
12

Anodic acetoxylation of DMF to afford compound **14**[11] (the acyclic counterpart of reaction **5**→**6**) and related reactions are known. Cation **13** has been shown [12] to be the key intermediate in the anodic acetoxylation, see equation (1). In principle, cation **13** could be the result of either an ECE or an EEC process.[13] (The symbols



13 **14** (1)

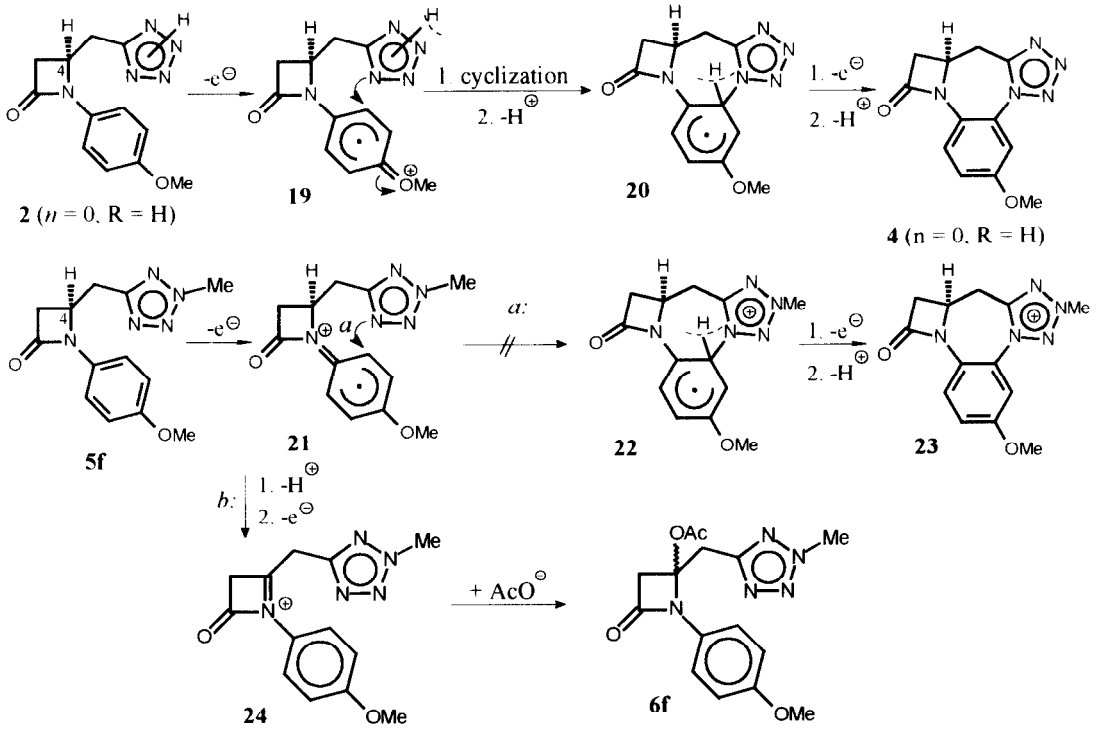
ECE and EEC describe three-step processes, E and C meaning electron transfer and chemical steps, respectively, following each other in the order indicated.) Since LTA and anodic oxidations are often very similar,[14] the mechanism depicted in Scheme 2 is suggested for reaction **5**→**6** or **9**, **10** brought about by LTA.



Scheme 2: Suggested mechanism of reaction **5** → **6** or **9**, **10**, brought about by LTA. PMP = 4-methoxyphenyl (Since compound **6d** was not converted in a separate experiment into a mixture of compounds **9** and **10**, the latter must be formed directly from cation **18** by deprotonation)

Since the *N*-substituent of azetidinones **5** is 4-methoxyphenyl (PMP), the positive charge and the radical center of radical cations **15** will be delocalized to a considerable extent into the PMP groups. As a result, the tendency of radical cations **15** to eject a proton from position 4 will probably be diminished and their oxidation to the corresponding dications **17** will be facilitated. Since, furthermore, LTA is known to be a two--electron oxidant, the EEC path *b* (Scheme 2) may presently not be considered to be ruled out with certainty.

For the dissimilar behaviour of compound **5f** and its analogue **2** (n = 0, R = H) carrying an *N*-*un*substituted tetrazole ring (see above) the following explanation is offered. The key step of the LTA oxidation of compound **2** (n = 0, R = H) is cyclization of intermediate **19** with concomitant loss of a proton to afford radical **20** (Scheme 3). In the case of compound **5f** a similar transformation is impossible due to the absence of an NH group in the tetrazole ring. Instead only radical cation **22** could be formed which is probably less stable in dioxane (the solvent used in these reactions) than radical **20**. Therefore it is not formed and the main reaction of radical cation **21** will be deprotonation in position 4 (path *b*) followed by oxidation and acetoxylation at the same site as shown in Scheme 2.



Scheme 3. The contrasting behaviour of compound **5f** and its *N*-demethyl analogue **2** (n = 0, R = H) on treatment with LTA. [Both reactions are depicted as ECE processes, but the final result would be the same if they were EEC processes, *i.e.* the cyclization took place on the dications, the two electron oxidation products of compounds **2** (n = 0, R = H) and **5f**.]

EXPERIMENTAL

All reactions were monitored by t.l.c. (DC-Alufolien 60 F_{254}, Merck) and allowed to go to completion. Separations of product mixtures by flash chromatography (c.c.) were carried out using Kieselgel G (Merck) as the adsorbent unless otherwise stated (pressure differences between the two ends of the columns 10-25 kPa). For preparative t.l.c. separations 20×20 cm glass plates coated with Kieselgel $PF_{254+366}$ (Merck; thickness of adsorbent layer 1.5 mm) were used. The solvents are given in parentheses. Dichloromethane is abbreviated as DCM. The purity of the products was checked, in combination with IR spectroscopy, by t.l.c. on DC--Alufolien 60 F_{254} (Merck); the individual compounds were detected by UV irradiation or by using iodine, 5% ethanolic molybdo- or tungstophosphoric acids as the reagents. $MgSO_4$ was used as the drying agent. Evaporations to dryness as well as the removal of volatile components of reaction mixtures by distillation were carried out at reduced pressures (*ca* 2.5 kPa, unless otherwise stated).

All new crystalline compounds described in the present paper were colourless. Melting points were determined on a Kofler hot-stage m.p. apparatus. IR spectra were recorded on a Specord-75 (Zeiss, Jena) spectrometer. ^1H and ^{13}C n.m.r. spectra were obtained with Varian VRX-400 and Unity INOVA-400 spectrometers in $CDCl_3$ solutions, unless otherwise stated, and using tetramethylsilane as the internal reference. *J* values in Hz are given in parentheses. The δ values of the 4-methoxyphenyl groups were found in most cases at *ca* 3.8 ppm (MeO) and 6.9 + 7.3 ppm (AA'BB', *J ca* 9; 4×ArH); therefore, except when differing by more than 0.1 ppm from these standard values, their chemical shifts will be omitted from the individual spectra. Exact molecular mass determinations were made at 70 eV with a Finnigan-MAT 95 SQ instrument of reversed geometry equipped with a direct inlet system using PFK (perfluorokerosene) as the reference.

Starting compounds

Compounds **5a** [first prepared in this laboratory [16], m.p. 92°C; ν_{max} (KBr) 1760, 1740 cm^{-1} [16]], **5b** [17], **5c** [18], **5d** [18], **5f** [18], **7c** [17], **11** [19] and **12** [19] were prepared by literature methods.

*1-[*rac*-1-(4-Methoxyphenyl)-4-oxoazetidin-2-ylmethyl]-imidazole* (**5e**)

A mixture of *rac*-4-iodomethyl-1-(4-methoxyphenyl)-azetidin-2-one [18] (2.2 g, 6.95 mmol), imidazole (0.57 g, 8.3 mmol), Et_3N (0.97 mL, 6.95 mmol) and dry THF (15 mL) was refluxed for 30 h and evaporated to dryness. The residue was taken up in DCM and water, the two phases were separated, the organic phase was washed with water and extracted with 1N HCl. The combined aqueous-acidic phases were made alkaline (pH 12) by adding 10N NaOH with ice-cooling and re-extracted with DCM. The combined organic phases were dried and evaporated to dryness to afford the title compound as a faint yellow oil [1.1 g, 62%; HRMS (EI): M^+ found 257.1170; $C_{14}H_{15}N_3O_2$ requires 257.11643; ν_{max} (KBr) 1740 cm^{-1}; δ_H[20] 2.72 (dd, 1 H, *J* 15.0, 2.0, 3'-H_a), 3.16 (dd, 1 H, *J* 15.0, 4.7, 3'-H_b), 4.3-4.45 m (3 H, 2'-H + 2'-CH_2), 6.81 (br s, 1 H) + 7.06 (br s; 1 H) (4-H + 5-H), 7.46 br s (1 H, 2-H)].

rac-cis- *and* rac-trans-*1-(4-Methoxyphenyl)-4-phenyl-3-phthalimidoazetidin-2-one* (**5g** and **5h**)

Phthalimidoacetyl chloride (4.45 g, 20 mmol) in DCM (50 mL) was added dropwise to a mixture of *N*-(4-methoxyphenyl)phenylmethanimine (4.2 g, 20mmol), Et_3N (3.1 mL, 22 mmol) and DCM (50 mL) with continuous stirring at room temperature. Stirring was continued for 1 h. The mixture was allowed to stand overnight, extracted with 1N HCl, washed with water, dried and evaporated to dryness to afford a roughly 1:1

mixture (t.l.c.) of the two diastereoisomeric title compounds (3.0 g, 38%). By flash chromatography (DCM) 0.4 g, each, of compounds **5h** [m.p. 190°C (from MeOH); HRMS (EI): $M^{+\cdot}$ found 398.1272; $C_{24}H_{18}N_2O_4$ requires 398.1267; ν_{max} (KBr) 1790w, 1770, 1730 cm^{-1}; δ_H 5.27 (d, 1 H, *J* 2.6; 3-H), 5.34 (d, 1 H, *J* 2.6, 4-H), 7.32-7.41 (m, 5 H, Ph), 7.75m + 7.86m (2 H + 2 H, PhthN)] and **5g** [m.p. 220-223°C (from MeOH); HRMS (EI): $M^{+\cdot}$ found 398.1281; $C_{24}H_{18}N_2O_4$ requires 398.12666; ν_{max} (KBr) 1780w, 1750, 1720 cm^{-1}; δ_H 5.44 (d, 1 H, *J* 5.5; 4-H), 5.66 (d, 1 H, *J* 5.5; 3-H), 7.07-7.25 (m, 5 H, Ph), 7.62m + 7.67m (2 H + 2 H, PhthN)] were separated in pure form from the mixture.

Ethyl rac-*1-(4-methoxyphenyl)-5-oxopyrrolidine-2-carboxylate* (**7a**)

(*a*) Diethyl (4-methoxyanilino)malonate [19] (9.8 g, 35 mmol) and subsequently, with ice-water cooling, ethyl acrylate (3.75 mL, 34.8 mmol) were added to an ethanolic (40 mL) solution of metallic sodium (80 mg, 3.5 mmol). The cooling bath was removed and the mixture was stirred for 10 min, neutralized with 1N HCl, and its ethanol content was distilled off. EtOAc (100 mL) was added and the mixture was washed with water, dried and evaporated to dryness to afford crude *triethyl 1-(4-methoxyanilino)propane-1,1,3-tricarboxylate* [13.2 g, quantitative; m.p. 42-43°C; ν_{max} (KBr) 1730, 1680 cm^{-1}].

(*b*) The above crude product was refluxed with acetic acid (25 mL) for 2 h and the mixture was evaporated to dryness to afford crude *diethyl 1-(4-methoxyphenyl)-5-oxopyrrolidine-2,2-dicarboxylate* (13 g, quantitative).

(*c*) A mixture of the crude diester, NaCl (2.7 g), water (1.4 mL) and DMSO (12 mL) was stirred for 24 h at 185-190°C, allowed to cool, diluted with ethyl acetate (50 mL) and poured into brine (100 mL). The two phases were separated, the aqueous phase was extracted with ethyl acetate, the combined organic phases were washed with brine, dried and evaporated to dryness to afford the title compound [7.5 g, 82%; m.p. 78°C (from i-PrOH); HRMS (EI): $M^{+\cdot}$ found 263.1161; $C_{14}H_{17}NO_4$ requires 263.11576; ν_{max} (KBr) 1740, 1700 cm^{-1}; δ_H 1.20 (t, 3 H, *J* 7.0, $COOCH_2CH_3$), 2.12-2.78 (m, 2 H + 2 H, 3-H_2 + 4-H_2), 4.16 (m, 2 H, $CO_2CH_2CH_3$), 4.63 (dd, 1 H, *J* 8.8, 3.0; 5-H).

Reactions of compounds **5a-5h**, **7a**, **7c**, **11** *and* **12** *with LTA*

Mixtures of the title compounds (1 mmol), LTA (1mmol) and dry dioxane (10 mL) were refluxed and the progress of the reaction was monitored by t.l.c. [except for the reactions of compounds **5e** (DCM-MeOH, 14:1) and **5g** (DCM-EtOAc, 20:1), DCM-acetone mixtures of diverse compositions (7:1-50:1) were used as the solvents]. If, after 1 h, the substrate was not consumed, a further amount of LTA (1-4 mmol) was added and refluxing was continued until the reaction was complete. Kieselgel G 60 was added and the mixtures were evaporated to dryness. The residues were worked up by flash chromatography (DCM→DCM:acetone, 7:0.5). The combined fractions containing the desired products were evaporated to dryness. Except in one case (**6f**), the residues crystallized when triturated with diethyl ether.

The following products were obtained (total amounts in mol-equivalents of LTA used and total reaction times are given in parentheses; yields are non-optimized):

Ethyl rac-*2-Acetoxy-1-(4-methoxyphenyl)-4-oxoazetidine-2-carboxylate* (**6a**) (4 LTA, 4 h) [78%; m.p. 112°C; HRMS (EI): $M^{+\cdot}$ found 307.1093; $C_{15}H_{17}NO_6$ requires 307.1056; ν_{max} (KBr) 1775, 1750/1740 cm^{-1} d; δ_H 1.19 (t, 3 H, *J* 7.0, $CO_2CH_2CH_3$), 2.24 (s, 3 H, OAc), 3.29 (d, 1 H, *J* 15.5, 3-H_a), 3.93 (d, 1 H, *J* 15.5; 3-H_b), 4.24 (m, 2 H, $CO_2CH_2CH_3$)] from compound **5a**;

rac-*4-Acetoxy-4-cyano-1-(4-methoxyphenyl)azetidin-2-one* (**6b**) (3 LTA, 4 h) [73%; m.p. 103-104°C; HRMS (EI): M^+ found 260.0802; $C_{13}H_{12}N_2O_4$ requires 260.0797; ν_{max} (KBr) 2240w, 1800, 1760 cm^{-1}; δ_H 2.25 (s, 3 H, OAc), 3.48 (d, 1 H, *J* 15.5, 3-H_a), 3.94 (d, 1 H, *J* 15.5; 3-H_b)] from compound **5b**;

rac-*4-Acetoxy-4-(acetoxymethyl)-1-(4-methoxyphenyl)-azetidin-2-one* (**6c′**) (3 LTA, 2 h) [58%; m.p. 97--103°C; HRMS (FAB): $M{\cdot}H^+$ found 308.1132; $C_{15}H_{18}NO_6$ requires 308.1134; ν_{max} (KBr) 1760, 1750/1740 cm^{-1} d; δ_H 1.99 (s, 3 H, OAc), 2.18 (s, 3 H, OAc), 3.38 (d, 1H, *J* 15.7, 3-H_a), 3.49 (d, 1 H *J* 15.7; 3-H_b), 4.59 (d, 1 H, *J* 11.9, 4-CH_a), 4.62 (d, 1 H, *J* 11.9; 4-CH_b); δ_C 20.48 + 21.35 +169.11 + 169.76 (2xOAc), 47.32 (C-3), 55.45 (OMe), 60.63 (4-CH_2), 88.59 (C-4), 114.45 (C-3 + C-5, PMP), 121.38 (C-2 + C-6, PMP), 128.42 (C-1, PMP), 157.40 (C-4, PMP), 162.32 (C-2)] from compound **5c**;

rac-*4-Acetoxy-4-cyanomethyl-1-(4-methoxyphenyl)azetidin-2-one* (**6d**) (4 LTA, 3 h) [16%, m.p. 83--85°C; HRMS (EI): M^+ found 274.0973; $C_{14}H_{14}N_2O_4$ requires 274.0954; ν_{max} (KBr) 1775, 1750 cm^{-1}; δ_H 2.22 (s, 3 H, OAc), 3.26 (d, 1 H, *J* 17.1, 4-CH_a), 3.45 (d, 1 H, *J* 16.0, 3-H_a), 3.46 (d, 1 H, *J* 17.1; 4-CH_b), 3.59 (d, 1 H, *J* 16.0, 3-H_b)] with

(Z)-4-Cyanomethylidene-1-(4-methoxyphenyl)azetidin-2-one (**9**) [25%; m.p. 153-154°C; HRMS (EI): M^+ found 214.0722; $C_{12}H_{10}N_2O_2$ requires 214.0742; ν_{max} (KBr) 2220, 1820, 1760br, 1670 cm^{-1}, δ_H 3.71 (d, 2 H, *J* 1.1; 3-H_2), 4.68 (t, 1 H, *J* 1.1; CHCN); NOE: 4.68 (CHCN)→3.71 (3-H_2); 7.36 (2-H + 6-H, PMP) → 6.98 (3-H + 5-H, PMP); δ_C 45.40 (C-3), 55.50 (OMe), 68.06 (CHCN), 114.37 (C-3 + C-5, PMP), 114.44 (CN), 124.58 (C-1, PMP), 126.03 (C-2 + C-6, PMP), 153.19 (C-4), 159.76 (C-4, PMP), 163.62 (C-2)] and

(E)-4-Cyanomethylidene-1-(4-methoxyphenyl)azetidin-2-one (**10**) [14%; crude product; contaminated by compounds **6d** (*ca* 25%) and **9** (*ca* 20%); HRMS (EI): M^+ found 214.0735; $C_{12}H_{10}N_2O_2$ requires 214.0742; ν_{max} (KBr) 2220, 1810, 1750/1740d, 1650 cm^{-1} br, δ_H[21] 3.86 (d, 2 H, *J* 1.3; 3-H_2), 5.08 (t, 1 H, *J* 1.3; CHCN); NOE: 5.08 (CHCN)→7.30 (2-H + 6-H, PMP); δ_C[21] 45.23 (C-3), 55.57 (OMe), 69.85 (CHCN), 114.95 (C-3 + C-5, PMP), 116.29 (CN), 122.57 (C-2 + C-6, PMP), 126.37 (C-1, PMP), 154.81 (C-4), 158.83 (C-4, PMP), 162.13 (C-2)] as the co-products from compound **5d**;

rac-*1-[2-Acetoxy-1-(4-methoxyphenyl)-4-oxoazetidin-2-ylmethyl]imidazole* (**6e**) (5 LTA, 3 h) [22%; m.p. 111-114°C; HRMS (EI): M^+ found 315.1262; $C_{16}H_{17}N_3O_4$ requires 315.1219; ν_{max} (KBr) 1750br cm^{-1}; δ_H[20] ($CDCl_3$ + DMSO-d_6, *cca* 25:1, v/v) 2.25 (s, 3 H, OAc), 3.16 (d, 1H, *J* 15.8, 3′-H_a), 3.32 (d, 1 H, *J* 15.8; 3′-H_b), 4.62 (d, 1 H, *J* 14.5, 2′-CH_a), 4.72 (d, 1 H, *J* 14.5; 2′-CH_b), 6.70 (t, 1 H, *J* 1.4; 4-H), 7.00 (t, 1 H, *J* 1.4; 5-H), 7.28 (t, 1 H, *J* 1.4; 2-H); δ_C[20] ($CDCl_3$ + DMSO-d_6) 21.38 + 169.31 (OAc), 46.16 + 47.01 (C-3′ + 2′-CH_2), 55.36 (OMe), 89.40 (C-2′), 114.77 (C-3 + C-5, PMP), 119.80 (C-4), 120.41 (C-2 + C-6, PMP), 128.09 (C-1, PMP), 129.82 (C-5), 137.97 (C-2), 157.21 (C-4, PMP),161.08 (C-4′)] from compound **5e**;

rac-*5-[2-Acetoxy-1-(4-methoxyphenyl)-4-oxoazetidin-2-ylmethyl]-2-methyltetrazole* (**6f**) (4 LTA, 4 h) [60%; faint yellow oil; HRMS (EI): M^+ found 331.1279; $C_{15}H_{17}N_5O_4$ requires 331.1281; ν_{max} (film) 1760, 1740 cm^{-1}; δ_H[22] 2.21 (s, 3 H, OAc), 3.42 (d, 1 H, *J* 15.7, 3′-H_a), 3.64 (d, 1H, *J* 15.7; 3′-H_b), 3.74 (d, 1 H, *J* 15.0, 2′-CH_a), 4.02 (d, 1 H, *J* 15.0; 2′-CH_b), 4.25 (s, 3 H, *N*-Me)] from compound **5f**;

rac-cis-*4-Acetoxy-1-(4-methoxyphenyl)-4-phenyl-3-phthalimidoazetidin-2-one* (**6g**) (1 LTA, 1 h) [90%, m.p. 166-167°C; HRMS (EI): M^+ found 456.1327; $C_{26}H_{20}N_2O_6$ requires 456.1321; ν_{max} (KBr) 1800, 1780, 1750w, 1725 cm^{-1}; δ_H 2.17 (s, 3 H, OAc), 6.35 (s, 1 H, 3-H), 6.87d + 7.55d (2x2 *aryl*-H, PMP), 7.15-7.25m + 7.44m (5 H, Ph), 7.6-7.7m (4 H, PhthN)] from compound **5g**;

Ethyl rac-*2-Hydroxy-1-(4-methoxyphenyl)-5-oxopyrrolidine-2-carboxylate* (**8'a**) (3 LTA, 2.5 h) [80%; m.p. 100-101°C ; HRMS (EI): $M^{+\cdot}$ found 279.1132; $C_{14}H_{17}NO_5$ requires 279.1107; ν_{max} (KBr) 3500-3100, 1740, 1710/1690 cm^{-1} d; δ_H 1.26 (t, 3 H, *J* 7.1, $CO_2CH_2CH_3$), 2.27 (m, 2 H, 3-H_2),2.57-2.80 (m, 2 H, 4-H_2), 4.23 (q, 2 H, *J* 7.1; $CO_2CH_2CH_3$), 4.40 (s, 1 H, OH), 6.87d + 7.13d (2x2 *aryl*-H, PMP)] from compound **7a**.

The following compounds were not acetoxylated under the conditions given above: **5h** (3 LTA, 10 h, slow decomposition, 46 % recovered unchanged), **7c** (3 LTA, 3 h; decomposition), **11** (3 LTA, 5 h; 80% recovered unchanged) and **12** (3 LTA, 5 h; 46% recovered unchanged, the rest decomposed).

ACKNOWLEDGMENTS

The authors thank Miss K. Ófalvi for the IR spectra. L. T. G, J. F. and K. L. are grateful to OTKA (Hungarian Scientific Research Fund; Grant No. T-023742) and to the Hungarian Ministry of Education (Grant FKFP 0349/1997) for financial assistance.

REFERENCES AND NOTES

1. Simple and Condensed β-Lactams. Part 35. For part34, see ref. [2]
2. Le Thanh Giang, Fetter J, Kajtár-Peredy M, Lempert K, Bertha F, Czira G, Czuppon T. Tetrahedron 1999; 55: 8457-8474
3. Racemic compounds. For convenience only one enantiomer is shown.
4. 4-Acetoxyazetidin-2-ones related to the compounds **6** are known and were obtained *inter al.* from 4-unsubstituted and 4-monosubstituted azetidin-2-ones by acetoxylation with peracetic acid, molecular oxygen and acetaldehyde in the presence of transition metal (Ru, Os, Cu) based catalysts [5-8], or by anodic oxidation in acetic acid or in mixtures of acetic acid and acetonitrile [9].
5. Murakashi Sh-I, Naota T, Kuwabara T, Saito T, Kumobayashi H, Akutagawa S. J. Am. Chem. Soc. 1990; 112: 7820-7822
6. Murakashi Sh-I, Saito T, Naota T, Kumobayashi H, Akutagawa S. Tetrahedron Lett. 1991; 32: 2145-2148
7. Murakashi Sh-I, Saito T, Naota T, Kumobayashi H, Akutagawa S. Tetrahedron Lett. 1991; 32: 5991-5994
8. Eaton ChJ, Lowe SG, Wang P. J. Chem. Soc. Perkin Trans. 1 1990; 277-282
9. (a) CIBA-Geigy. Eur. Pat. Appl. EP 290395; Chem. Abstr. 1988; 110: 192526; (b) Mori M, Kagechika K, Tohjima K, Shibashaki M. Tetrahedron Lett. 1988; 29: 1409-1412
10. Simig Gy, Fetter J, Hornyák Gy, Zauer K, Doleschall G, Lempert K, Nyitrai J, Gombos Zs, Gizur T, Barta-Szalai G, Kajtár-Peredy M. Acta Chim Hung. 1985; 119: 17-32
11. Ross SD, Finkelstein M, Petersen RC. J. Am. Chem. Soc. 1964; 86: 2745-2747
12. Eberson L, Nyberg K. J. Am. Chem. Soc. 1966; 88: 1686-1691
13. For the related anodic methoxylation of *N, N*-dimethyl-benzylamine (leading to a mixture of two isomeric products, methoxylated at the methyl and methylene group, respectively), both isomeric cationic intermediates (corresponding to cation **13**) have been shown[15] to be formed *via* an ECE process.
14. Eberson L, In: S. Patai editor. The Chemistry of Carboxylic Acids and Esters. London etc. Wiley-Interscience, 1969: 97
15. Barry JE, Finkelstein M, Mayeda EA, Ross SD. J. Org. Chem. 1974; 39: 2695-2699
16. (a) Greff Z. Synthesis of Some 2-Isoxacepheme- and 2-Isocephemecarboxylic Acids. Dr. Techn. Thesis (in Hungarian). Technical University Budapest, 1988. (b) Nyitrai J, Greff Z. Unpublished.
17. Le Thanh Giang, Fetter J, Lempert K, Kajtár-Peredy M, Gömöri Á. Tetrahedron 1996; 52: 10169-10184
18. Fetter J, Keskeny E, Czuppon T, Lempert K, Kajtár-Peredy M, Tamás J. J. Chem. Soc. Perkin Trans. 1 1992; 3061-3067
19. Simig Gy, Doleschall G, Hornyák Gy, Fetter J, Lempert K, Nyitrai J, Huszthy P, Gizur T, Kajtár-Peredy M. Tetrahedron 1985; 41: 479-484
20. Primed locants refer to the azetidine, unprimed locants to the imidazole ring
21. The chemical shifts of compound **10** were extracted from the NMR spectra of the mixture.
22. Primed locants refer to the azetidine ring.