Stereoselective Ring-Opening of Acetylated Pyranose-1,2-(ethyl orthoacetates)

Setsuo Saito,*a Shigeya Sumita,*b Koki Ichinose,*a and Yasuhiko Kanda*

Faculty of Pharmaceutical Sciences, Josai University,* Keyakidai 1-1, Sakado, Saitama 350-02, Japan and Shiratori Pharmaceutical Co. Ltd.,* Tsudanuma 6-11-24, Narashino, Chiba 275, Japan. Received July 23, 1992

When acetylated pyranose-1,2-(ethyl orthoacetates) were hydrolyzed in acidic solvents, the ring-opening of the orthoacetate rings was influenced by the axial or equatorial OAc group at C-4 on the pyranoses; on acid-catalyzed hydrolysis, 3,4,6-tri-O-acetyl-2,3-d-galactopyranose (8) and methyl 3,4-di-O-acetyl-2,3-d-galactouronopyranose-1,2-(ethyl orthoacetate) (16) having an axial OAc group at C-4 on the pyranose rings gave 1,3,4,6-tetra-O-acetyl-2,3-d-galactopyranose (9) and methyl 1,3,4-tri-O-acetyl-2,3-d-galactouronopyranose (23), respectively, whereas 3,4,6-tri-O-acetyl-2,3-d-glucopyranose (10) and methyl 3,4-di-O-acetyl-2,3-d-glucouronopyranose-1,2-(ethyl orthoacetate) (22) having an equatorial OAc group at C-4 on the pyranose rings gave 2,3,4,6-tetra-O-acetyl-2,3-d-glucopyranose (11) and methyl 2,3,4-tri-O-acetyl-2,3-d-glucouronopyranose (24), respectively. On the acid-catalyzed hydrolysis, 3,4-di-O-acetyl-2,3-d-arabinopyranose-1,2-(ethyl orthoacetate) (34) having an axial OAc group at C-4 on the pyranose ring gave a mixture of 1,3,4,6-tri-O-acetyl-2,3-d-arabinopyranose (35) and 2,3,4-tri-O-acetyl-2,3-d-arabinopyranose (36). These selectivities of ring-opening of the 1,2-(orthoacetates) were considered to have resulted from the differences of the conformers of the 1,2-(orthoacetides) intermediates derived from the 1,2-(orthoacetates) and the orientation of the acetyl groups at C-4 on the pyranose rings.

Keywords pyranose-1,2-(ethyl orthoacetate); acid-catalyzed hydrolysis; 1,2-(orthoacid) intermediate; stereoselectivity; half-chair conformer; axial acetyl group

Acetylated pyranose-1,2-(alkyl orthoacetates)1–6 have been utilized as starting materials for synthesis of various O-glycosides49 and oligosaccharides7 as well as acetylated pyranose bromides.9 The 1,2-(alkyl orthoacetates) undergo alkaline-1,3,5,9 and acid-catalyzed hydrolyses1,6,10 resulting in the opening of the orthoacetate rings to give 2-O-acetyl-pyranoses. It is known that the ring-opening of the orthoacetates in alkaline hydrolysis is caused by a direct nucleophilic attack on the anemic carbon atom by hydroxyl ion (OH⁻), whereas in acid-catalyzed hydrolysis proceeds via unstable orthoacid intermediates derived from the orthoacetates. In this paper, we will report the stereoselective ring-openings of the acetylated pyranose-1,2-(ethyl orthoacetates) on acid-catalyzed hydrolysis.

A few reports have appeared on stereoselective ring-openings of the 1,2-(alkyl orthoacetates). Franks and Montgomery11 examined the acid-catalyzed hydrolysis of β-D-mannopyranose-1,2-(benzyl orthoacetate) (1) to give 2-O-acetyl-δ-mannopyranose (2)12 by using 3,4,6-tri-O-benzyl-β-D-mannopyranose-1,2-(ethyl orthoacetate) (3) as a model substrate for the hydrolysis instead of 1; the reaction of 3 with methanol in the presence of a catalytic amount of p-toluensulfonic acid (p-TsOH) gave a product (5) having a 2-O-axial extor ester group. From this experimental result, they proposed a dioxolanium intermediate (4) which was attacked by methanol at the anomeric carbon from the α-side (less steric hindrance) of the pyranose ring (Fig. 1).

King and Allbutt13 explained the ring-opening of the 1,2-(alkyl orthoacetate) ring on the basis of the result of hydrolysis of 9β,10x-decalin-2β,3β-diyll-(ethyl orthoacetate) (6) with 20% H₂O in acetic acid to give 3β-hydroxy-9β,10x-decalin-2β-yl acetate (7) as follows. When the two conformers 6α and 6β for 6 are compared (Fig. 2), the endo methyl group on the orthoacetate ring and 4β-hydrogen on the decalin ring in 6β come close to each other, resulting in steric hindrance, so that the conformer 6α is more stable than 6β. In the conformer 6α, the exo electrons of the axial
oxygen in the orthoacetate ring can comparatively readily become anti-periplanar to the C-O bond, where C is the carbon in the orthoacetate ring and O is the equatorial oxygen on the decalin ring. The anti-periplanarity might make the cleavage of the C-O bond easier according to the orbital orientation theory proposed by Deslongchamps et al.,\textsuperscript{14} to give an axial ester-equatorial alcohol 7. Lemieux and Driguez\textsuperscript{15} reported that the hydrolysis of 3,4,6-tri-O-acetyl-α-D-galactopyranose-1,2-(ethyl orthoacetate) (8) with 5\% H₂O in acetic acid gave quantitatively 1,3,4,6-tetra-O-acetyl-α-D-galactopyranose (9) (type A product, formed through cleavage of the C-O(1) bond, where C is the carbon on the orthoacetate ring and O(2) is the oxygen at C-2 on the pyranose ring) (Fig. 3). They explained the ring-opening of 8 to 9 as follows; the strain of the strongly distorted half-chair pyranose ring of 8 was relieved by the stretching and eventual cleavage of the C-O(2) bond of the orthoacetate ring, giving 9.

During our investigation of the synthesis of glycyrrhetic acid glycosides having β(1→2)-linked disaccharides\textsuperscript{16} derived from various acetylated pyranose-1,2-(ethyl orthoacetates) as starting materials, it was found that the hydrolysis of 3,4,6-tri-O-acetyl-α-D-glucopyranose-1,2-(ethyl orthoacetate) (10)\textsuperscript{3} under the same reaction conditions as those of Lemieux and Driguez gave quantitatively 2,3,4,6-tetra-O-acetyl-β-D-glucopyranose (11) (type B product formed through cleavage of the C-O(1) bond, where C is the carbon on the orthoacetate ring and O(1) is the anomic oxygen on the pyranose) (Fig. 3). The ¹H-NMR spectrum of 11 exhibited two anemic protons due to β- and α-anomers at δ 4.82 (d, J=9.0 Hz) and 5.47 (d, J=4.0 Hz) with the integration ratio of 3:1. Other protons could not be assigned completely because of signal overlapping due to a mixture of α- and β-anomers. Each anomic proton signal was shifted to higher field than the corresponding ones of α- (13)\textsuperscript{17} and β-D-glucopyranose peracetate (14),\textsuperscript{18} observed at δ 6.33 (d, J=5.7 Hz) and 5.13 (d, J=8.1 Hz) (see the experimental section), respectively. According to King and Allbutt\textsuperscript{13} and Lemieux and Driguez,\textsuperscript{15} the ring-opening of the orthoacetate ring of 10 should give the type A product, 1,3,4,6-tetra-O-acetyl-α-D-glucopyranose 12, because the steric circumstances around the orthoacetate ring fused to the pyranose ring of 10 are almost the same as in 8. In practice, however, the reaction of 10 with 5\% H₂O in acetic acid gave the type B product 11. Moreover, although the mechanism proposed by Franks and Montgomery\textsuperscript{11} could explain the ring-opening of 10 to 11, it could not account...
for that of 8 to give 9. If the ring-opening of the orthoacetate ring of 8 proceeds via a cation intermediate such as 4 in Fig. 1, the type B product, 2,3,4,6-tetra-O-acetyl-p-galactopyranose (15), should be obtained on hydrolysis in 5% H₂O in acetic acid, whereas 8 gave quantitatively the type A product 9.

The structural difference between 8 and 10 is that the former bears an axial OAc group at C-4 on the pyranose ring and the latter an equatorial one. As it was thought that this difference influences the ring-openings of the orthoacetate rings in 8 and 10, hydrolysis with 5% H₂O in acetic acid of 1,2-(ethyl orthoacetates) 16 having an axial OAc group at C-4 on the pyranose ring [synthesized from 1,2,3,4-di-O-isopropylidene-α-D-galactopyranose (17)³⁹ (Fig. 4)] and 22 having an equatorial one were further investigated. Compound 16 gave quantitatively the type A product (23), while compound 22 gave the type B product (24). The electron impact mass spectra (EI-MS) of 23 and
Table I. $^1$H-NMR Spectral Data for Pyranose-1,2-(ethyl orthoacetates) 8, 10, 16, 22 and 34

<table>
<thead>
<tr>
<th></th>
<th>8</th>
<th>10</th>
<th>16</th>
<th>22</th>
<th>34</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-1</td>
<td>5.80 (d, 4.4)</td>
<td>5.73 (d, 5.1)</td>
<td>5.93 (d, 4.0)</td>
<td>5.86 (d, 4.8)</td>
<td>5.56 (d, 4.0)</td>
</tr>
<tr>
<td>H-2</td>
<td>4.32 (dd, 6.6, 4.4)</td>
<td>4.34 (ddd, 5.1, 2.8, 1.1)</td>
<td>4.39 (dd, 6.1, 4.0)</td>
<td>4.32 (dd, 4.8, 2.9, 1.1)</td>
<td>4.29 (dd, 4.8, 4.0)</td>
</tr>
<tr>
<td>H-3</td>
<td>5.06 (dd, 6.6, 3.3)</td>
<td>5.20 (dd, 2.8, 2.8)</td>
<td>5.07 (dd, 6.1, 2.9)</td>
<td>5.24 (dd, 2.9, 2.6)</td>
<td>5.29 (dd, 4.8, 3.7)</td>
</tr>
<tr>
<td>H-4</td>
<td>5.43 (dd, 3.3, 2.2)</td>
<td>4.92 (dd, 9.5, 2.8, 1.1)</td>
<td>5.77 (dd, 4.6, 2.9)</td>
<td>5.15 (dd, 7.3, 2.6, 1.1)</td>
<td>5.25 (dd, 5.1, 4.8, 3.7)</td>
</tr>
<tr>
<td>H-5</td>
<td>4.33 (ddd, 6.6, 2.2)</td>
<td>3.96 (dd, 9.5, 5.1, 3.3)</td>
<td>4.77 (dd, 4.6)</td>
<td>4.31 (dd, 7.3)</td>
<td>4.05 (dd, 12.1, 4.8)</td>
</tr>
<tr>
<td>H-5'</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>3.73 (dd, 12.1, 5.1)</td>
</tr>
<tr>
<td>H-6</td>
<td>4.17 (dd, 11.4, 6.6)</td>
<td>4.80 (dd, 9.2, 3.3)</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>H-6'</td>
<td>4.11 (dd, 11.4, 6.6)</td>
<td>4.24 (dd, 9.2, 5.1)</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>CH$_4$</td>
<td>1.67</td>
<td>1.74</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>CH$_3$CH$_2$</td>
<td>1.19 (t, 7.3)</td>
<td>1.20 (t, 7.0)</td>
<td>1.21 (t, 7.3)</td>
<td>1.29 (t, 7.3)</td>
<td>1.20 (t, 7.3)</td>
</tr>
<tr>
<td>CH$_3$CO</td>
<td>3.56 (q, 7.3)</td>
<td>3.55 (q, 7.0)</td>
<td>—</td>
<td>3.53 (q, 7.3)</td>
<td>3.55 (q, 7.3)</td>
</tr>
<tr>
<td>OCH$_3$</td>
<td>—</td>
<td>—</td>
<td>3.75</td>
<td>3.75</td>
<td>—</td>
</tr>
<tr>
<td>Ac</td>
<td>2.06, 2.07, 2.11</td>
<td>2.11, 2.12, 2.13</td>
<td>2.06, 2.08</td>
<td>2.09, 2.12</td>
<td>2.09, 2.12, 2.18</td>
</tr>
</tbody>
</table>

$^a$ Multiplicities and coupling constants ($J$ in Hz) are given in parentheses. The signal assignments were based on decoupling and $^1$H-1H-correlation spectroscopy (COSY) methods.

24 showed molecular ion peaks at $m/z$ 334. In the $^1$H-NMR spectrum of 23, the anomic and H-2 protons were observed at $\delta$ 6.46 (d, $J$ = 4.0 Hz) and 4.25 (dd, $J$ = 10.6, 4.0 Hz), respectively, suggesting that the substituents at C-1 and 2 are OAc and OH groups in axial and equatorial orientations, respectively. On the other hand, in the $^1$H-NMR spectrum of 24, the anomic and H-2 protons were observed at $\delta$ 5.53 (d, $J$ = 3.7 Hz) and 4.89 (dd, $J$ = 10.3, 3.7 Hz), respectively, and the spectrum showed that compound 24 mostly existed as the $\alpha$-isomer (more than 97%). Furthermore, as we reported in the previous paper, the benzylation of pyranose-1,2-(ethyl orthoacetates) 25–27 gave only the type B products 28–30 upon hydrolysis in 5% H$_2$O in acetic acid.

The $^1$H-NMR spectral data for acetylated pyranose-1,2-(ethyl orthoacetates) studied this time are listed in Table I. From the values of the coupling constants, compounds 8 and 10 are considered to take the half-chair conformers 8A and 10A, respectively, as shown in Fig. 5. In those conformers, the carbonyl oxygen of the axial acetyl group at C-4 in 8A can lie close to C-1 or C-2 on the pyranose ring, resulting in formation of intermediates 8B and 8C, respectively, while that of the equatorial acetyl group in 10A can not (Fig. 6). As the product obtained by the hydrolysis of 8 was 9, the ring-opening of the orthoacetate ring of 8 seemed to proceed via the intermediate 8C; C-2 seemed to be attacked by an H$_2$O molecule from the $\alpha$-side, resulting in opening of the dioxoleneium cation ring to give 9. In order to examine the mechanism of the ring-opening, 8 was treated with acetic acid, but the product was the $\beta$-pyranose peracetate 31, not the $\alpha$-pyranose peracetate 32, consequently eliminating the mechanism of ring-open-

via intermediates 8B and 8C.

Hydrolyses of 8 and 10 with 10% H$_2$O in MeOH in the presence of a catalytic amount of $\beta$-TsOH quantitatively gave 9 and 11, respectively, as in the case of using 5% H$_2$O in acetic acid. These results suggest that, as proposed by Pascu, the ring-openings of 1,2-(orthoacetates) on acid-catalyzed hydrolysis in H$_2$O-containing solvents proceed via unstable 1,2-(orthoacids) as intermediates. We will now consider the orthoacid intermediate (33) which might be derived from 8 (Fig. 7). In the ring-opening of the orthoacetate ring, protonation at O(1) or O(2) of 33 might occur first. In the molecular stereomodel of 33, the acetyl carbonyl group at C-4 on the pyranose can come closer to O(1) than to O(2), so that the protonation at O(1) may be prevented, resulting in preferential formation of an intermediate protonated at O(2) of 33, from which 9 is derived through cleavage of the C–O(2) bond. Therefore, on acid-catalyzed hydrolysis, acetylated pyranose-1,2-(alkyl orthoacetates) having an axial OAc group at C-4 on the pyranoses give type A products. On the other hand, in the orthoacid intermediates derived from 1,2-(alkyl orthoacet-
respectively, though other protons on the pyranoses could not be assigned because of overlapping of the signals. In this case, from the coupling constants in the $^1$H-NMR spectrum (Table 1), compound 34 is considered to take a boat conformer (37), as shown in Fig. 9. In the conformer 37, the quasi-axial OAc group at C-4 on the pyranose ring is further from the anomic carbon than is the case in 8A, so that the participation of the carbonyl oxygen of the acetyl group is expected to decrease. This is why the ring-opening giving the type B product 36 predominates over that giving the type A product 35.

Experimental

Materials 1,2-(Ethyl orthoacetates) 8, 10 and 22 were prepared according to the published procedure. $^2,^3,^4,^9,^{10}$ 2-Chloro-1,3-dimethylimidazolium chloride (DMC) was kindly provided by Shriramor Pharmaceutical Co., Ltd. Other chemicals and solvents were of reagent grade, and were obtained from commercial sources.

Measurements The TLC was done on Kieselgel HF254 plates (Merck), and spots were detected by spraying the plates with dilute H$_2$SO$_4$ followed by heating at 80°C for 10 min. Column chromatography was carried out on Wakogel C-200. Melting points were determined on a micro melting point apparatus, and are given as uncorrected values. $^1$H-NMR spectra were obtained with a JEOL JNM-GX 270 MHz, chemical shifts are given in ppm with tetramethylsilane as an internal standard. EI-MS were recorded on a JEOL JMS-DX 300 mass spectrometer.

Hydrolysis of 10 in 5% H$_2$O in Acetic Acid Compound 10 (6g) was dissolved in 5% H$_2$O in acetic acid (15 ml) and the solution was allowed to stand for 15 min at room temperature. The reaction mixture was poured into ice-water (50 ml) and extracted with CH$_2$Cl$_2$ (30 ml x 3). The combined organic extracts were successively washed with NaHCO$_3$-saturated aqueous solution and water, dried over MgSO$_4$, and filtered. The filtrate was evaporated to give II (5.1g, 91.9%). EI-MS m/z (rel. intensity): 331 (2, M$^+$-OH), 242 (6), 200 (23), 199 (8), 186 (6), 167 (9), 157 (75), 145 (19), 140 (33), 139 (8), 126 (30), 115 (74), 103 (24), 102 (20), 98 (100). The $^1$H-NMR spectrum (CDCl$_3$) shows two anomic protons due to β- and α- anomers at δ 4.82 (d, J=9.0 Hz) and 5.47 (d, J=4.0 Hz) with the integration ratio of 3:1, respectively. Other protons could not be assigned because of signal overlapping. Anal. Calcd. for C$_{12}$H$_{20}$O$_6$: C, 48.28; H, 5.79. Found: C, 48.12; H, 5.83.

Preparation of 18 A solution of 17 (10g) in acetonitrile (40 ml) was added dropwise to a solution of KIO$_3$ (24g), ruthenium dioxide (34mg) in H$_2$O (80 ml) and acetone (40ml) at room temperature. The reaction mixture was further stirred for 2.5 h, then extracted with CH$_2$Cl$_2$ (60 ml x 3). The combined organic extracts were washed with H$_2$O, dried over MgSO$_4$, and filtered. The filtrate was evaporated to give compound 18 (mp 153–155°C, 5.3 g, 50%, after recrystallization from ether-ρ-hexane). EI-MS m/z (rel. intensity): 259 (3, M$^+$-CH$_3$), 201 (39), 129 (12), 141 (26), 114 (6), 113 (60), 101 (15), 100 (30). $^1$H-NMR spectrum (CDCl$_3$) δ: 8.61 (brs, COOH), 5.66 (d, J=4.8 Hz, H-1), 4.70 (d, J=7.7, 2.6 Hz, H-3), 4.63 (dd, J=7.7, 2.6 Hz, H-4), 4.47 (d, J=2.6 Hz, H-5), 4.40 (dd, J=4.8, 2.6 Hz, H-2), 1.54, 1.47, 1.36, 1.35 (each s, CH$_3$). Anal. Calcd. for C$_{12}$H$_{18}$O$_4$; C, 52.55; H, 6.62. Found: C, 52.35; H, 6.69.

Preparation of 19 DMC (10g), pyridine (5ml) and methanol (10ml) were added to a solution of 18 (1.5g) in CH$_2$Cl$_2$ (100 ml), then the mixture was stirred for 20h, poured into ice-water (300 ml) and extracted with CH$_2$Cl$_2$ (100 ml x 3). The combined organic extracts were successively washed with 5% HCl, NaHCO$_3$-saturated aqueous solution and water, dried over MgSO$_4$, and filtered. The filtrate was evaporated to give a residue, which was subjected to column chromatography (benzene-acetone, gradient up to 5%) to give 19 (1.3g, 81.8%). EI-MS m/z (rel. intensity): 273 (2, M$^+$-CH$_3$), 215 (21), 171 (14), 155 (8), 143 (14), 131 (38), 129 (6), 127 (49), 114 (38), 113 (60). $^1$H-NMR spectrum (CDCl$_3$) δ: 5.66 (d, J=4.8 Hz, H-1), 4.67 (dd, J=7.7, 2.6 Hz, H-3), 4.58 (dd, J=7.7, 2.6 Hz, H-4), 4.45 (d, J=2.6 Hz, H-5), 4.38 (dd, J=4.8, 2.6 Hz, H-2), 3.82 (s, OCH$_3$), 1.54, 1.45, 1.31, 1.34 (each s, CH$_3$). Anal. Calcd. for C$_{12}$H$_{18}$O$_4$; C, 54.16; H, 6.99. Found: C, 54.02; H, 7.03.

Preparation of 20 Compound 19 (1.3g) was dissolved in 20% H$_2$O$_2$ in acetic acid (50ml) and the solution was refluxed at 100°C for 12h. After cooling of the mixture, acetic anhydride (50ml) was added and the whole was allowed to stand overnight at room temperature. The reaction mixture
was coevaporated with toluene (100 ml x 5) to give a residue, which was subjected to column chromatography (benzene-acetone, gradient up to 5%) to give 20 (1.2 g, 70.9%). EI-MS m/z (rel. intensity): 345 (trace, M−COCH3), 317 (trace, M−Br), 236 (6), 210 (15), 197 (11), 197 (10), 173 (8), 172 (7), 156 (9), 155 (100). 1H-NMR spectrum (CDCl3): δ 6.77 (d, J = 4.0 Hz, H-1), 5.88 (dd, J = 3.3, 1.4 Hz, H-4), 5.45 (dd, J = 10.6, 3.3 Hz, H-3), 5.10 (dd, J = 10.6, 4.0 Hz, H-2), 4.88 (d, J = 1.4 Hz, H-5), 3.78 (s, OCH3), 2.12, 2.03 (each s, Ac). Anal. Calcd for C13H11BrO2C: C 47.92; H 4.31. Found: C 47.95; H 4.44.

Preparation of 16 A solution of 21 (250 mg), tetraethyl ammonium bromide (50 mg) and diethyl ether (0.07 ml) in cyclohexane (5 ml) was warmed at 50°C overnight. The reaction mixture was filtered. The filtrate was poured into ice-water (20 ml) and extracted with CHCl3 (20 ml x 3). The combined organic extracts were successively washed with 5% HCl, NaHCO3-saturated aqueous solution and water, dried over MgSO4, and filtered. The filtrate was evaporated to give a residue which was subjected to column chromatography (benzene-acetone, gradient up to 2%) to give 31 (180 mg, 87.6%). EI-MS m/z (rel. intensity): 317 (trace, M−OEt), 303 (8), 275 (11), 245 (6), 232 (27), 231 (10), 215 (22), 197 (11), 190 (22), 185 (6), 173 (28), 172 (19), 157 (18), 155 (100). 1H-NMR spectrum: see Table 1. Anal. Calcd for C13H13O2C: C 47.92; H 6.12. Found: C 47.89; H 6.18.

Hydrolysis of 16 in 5% H2O in Acetic Acid Compound 16 (200 mg) was dissolved in 5% H2O in acetic acid (2 ml) and the solution was allowed to stand for 15 min, then treated as described for the hydrolysis of 10 to give 23 (170 mg, 91.8%). EI-MS m/z (rel. intensity): 334 (M+, 317 (M−OEt), 275 (11), 245 (6), 232 (27), 231 (10), 215 (17), 197 (12), 190 (20), 185 (6), 173 (28), 172 (19), 157 (18), 155 (100). 1H-NMR spectrum: see Table 1. Anal. Calcd for C13H13O2C: C 47.92; H 6.12. Found: C 47.89; H 6.51.

Hydrolysis of 22 in 5% H2O in Acetic Acid Compound 22 (5.5 g) dissolved in 5% H2O in acetic acid (10 ml) and the solution was allowed to stand for 15 min at room temperature, then treated as described for the hydrolysis of 10 to give 24 (46.6, 90.6%). EI-MS m/z (rel. intensity): 334 (M+, 317 (M−OEt), 275 (15), 274 (8), 245 (9), 232 (32), 215 (30), 197 (15), 190 (16), 185 (8), 173 (25), 172 (14), 157 (26), 155 (100). 1H-NMR spectrum (CDCl3): δ 5.57 (dd, J = 10.3, 9.5 Hz, H-3), 5.53 (d, J = 3.7 Hz, H-1), 5.17 (dd, J = 10.3, 9.5 Hz, H-4), 4.89 (dd, J = 10.3, 3.7 Hz, H-2), 4.59 (d, J = 10.3 Hz, H-5), 3.75 (s, OCH3), 2.17, 2.11, 2.08 (each s, Ac). Anal. Calcd for C13H13O2C: C 46.71; H 5.43. Found: C 46.66; H 5.45.

Hydrolysis of 3 in 10% H2O in MeOH Containing p-TsOH Compound 3 (1 g) was dissolved in 10% H2O in MeOH (10 ml), then a solution of p-TsOH (20 mg) in CH3Cl (1 ml) was added. The mixture was allowed to stand for 15 min at room temperature, then poured into ice-water (50 ml) and extracted with CHCl3 (30 ml x 3). The combined organic extracts were successively washed with NaHCO3-saturated aqueous solution and water, dried over MgSO4, and filtered. The filtrate was evaporated to give 4 (140 mg, 92.9%).

Hydrolysis of 10 in 10% H2O in MeOH Containing p-TsOH Compound 10 (1 g) was dissolved in 10% H2O in MeOH (10 ml), then a solution of p-TsOH (20 mg) in CH3Cl (1 ml) was added. The mixture was treated as described above to give 11 (830 mg, 89.7%).

References