Electronic Supplementary Information

From vinyl Pyranoses to Carbasugars by an iron-catalyzed Reaction complementary to Classical Ferrier Carbocyclisation

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Supporting Information

(11 pages)

I - General Methods

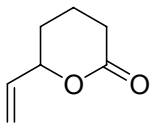
All reactions were carried out under argon or nitrogen atmosphere. TLC spots were examined under UV light and revealed by sulfuric acid-anisaldehyde, $KMnO_4$ solution or phosphomolybdic acid. Dichloromethane was distilled from calcium hydride, tetrahydrofuran and diethylether were distilled from sodium/benzophenone, methanol was distilled over magnesium.

CAUTION: all reactions involving $Fe(CO)_5$ have to be carried out under a well ventilated hood. These iron carbonyl-mediated reactions have been performed in usual pyrex glassware equipment. At the end of the reaction the residue of $Fe(CO)_5$ can be destroyed by addition of strong oxidizing agents such as $Ce(NH_4)_2(NO_3)_6$ or $FeCl_3$.

NMR spectra were obtained at 300 MHz or 500 MHz for ^1H and 75 MHz or 125MHz for ^{13}C with BRUCKER AVANCE 300 or 500 spectrometers. Chemical shifts are given in parts per million (δ) relative to chloroform (7.26 ppm) or benzene (7.16 ppm) residual peaks. Assignments of ^1H and ^{13}C resonances for complex structures were confirmed by extensive 2D experiments (COSY, HMQC, HMBC). Mass spectral analyses were performed at the Centre Régional de Mesures Physiques de l'Ouest (CRMPO) in Rennes (France). Rotation data were recorded on a Perkin-Elmer 241 Polarimeter.

II Experimental procedures and characterizations

II.1 Tetrahydro-6-vinylpyran-2-one (4a)



To a solution 4-bromoorthobutyrate (764 µL, 4.40 mmol) in diethyl ether (12 mL) cooled at −78°C was added dropwise a solution of *t*-butylithium (5.24 mL, 7.86 mmol, 1.5 M in hexane). The cloudy mixture was stirred at −78°C for 1h and then at 0°C for 50 min. After recooling to −78°C, a solution of acrolein (120 µL, 1.57 mmol) in Et_2O (3 mL) was added and

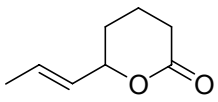
reaction mixture was stirred at −78°C for 30 min and then at 0°C for 40 min. The reaction mixture was quenched with saturated solution of ammonium chloride (15 mL). Aqueous phase was extracted with Et_2O (2 x 20 mL) and the combined organic phases were dried over $MgSO_4$, filtered and concentrated under reduced pressure. The orthoester group was hydrolyzed by stirring during 20 min the previous crude oil in a THF-H_2O (15 mL – 5 mL) solution in presence of 5 drops of HCl 6N. After extraction with diethyl ether, the residue was purified by column chromatography on silica gel with Pentane/AcOEt (60/40) as eluent to afford hydroxy ester **3a** as a colorless oil.

This product (155 mg, 0.981 mmol) was dissolved in anhydrous acetonitrile (10 mL) in presence of DBU (175 µL, 1.18 mmol) and the reaction mixture was stirred overnight at room temperature. After concentration of the residue *in vacuo*, reaction mixture was resolubilized in acetonitrile and stirred during 2h at room temperature. Solvent was evaporated and the residue was purified by column chromatography on silica gel with CH_2Cl_2 as eluent to afford the lactone **4a** (100 mg, 81%) as a colorless oil [Rf 0.2; AcOEt/Pentane: 9/1].

^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.56-2.00 (m, 4H), 2.39-2.61(m, 2H), 4.79 (m, 1H), 5.18-5.34 (m, 2H), 5.84 (ddd,1H, *J* = 5.5, 10.6, 16.2Hz).

^{13}C NMR (75 MHz, $CDCl_3$): δ = 18.0, 27.8, 29.5, 30.9, 80.2, 116.8, 136.1, 171.1.

II.2 Tetrahydro-6-((E)-prop-1-enyl)pyran-2-one(4b)

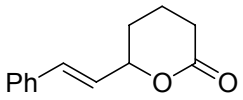


This compound was obtained by the method employed for the preparation of **4a**, and using 4-bromoorthobutyrate (764 µL, 4.40 mmol), *t*-BuLi (5.24 mL, 7.86 mmol, 1.5 M in hexane), crotonaldehyde (130 µL, 1.57 mmol), Et_2O (15 mL), DBU (224 µL, 1.50 mmol) and CH_3CN (10 mL). Purification by column chromatography using CH_2Cl_2 as eluent afforded the lactone **4b** as a colorless oil (120 mg, 54% overall yield) [Rf: 0.2; Et_2O/Pentane 5/5].

^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.54-1.96 (m, 7H), 2.36-2.60 (m, 2H), 4.72 (m, 1H), 5.44-5.53 (m, 1H), 5.70-5.81 (m, 1H).

^{13}C NMR (75 MHz, $CDCl_3$): δ = 17.6, 18.2, 28.3, 29.5, 80.7, 129.3, 129.4, 171.4.

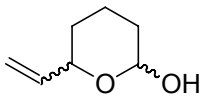
II.3 Tetrahydro-6-styrylpyran-2-one(4c)



This compound was obtained by the method employed for the preparation of **4a**, and using 4-bromoorthobutyrate (764 µL, 4.40 mmol), *t*-BuLi (5.24 mL, 7.86 mmol, 1.5 M in hexane), *trans*-cinnamaldehyde (205 µL, 1.57 mmol), Et_2O (15 mL), DBU (224 µL, 1.50 mmol) and CH_3CN (10 mL). Purification by column chromatography using CH_2Cl_2 as eluent afforded the lactone **4c** as a colorless oil (205 mg, 59% overall yield) [Rf: 0.6; CH_2Cl_2/Et_2O: 9/1].

^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.71-2.13 (m, 4H), 2.48-2.71 (m, 2H), 4.98-5.04 (m, 1H), 6.22 (dd, 1H, *J* = 15.9, 6.0Hz), 6.69 (dd, *J* = 16.0, 0.9Hz), 7.35 (m, 5H).
^{13}C NMR (75 MHz, $CDCl_3$): δ = 18.3, 28.5, 29.6, 80.4, 126.7, 127.1, 128.2, 128.7, 132.1, 136.6, 171.2.
HRMS *m/z* $\mathbf{M^+}$ Calculated for $C_{13}H_{14}O_2$: **202.0994**, found **202.1001**.

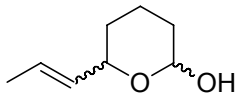
II.4 Tetrahydro-6-vinyl-2H-pyran-2-ol (5a)



To a solution of lactone **4a** (73 mg, 0.58 mmol) in CH_2Cl_2 (4 mL) cooled at −78°C was added dropwise a solution of DIBAl-H (1.1 mL, 1.1 mmol, 1.0 M solution in toluene). The reaction mixture was stirred at −78°C for 2h and then was quenched with a saturated solution of sodium and potassium tartrate (5 mL). After stirring during 1h and decantation, aqueous phase was extracted with CH_2Cl_2 (2 x 5 mL). The combined organic phases were dried over $MgSO_4$, filtered and concentrated under reduced pressure to afford pure lactol **5a** as a colorless oil (59 mg, 80% yield, mixture of diastereoisomers: 50/50 by ^{1}H NMR) [Rf: 0.25; CH_2Cl_2/Et_2O: 9/1]

^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.33-1.92 (m, 12H), 3.19 (s, 1H), 3.69 (d, 1H, *J* = 5.5 Hz,), 3.93-4.02 (m, 1H), 4.46-4.51 (m, 1H), 4.76-4.81 (m, 1H), 5.09-5.30 (m, 4H), 5.34-5.38 (m, 1H), 5.79-5.95 (m, 2H).
^{13}C NMR (75 MHz, $CDCl_3$): δ = 17.2, 21.9, 29.5, 30.4, 31.2, 32.4, 69.7, 91.9, 96.5, 115.0, 115.2, 138.2, 139.2.
HRMS *m/z* **[M-H_2O]+** Calculated for $C_7H_{10}O$: **110.0732**, found **110.0728**.

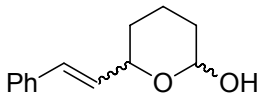
II.5 Tetrahydro-6-(prop-1-enyl)-2H-pyran-2-ol (5b):



This compound was obtained by the method used for the preparation of **5a**, starting with 135 mg of lactone **4b**, 1.45 mL of DIBAL-H (as a 1M solution in toluene). Purification by column chromatography using Et_2O/Pentane 1/1 as eluent afforded the lactol **5b** as a colorless oil (105 mg, 77%, mixture of diastereoisomers: 45/55 by ^1H NMR) [Rf: 0.3; Et_2O/Pentane 1/1].

^1H NMR (300 MHz, $CDCl_3$): δ = 1.23-1.91 (m, 6H), 1.68 (d, *J* = 6.4Hz, 3H), 3.20 (broad s, 1H), 3.70 (br, 1H), 3.89 (dd, *J* = 6.9, 10.4Hz, 1H), 4.39 (t, *J* = 9.3Hz, 1H), 4.72 (d, *J* = 8.9Hz, 1H), 5.29 (broad s, 1H), 5.48 (dd, *J* = 6.3, 17.1Hz, 1H), 5.68 (dq, *J* = 6.3, 15.3Hz, 1H).
^{13}C NMR (75 MHz, $CDCl_3$): δ = 17.7, 17.8, 21.9, 29.5, 30.7, 31.5, 32.4, 69.7, 70.0, 91.9, 96.4, 127.2, 127.4, 131.3, 132.1.
HRMS *m/z* $\mathbf{M^+}$ Calculated for $C_8H_{14}O_2$: **142.0994**, found **142.0996**.

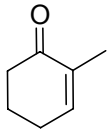
II.6 Tetrahydro-6-styryl-2H-pyran-2-ol (5c):



This compound was obtained by the method used for the preparation of **5a**, starting with 95 mg of lactone **4c**, 0.52 mL of DIBAL-H (as a 1M solution in toluene). Purification by column chromatography using CH_2Cl_2/Et_2O:9/1 as eluent afforded the lactol **5c** as a colorless oil (70mg, 73%, mixture of diastereoisomers: 50/50 by ^1H NMR) [Rf: 0.3; CH_2Cl_2/Et_2O: 9/1].

^1H NMR (300 MHz, $CDCl_3$): δ = 1.36-2.04 (m, 12H), 3.41-3.59 (m, 1H), 3.91-4.09 (m, 1H), 4.12-4.18 (m, 1H), 4.66-4.72 (m, 1H), 4.82-4.87 (m, 1H), 5.40-5.44 (m, 1H), 6.22 (dd, 1H, *J* = 16.0, 6.2 Hz), 6.27 (dd, 1H, *J* = 16.0, 6.2 Hz), 6.61 (d, 1H, *J* = 16.0 Hz), 6.64 (d, 1H, *J* = 16.0 Hz), 7.24-7.42 (m, 12H).
^{13}C NMR (75 MHz, $CDCl_3$): δ = 17.3, 22.0, 29.6, 30.9, 31.6, 32.4, 69.6, 76.8, 92.0, 96.5, 126.46, 126.50, 127.56, 127.63, 128.5, 129.6, 130.3, 130.4, 130.5, 136.8, 136.9.
HRMS *m/z* $\mathbf{M^+}$ Calculated for $C_{13}H_{16}O_2$: **204.1150**, found **204.1158**.

II.7 2-Methylcyclohex-2-enone (6a)



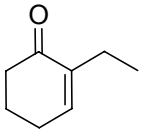
A solution of lactol **5a** (50mg, 0.39 mmol) and $Fe(CO)_5$ (5µL) in dry THF (2 mL), under magnetic stirring in a pyrex round bottomed flask, was irradiated with a Philip HPK125 W during 1 hour. After being cooled to room temperature and concentrated, the residue was diluted in diethylether, filtered on a short pad of silica gel and concentrated under vacuum to afford a mixture of aldol products (45 mg).

To an ice–cold solution of previous aldol products and Et_3N (10 equiv) in CH_2Cl_2, was added MsCl (3equiv) at 0°C. After being stirred at RT during 24 hours the mixture was diluted with CH_2Cl_2 and H_2O. Then the organic phase was separated and the aqueous phase was extracted with CH_2Cl_2. The combined organic phases were dried over $MgSO_4$, filtered and concentrated under vacuum to afford a residue, which was purified by chromatography on silica gel with Pentane/Et_2O (80/20) as eluent to afford cyclohexenone **6a** as a colorless liquid 18 mg, (42% over 2 steps) [Rf: 0.7; Pentane/Et_2O: 1/1].

^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.70 (q, 3H, *J* = 1.8Hz), 1.9 (quin, 2H, *J* = 6.4Hz), 2.30-2.20 (m, 2H), 2.40 (t, 2H, *J* = 6.7Hz), 6.70-6.64 (m, 1H).

^{13}C NMR (75 MHz, $CDCl_3$): δ =16.0, 23.3, 26.0, 38.3, 135.7, 145.6, 200.0.

II.8 2-Ethylcyclohex-2-enone (6b)

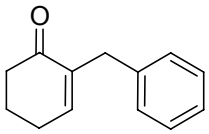


This compound was obtained by the method used for the preparation of **6a**, starting with 100 mg of lactol **5b** (0.7 mmol). Purification by column chromatography using Et_2O/Pentane 1/1 as eluent (Rf: 0.7) afforded the cyclohexenone **6b** as a colorless oil (43 mg, 50% over 2 steps) [Rf: 0.7; Pentane/Et_2O: 1/1].

^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.01 (t, 3H, *J* = 1.0Hz), 1.98 (q, 2H, *J* = 6.3Hz), 1.98 (q, 2H, *J* = 7.4Hz), 2.33-2.38 (m, 2H) 2.43 (t, 2H, *J* = 6.7Hz), 6.71 (broad s, 1H).

^{13}C NMR (75 MHz, $CDCl_3$): δ = 12.8, 22.5, 23.2, 26.0, 38.6, 141.2, 143.9, 199.6.

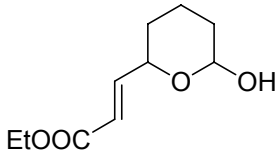
II.9 2-Benzylcyclohex-2-enone (6c)



This compound was obtained by the method used for the preparation of **6a** starting with 70mg of lactol **5c** (0.34 mmol). Purification by column chromatography using Et_2O/Pentane 1/1 as eluent afforded the cyclohexenone **6c** as a colorless oil (35 mg, 55% over 2 steps) [Rf: 0.5; Et_2O/Pentane 1/1].

^{1}H NMR (300 MHz, $CDCl_3$): δ = 2.0 (q, 2H, *J* = 6.7 Hz), 2.32-2.37 (m, 2H) 2.47 (t, 3H, *J*= 6.7Hz), 3.54 (d, 2H, *J* = 1.1Hz), 6.57 (t, 1H, *J* = 4.2Hz), 7.18-7.32 (m, 5H).
^{13}C NMR (75 MHz, $CDCl_3$): δ = 23.1, 26.1, 35.4, 38.5, 126.1, 128.4, 129.2, 139.5, 139.8, 146.4, 199.0.

II.10 (*E*)-Ethyl 3-(6-hydroxy-tetrahydro-2H-pyran-2-yl)acrylate (5d)



Step 1: synthesis of lactol 5a by route 2

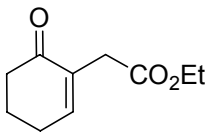
The commercially available glutaraldehyde, as a 50% aqueous solution, was saturated with sodium chloride an extracted 5 times with ether. The ether extract was dried over anhydrous magnesium sulfate, filtered, and concentrated under reduced pressure to give crude glutaraldehyde. To the solution of previous glutaraldehyde (1 g, 10 mmol) in THF (20 mL) at 0°C was added vinylmagnesium bromide (12 mL, 1M in THF). After 2 h, the reaction was quenched by 10% NH_4Cl (20 mL). The aqueous phase was extracted by Et_2O (3x20 mL). The combined organic phases were dried over Mg_2SO_4, filtered and concentrated under reduced pressure to afford a residue, which was purified by chromatography on silica gel with Pentane/AcOEt (9/1) as eluent to give pure lactol **5a** as a colorless oil (820 mg, 64%).

Step 2: synthesis of lactol 5d by metathesis reaction

A solution of lactol **5a** (128 mg, 1 mmol), ethyl acrylate (660 µl, 6 mmol) and second-generation Grubbs catalyst (16 mg, 3% mol) was heated at 40°C in CH_2Cl_2 (10 mL) during 16 h. The solvent was removed under vacuum and the residue was purified by column chromatography on silica gel using as eluent mixtures of pentane and Et_2O (95:5 then 60:40). The lactol **5d** was obtained as a viscous oil (112 mg, 56%) [Rf: 0.1; CH_2Cl_2/Et_2O: 9/1].

^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.22 (t, *J* = 7.1Hz, 3H), 1.29-1.93 (m, 6H), 3.87 (broad s, 1H), 4.14 (q, *J* = 7.3Hz, 1H), 4.35 (d, *J* = 6.1Hz, 1H), 4.61 (m, 1H), 4.73 (m, 1H), 5.30 (s, 1H), 5.94 (dd, *J* = 1.8Hz, 1H), 6.85 (dd, *J* = 4.6, 15.7Hz)
^{13}C NMR (75 MHz, $CDCl_3$): δ = 14.1, 17.3, 22.0, 29.5, 30.0, 30.7, 32.1, 60.4, 60.42, 67.5, 67.9, 74.6, 91.7, 96.4, 119.7, 120.1, 146.9, 148.4, 166.7, 166.8.
HRMS *m/z* Calculated for **[M-H_2O]+.**:C_{10} H_{14} O_3 **182.0943** found **182.0941**.

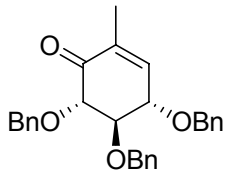
II.11 **Ethyl 2-(6-oxocyclohex-1-enyl)acetate (6d)**



This compound was obtained by the method used for the preparation of **6a** starting with 100mg of lactol **5d** (0.5 mmol). Purification by column chromatography using Et_2O/Pentane 1/1 as eluent afforded the cyclohexenone **6d** as a colorless oil (50 mg, 55% over 2 steps) [Rf: 0.5; Et_2O/Pentane: 1/1].

^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.18 (t, *J* = 7.1Hz, 3H), 1.97 (quin, *J* = 6.4Hz, 2H), 2.34 (m, 2H), 2.41 (t, *J* = 6.8Hz, 4H), 3.11 (d, *J* = 1.1Hz, 2H), 4.06 (q, *J* = 7.1Hz, 2H), 6.81 (t, *J* = 4.2Hz, 1H)
^{13}C NMR (75 MHz, $CDCl_3$): δ = 14.1, 22.9, 26.0, 35.4, 37.9, 60.8, 133.6, 148.3, 171.4, 198.3.

II.12 (4*S*,5*R*,6*S*)-4,5,6-Tris(benzyloxy)-2-methylcyclohex-2-enone (9)



A solution of lactol **7** (890 mg, 2 mmol) and $Fe(CO)_5$ (26 µl, 10%mol) in dry THF (20 mL) was irradiated with a Philip HPK125 W during 1 hour. After being cooled to room temperature and concentrated, the residue was diluted in ether, filtered on a short pad of silica gel and concentrated under vacuum to afford a mixture of aldol products. The crude product was purified by column chromatography on silica gel with Pentane/AcOEt: 7/3 as eluent to afford 845 mg of product **8** (95%, a 45/50/5 mixture of isomers by ^{1}H NMR).

To an ice–cold solution of previous aldol products (700 mg, 1.57 mmol) and Et_3N (660µl, 3 equiv) in dry CH_2Cl_2 (15 mL), was added MsCl (243 µl, 2equiv) at 0°C. After being stirred at RT for 24 hours, the mixture was diluted with CH_2Cl_2 and H_2O. The organic phase was separated and the aqueous phase was extracted with CH_2Cl_2 (3x20 mL). The combined organic phases were dried over $MgSO_4$, filtered and concentrated under vacuum to afford a residue, which was purified by chromatography on silica gel with Pentane/AcOEt (9/1) as eluent to afford cyclohexenone **9** as a white solid (464 mg, 69%) [Rf: 0.3; Pentane/AcOEt: 9/1].

Mp:64-66°C

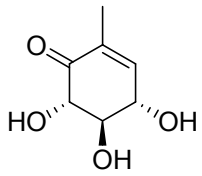
^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.75 (dd, *J* = 2.1, 1.6Hz, 3H), 3.87 (dd, *J* = 10.7, 7.8Hz, 1H), 3.95 (d, *J* = 10.7Hz, 1H), 4.24 (ddq, *J* = 7.8, 3.3, 2.1Hz, 1H), 4.67 (d, *J* = 11.5Hz, 2H), 4.73 (d, *J* = 10.9Hz, 1H), 4.76 (d, *J* = 11.6Hz, 1H), 4.89 (d, *J* = 10.9Hz, 1H), 5.03 (d, *J* = 10.3Hz, 1H), 6.52 (dq, *J* = 3.3, 1.6Hz, 1H), 7.23-7.39 (m, 15H).

^{13}C NMR (75 MHz, $CDCl_3$): δ = 15.3, 73.5, 74.6, 75.6, 78.5, 83.9, 84.7, 127.78, 127.8, 127.91, 127.98, 128.2, 128.3, 128.38, 128.41, 128.6, 135.0, 137.8, 137.9, 138.3, 143.0, 197.6.

HRMS *m/z* Calculated for **[M +Na]+.**$C_{28}H_{28}O_4Na$: **451.1885** found **451.1876**.

$[\alpha]^{20}_D$ -3.6 (*c* 0.19, MeOH).

II.13 (4*S*,5*R*,6*S*)-4,5,6-Trihydroxy-2-methylcyclohex-2-enone (10)



The cyclohexenone **9** (142 mg, 0.33 mmol) was dissolved in anhydrous CH_2Cl_2 under argon and anhydrous $FeCl_3$ (162 mg, 3 equiv) was added at 0°C. After 15 min the reaction was complete as indicated by TLC analysis and quenched with H_2O (5mL). It was stirred for 1 min and then extracted with AcOEt (3x30mL). The organic layers were dried over Na_2SO_4, filtered, and the solvent was removed under pressure. This crude reaction mixture was purified by flash silica gel column chromatography (AcOEt as eluent) to afford 4-*epi*Gabosine A as a white solid 28 mg (55% yield) [Rf: 0.2; AcOEt/MeOH: 8/2].

Mp:100-102°C

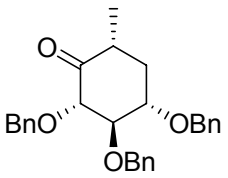
^{1}H NMR (300 MHz, MeOD): δ = 1.82 (t, *J* = 1.8Hz, 3H), 3.32 (broad s, $3H_{OH}$), 3.54 (dd, *J* = 10.9, 8.2Hz, 1H), 4.00 (d, *J* = 10.9Hz, 1H), 4.30 (ddq, *J* = 8.2, 3.1Hz, 1H), 6.67 (dq, *J* = 3.2Hz, 1.6Hz, 1H).

^{13}C NMR (75 MHz, MeOD): δ= 15.2, 72.6, 78.0, 80.0, 134.8, 147.9, 200.1.

HRMS *m/z* Calculated for **[M +Na]+.**$C_7H_{10}O_4Na$: **181.0471** found **181.0474**.

$[\alpha]^{20}_D$ + 47.3 (*c* 0.3, MeOH).

II.14 (2*S*,3*R*,4*S*,6*R*)-2,3,4-tris(benzyloxy)-6-methylcyclohexanone (11)



To a solution of **9** (100 mg, 0.232 mmol) in absolute ethanol (2.5 mL) was added palladium on activated carbon (7 mg). The flask was flushed with hydrogen three times. The reaction mixture was then stirred vigorously under an atmosphere of hydrogen for 3 h. The reaction mixture was filtered through a pad of silica gel and concentrated under vacuum to afford cyclohexanone **11** as a white solid (95 mg, 95%).

Mp:74-76°C

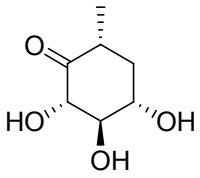
^{1}H NMR (500 MHz, $CDCl_3$): δ = 1.10 (d, *J* = 6.5Hz, 3H), 1.34 (dt, *J* = 11.6, 13.5Hz, 1H), 2.23 (dt, *J* = 13.1, 5.0Hz, 1H), 2.39 (ddq, *J* = 5.5, 12.3, 6.5Hz, 1H), 3.67 (dd, *J* = 9.6, 9.1Hz, 1H), 3.85 (ddd, *J* = 4.8, 8.9, 11.5Hz, 1H), 4.08 (dd, *J* = 9.8, 1.3Hz, 1H), 4.55 (d, *J* = 11.4Hz, 1H), 4.72 (d, *J* = 11.6Hz, 1H), 4.76 (d, *J* = 11.6Hz, 1H), 4.84 (d, *J* = 10.7Hz, 1H), 4.91 (d, *J* = 11.0Hz, 2H), 7.28-7.42 (m, 15H).

^{13}C NMR (125 MHz, $CDCl_3$): δ= 13.4, 35.2, 39.1, 72.9, 73.5, 75.9, 78.8, 85.8, 86.2, 127.67, 127.7, 127.8, 128.1, 128.2, 128.35, 128.4, 128.5, 137.8, 138.4, 138.5, 206.8.

$[\alpha]^{20}_D$ -39.8 (*c* 0.46, $CHCl_3$).

HRMS *m/z* Calculated for **[M+Na]+.** $C_{28}H_{30}O_4Na$: **453.2042** found **453.2038**.

II.15 (2*S*,3*R*,4*S*,6*R*)-2,3,4-Trihydroxy-6-methylcyclohexanone (12)



To a solution of **9** (200 mg, 0.467 mmol) in absolute ethanol (2.5 mL) was added palladium on activated carbon (7 mg). The flask was flushed with hydrogen three times and the reaction mixture was kept under hydrogen for 3 days at RT. When analytical TLC showed the absence of starting material **9** and reduced cyclohexanone **11**, the reaction mixture was filtered through a pad of silica gel. The filtrate was concentrated to afford pure target molecule **12** as a white solid (67mg, 90%).

Mp: 108-110°C

^{1}H NMR (300 MHz, MeOD): δ = 0.96 (d, *J* = 6.5Hz, 3H), 1.18 (dt, *J* = 13.2, 11.5, Hz, 1H), 2.07 (dt, *J* =13.0, 5.0Hz, 1H), 2.56 (ddq, *J* = 5.5, 10.3, 6.5Hz, 1H), 3.15 (dd, *J* = 9.3, 9.7Hz, 1H), 3.79 (ddd, *J* = 4.7, 9.0, 11.5Hz, 1H), 3.98 (dd, 10.0, 1.4Hz).

^{13}C NMR (75 MHz, MeOD): δ= 13.9, 39.0, 40.2, 71.8, 79.4, 81.4, 210.3.

$[\alpha]^{20}_D$ -107.8 (*c* 0.4, $CHCl_3$).

HRMS *m/z* Calculated for **[M]+.** $C_7H_{12}O_4$: **160.0735** found **160.0743**.