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SHORT COMMUNICATIONS

Influence of Steric Factors on the Direction of Reactions

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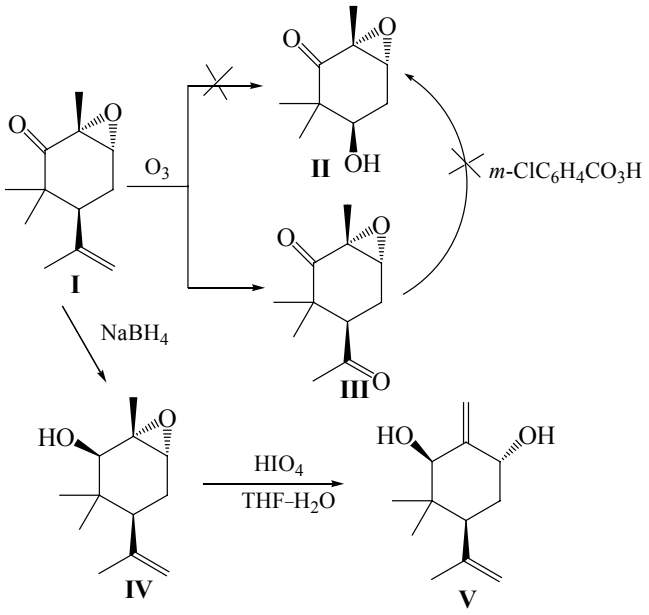
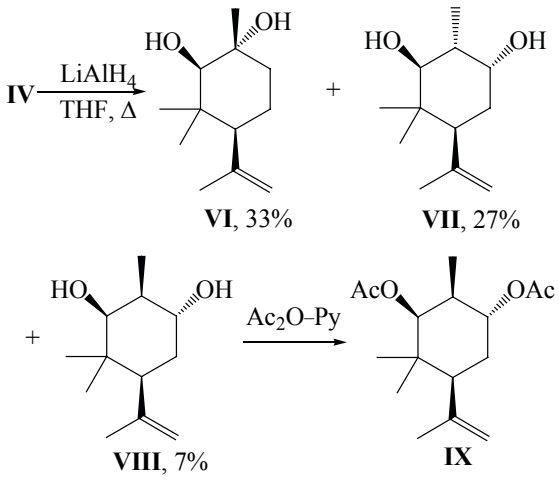
Sterical loading, topology, and the character of the organic molecule functionalization sometimes lead to the "uncommon" course of typical reactions with its participation. One of such compounds is epoxycyclohexanone **I** that we have recently described [1].



Our attempts to convert it into hydroxycyclohexanone **II** by ozonolysis under the conditions of Criegee rearrangement [2, 3] resulted only in diketone **III** [1] inert with respect to *m*-chloroperbenzoic acid. We also failed to perform the oxidative cleavage of epoxyalcohol **IV** by treating with HIO_4, we obtained only diol **V**. At the reduction of epoxyalcohol **IV** with $LiAlH_4$ alongside the expected diol **VI** we isolated regioisomeric diols **VII** and **VIII.** Usually the reduction with $LiAlH_4$ of trisubstituted epoxides provides a tertiary alcohol. The assignment of stereoisomeric diols **VII** and **VIII** was done based on the characteristic doublets of H^3 in the ^1H NMR spectra. Whereas for 2,3-*trans*-isomer **VII** $J_{3,2}$ is 11.2 Hz [δ(H^3) 3.30 ppm], in the isomer **VIII** $J_{3,2}$ is 5.2 Hz [δ(H^3) 3.51 ppm] (analogous examples have been described in [4]). For further identification diol **VIII** was converted into diacetate **IX**.



Thus except for the reduction of the epoxyketone **I** with sodium borohydride into alcohol **IV** the other reactions of these compounds proceeded by unexpected routes or with the partial formation of abnormal products.

(1*R*,3*R*,5*S*)-4,4-Dimethyl-5-isopropenyl-2-methylidenecyclohexane-1,3-diol (V). To a solution of 0.08 g (0.41 mmol) of compound **IV** in 5 ml of the mixture

THF–water, 3 : 1, was added 0.24 g (1.25 mmol) of HIO_4, and the mixture was stirred for 8 h. Then THF was distilled off, the residue was treated with $CHCl_3$, the combined organic solutions were washed with brine, dried with $MgSO_4$, and evaporated under a reduced pressure. The residue was subjected to column chromatography on SiO_2 (eluent petroleum ether–ethyl acetate, 2 : 1). Yield 0.03 g (~40%), $[\alpha]_D^{20}$ –10.0° (*C* 0.60, $CHCl_3$). ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 0.70 s and 1.08 s (6H, *gem*-CH_3), 1.61 br.s (2H, OH), 1.68 t (*J* 2.8, 3.6 Hz), 1.73 t (1H, CH_2, *J* 2.8, 3.4 Hz), 1.78 s (3H, CH_3), 1.87 d.t (1H, H^5, *J* 13.7, 3.4 Hz), 2.55 d.d (1H, CH_2, *J* 13.3, 3.6 Hz), 4.27 s (1H, H^3), 4.49 t (1H, H^1, *J* 2.8 Hz), 4.71 s (1H, $=CH_2$), 4.94 s (1H, $=CH_2$), 5.07 d (2H, $=CH_2$, *J* 2.0 Hz). ^{13}C NMR spectrum ($CDCl_3$), δ, ppm: 12.68 (CH_3), 24.42 and 25.83 (*gem*-CH_3), 35.19 (CH_2), 41.45 (C^4), 46.37 (C^5), 72.99 (C^1), 76.15 (C^3), 109.06 ($=CH_2$), 113.70 ($=CH_2$), 145.65 ($C^{1'}$), 149.96 (C^2).

Reduction of epoxide IV with $LiAlH_4$ in THF. To a solution of 0.3 g (1.53 mmol) of compound **IV** in 10 ml of anhydrous THF was added at stirring 0.23 g (6.05 mmol) of $LiAlH_4$, the mixture was boiled for 6 h. On cooling the reaction mixture to room temperature 5 ml of saturated NH_4Cl solution was added, THF was distilled off, the residue was treated with $CHCl_3$, the combined organic solutions were washed with 5% solution of HCl, next with brine, dried with $MgSO_4$, and evaporated. The residue was subjected to column chromatography on SiO_2 (eluent petroleum ether–ethyl acetate, 2 : 1). We obtained 0.1 g (33%) of compound **VI**, 0.08 g (27%) of diol **VII**, and 0.02 g (7%) of diol **VIII**.

(1*R*,2*R*,4*S*)-4-Isopropenyl-1,3,3-trimethylcyclohexane-1,2-diol (VI). Colorless crystals, R_f 0.3 (petroleum ether–ethyl acetate, 2 : 1), mp 77–77.5°C, $[\alpha]_D^{20}$ –10.3° (*C* 1.64, $CHCl_3$). ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 0.97 s (3H, *gem*-CH_3), 1.03 s (3H, *gem*-CH_3), 1.42 s (3H, CH_3), 1.45–1.70 m (4H, $2CH_2$), 1.73 s (3H, CH_3), 2.26 d.d (1H, H^4, *J* 6.8, 2.0 Hz), 2.65 br.s (1H, OH), 2.93 br.s (1H, OH), 3.10 s (1H, H^2), 4.65 br.s (1H, $=CH_2$), 4.87 br.s (1H, $=CH_2$). ^{13}C NMR spectrum ($CDCl_3$), δ, ppm: 23.02 and 24.28 (*gem*-CH_3), 25.45 (CH_2), 26.62 (CH_3), 28.19 (CH_3), 35.29 (CH_2), 38.54 (C^3), 46.99 (C^4), 72.33 (C^1), 83.26 (C^2), 113.10 ($=CH_2$), 146.70 ($C^{1'}$). Mass spectrum, *m/z* (I_{rel}, %): 198 $[M]^+$ (1), 180 $[M - H_2O]^+$ (8), 168 $[M - 2CH_3]^+$ (9), 165 $[M - H_2O - CH_3]^+$ (14%), 151 (10), 137 (20), 125 (20), 111 (30), 109 (82), 108 (49), 97 (78), 95 (78), (89), 72 (85), 71 (100), 69 (67), 68 (58), 58 (50), 55 (48), 53 (25).

(1*R*,2*R*,3*S*,5*S*)-5-Isopropenyl-2,4,4-trimethylcyclohexane-1,3-diol (VII). Colorless crystals, R_f 0.2 (petroleum ether–ethyl acetate, 2:1), mp 122–123°C, $[\alpha]_D^{20}$ –29.1° (*C* 1.4, $CHCl_3$). ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 0.83 s and 0.98 s (6H, *gem*-CH_3), 1.09 d (3H, CH_3, *J* 7.0 Hz), 1.23 br.s (1H, OH), 1.54 t (*J* 3.3 Hz), 1.59 t (1H, CH_2, *J* 3.3 Hz), 1.73 br.s (1H, OH), 1.75 s (3H, CH_3), 1.80–1.90 m (2H, CH), 2.33 d.d (1H, CH_2, *J* 13.5, 3.3 Hz), 3.30 d (1H, H^3, *J* 11.2 Hz), 3.91 q (1H, H^1, *J* 2.7 Hz), 4.68 s (1H, $=CH_2$), 4.90 s (1H, $=CH_2$). ^{13}C NMR spectrum ($CDCl_3$), δ, ppm: 13.38 (CH_3), 14.97 and 24.19 (*gem*-CH_3), 26.47 (CH_3), 34.97 (CH_2), 39.63 (C^4), 38.06 (C^5), 45.96 (C^2), 71.21 (C^1), 78.26 (C^3), 113.55 ($=CH_2$), 146.14 ($C^{1'}$). Mass spectrum, *m/z* (I_{rel}, %): 198 $[M]^+$ (2), 180 $[M - H_2O]^+$ (12), 165 $[M - H_2O - CH_3]^+$ (14), 147 (16), 137 (20), 129 (39), 122 (40), 109 (45), 107 (75), 96 (76), 81 (89), 71 (100), 69 (58), 59 (66), 55 (68), 53 (25).

(1*R*,2*S*,3*S*,5*S*)-5-Isopropenyl-2,4,4-trimethylcyclohexane-1,3-diol (VIII). Colorless crystals, R_f 0.15 (petroleum ether–ethyl acetate, 2:1), mp 160–162°C, $[\alpha]_D^{20}$ +21.0° (*C* 0.935, MeOH). ^{1}H NMR spectrum [$(CD_3)_2CO$], δ, ppm: 0.87 s and 0.98 s (6H, *gem*-CH_3), 0.97 d (3H, CH_3, *J* 7.2 Hz), 1.41 d.t (1H, CH_2, *J* 3.6 and 11.0 Hz), 1.76 s (3H, CH_3), 1.95–2.00 m (2H, CH), 2.45 d.d (1H, CH_2, *J* 11.9 and 3.6 Hz), 3.51 d (1H, H^3, *J* 5.2 Hz), 3.54 br.s (1H, OH), 3.66 t (1H, H^1, *J* 4.9 Hz), 3.84 br.s (1H, OH), 4.70 d.d (1H, $=CH_2$, *J* 0.7 and 1.8 Hz), 4.83 d.d (1H, $=CH_2$, *J* 1.3 and 2.5 Hz). ^{13}C NMR spectrum ($CDCl_3$), δ, ppm: 12.75 (CH_3), 17.41 and 22.90 (*gem*-CH_3), 28.21 (CH_3), 31.08 (CH_2), 39.39 (C^4), 41.81 (C^5), 46.79 (C^2), 70.81 (C^1), 74.61 (C^3), 112.53 ($=CH_2$), 147.10 ($C^{1'}$).

(1*R*,2S,3*S*,5*S*)-5-Isopropenyl-2,4,4-trimethylcyclohexane-1,3-diyl diacetate (IX). Colorless oily substance, $[\alpha]_D^{20}$ –20.0° (*C* 0.24, $CHCl_3$). ^{1}H NMR spectrum ($CDCl_3$), δ, ppm: 0.91 s and 0.97 s (6H, *gem*-CH_3), 0.99 d (3H, CH_3, *J* 7.5 Hz), 1.57–1.64 m (2H, CH, CH_2), 1.79 s (3H, CH_3), 1.97 d (*J* 3.3 Hz), 2.02 t (1H, CH, *J* 3.3 Hz), 2.08 s and 2.09 s (3H each, $COCH_3$), 2.34 d.d (1H, CH_2, *J* 11.4 and 3.6 Hz), 4.73 br.s (1H, $=CH_2$), 4.89–4.93 m (1H, H^3), 4.91 C (1H, $=CH_2$), 4.96 t (1H, H^1, *J* 3.8 Hz). ^{13}C NMR spectrum ($CDCl_3$), δ, ppm: 13.41 (CH_3), 19.0 and 23.37 (*gem*-CH_3), 20.96 and 21.39 ($CO\underline{C}H_3$), 28.14 (CH_3), 28.38 (CH_2), 35.31 (C^5), 38.43 (C^4), 47.39 (C^2), 74.04 (C^1), 78.14 (C^3), 114.45 ($=CH_2$), 145.24 ($C^{1'}$), 170.44 and 170.56 ($\underline{C}OCH_3$).

IR spectra were recorded on a spectrophotometer IR

Prestige-21 Shimadzu from thin films. ^{1}H and ^{13}C NMR spectra were registered on a spectrometer Bruker AM-300 at operating frequencies 300.13 and 75.47 MHz respectively, internal reference TMS. The optical rotation was measured on a polarimeter Perkin Elmer-341. Mass spectra were obtained on an instrument Thermo Finnigan MAT 95XP, ionizing electrons energy 70 eV, ionizing chamber temperature 200°C, temperature of sample admission 50–270°C, heating rate 22 deg/min. The reaction progress was monitored by TLC on Sorbfil plates (Russia), spots visualized by solution of anisaldehyde in ethanol acidified with sulfuric acid followed by heating to 120–150°C. In the column chromatography freshly distilled eluents were used: ethyl acetate and light petroleum ether (bp 40–70°).

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