

SHORT
COMMUNICATIONS

Stereocontrolled Acid Cyclization of (+)-Hanphillin

N. Merkhately, S. B. Abeuova, A. N. Iskanderov,
S. K. Aldabergenova, and B. B. TogizbaevaBuketov Karaganda State University, Universitetskaya ul. 28, Karaganda, 100028 Kazakhstan
e-mail: merhately@ya.ru

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In extension of our research in the field of biomimetic transformations of germacranic sesquiterpene γ -lactones [1, 2] we performed by the action of formic acid a stereocontrolled transannular carbocyclization of *E,E*-germanocranolide hanphillin (**I**) isolated from Noble Yarrow (*Achillea nobilis* L.), and obtained new *trans*-fused 5 α (H),10 β (CH₃)-eudesmanolides **II** and **III** in the yields of 65 and 30% respectively.

As shown in the scheme the acid-catalyzed 5,10-carbocyclization of compound **I** proceeds evidently through a regioselective protonation of the most electron-donor and spatially available $\Delta^{1,10}$ -double bond of compound **I** followed by a stereospecific nucleophilic attack by the $\Delta^{4,5}$ -double bond leading via a tertiary carbocation to the *trans*-fused eudesmanolides **II** and **III** (Scheme 1).

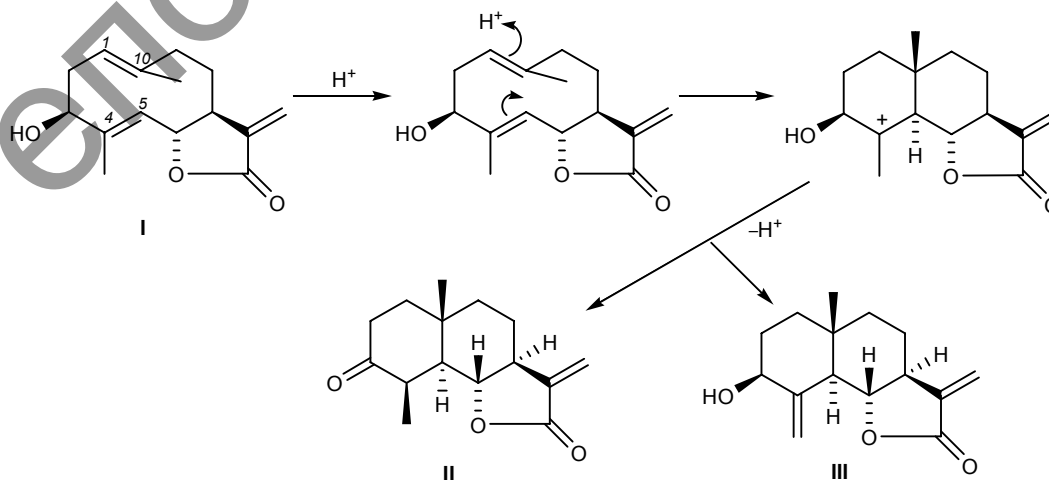
The stereocontrolled 5,10-carbocyclization of compound **I** occurs also in the presence of CH₃CO₃H

and C₆H₅CO₃H in CH₂Cl₂ at room temperature giving *trans*-eudesmanolides formerly isolated from plant sources [3, 4] epiartekalin (**IV**) and ridentin-B (**V**) in 45 and 53% yields (Scheme 2).

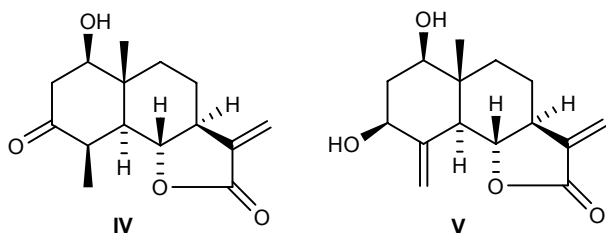
Compounds II and III. To a solution of 0.3 g (1.2 mmol) of compound **I** in 15 mL of CHCl₃ was added dropwise at room temperature 4.6 mL of 99% HCO₂H. The reaction mixture was stirred at room temperature, then washed with 10% solution of NaHCO₃ (2 × 10 mL), with water (3 × 10 mL), dried with MgSO₄, the solvent was distilled off in a vacuum. The residue (0.33 g) was chromatographed on a column packed with silica gel (eluent hexane–ethyl acetate, 2 : 3 and 1 : 4).

3-Oxo-eudesm-11(13)-en-6,12-olide, or (3a*S*,5a*S*,9*R*,9a*S*,9b*S*)-5a,9-dimethyl-3-methylidene-octahydronaphtho[1,2-*b*]furan-2,8(3*H*,4*H*)-dione (II). Yield 0.193 g (65%). *R*_f 0.54 (hexane–ethyl acetate, 2 : 3). Colorless crystals, mp 136–138°C.

Scheme 1.



Scheme 2.



$[\alpha]_D^{18} +96^\circ$ (*c* 0.02, CHCl_3). IR spectrum, ν , cm^{-1} : 1760 (C=O), 1700 (C=O), 1640 (C=C). ^1H NMR spectrum, δ , ppm: 1.43 s (3H, $\text{CH}_3\text{-C}^{10}$), 1.68 br.s (3H, $\text{CH}_3\text{-C}^4$), 4.12 q (1H, H^6 , J 10, 8.5 Hz), 5.52 d (1H, H^{13} , J 3.5 Hz), 6.26 d (1H, H^{13} , J 3.5 Hz). Mass spectrum, m/z (I_{rel} , %): 248 (32.4) $[M]^+$. Found, %: C 72.38; H 7.87. $\text{C}_{15}\text{H}_{20}\text{O}_3$. Calculated, %: C 72.58; H 8.06.

3-Hydroxyeudesma-4(15),11(13)-dien-6,12-olide, or (3a*S*,5a*S*,9a*R*,9b*S*)-8-hydroxy-5a-methyl-3,9-dimethylidenedecahydronaphtho[1,2-*b*]furan-2(3*H*)-one (III). Yield 0.074 g (30%). R_f 0.37 (hexane–ethyl acetate, 1 : 4). Colorless crystals, mp 175–177°C. $[\alpha]_D^{18} +106^\circ$ (*c* 0.02, CHCl_3). IR spectrum, ν , cm^{-1} : 1760 (C=O), 1650, 1640 (C=C). ^1H NMR spectrum, δ , ppm: 1.43 s (3H, CH_3C^{10}), 4.12 q (1H, H^6 , J 10, 8.5 Hz), 5.26 d (1H, H^{15} , J 1 Hz), 5.52 d

(1H, H^{13} , J 3.5 Hz), 5.92 d (1H, H^{15} , J 1 Hz), 6.26 d (1H, H^{13} , J 3.5 Hz). Mass spectrum, m/z (I_{rel} , %): 248 (44.7) $[M]^+$. Found, %: C 72.33; H 7.81. $\text{C}_{15}\text{H}_{20}\text{O}_3$. Calculated, %: C 72.58; H 8.06.

IR spectra were recorded on a spectrophotometer Avatar-360 from pellets with KBr. ^1H NMR spectra were registered on a spectrometer Bruker Avance-400 (operating frequency 400.13 MHz), solvent CDCl_3 , internal reference TMS. Mass spectra were obtained on an instrument Agilent 7890A. Specific rotation was measured on a polarimeter Perkin-Elmer 141. Melting points were determined on a small heating block Boëtius. TLC was carried out on Silufol UV-254 plates.

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