The Homoallylic Cations Involved in the Conversion of Presenegenin into Senegenin

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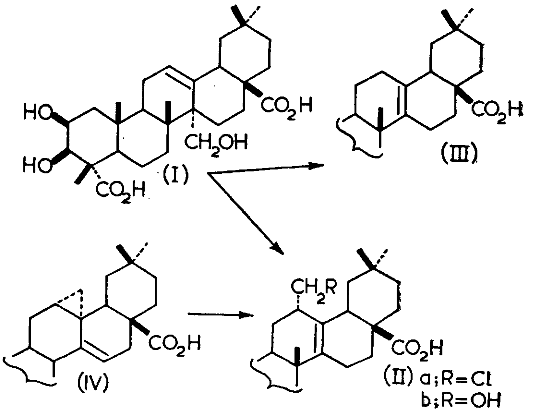
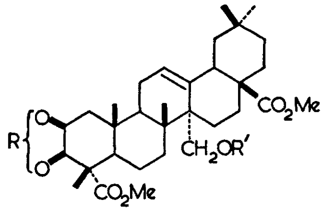
PRESENEGENIN, the parent sapogenin of *Polygala senega,* has been shown recently to have the structure and stereochemistry depicted by (I).[1–3] Treatment of the saponin (senegin) or of (I) with ethanolic hydrochloric acid gives a mixture of senegenin (IIa) and senegenic acid (III)[4] in approximately equal amounts. Senegenin is also obtained in almost quantitative yield by treatment of cyclosenegenin (IV) with hydrochloric acid. To date, the mechanism of the conversion of presenegenin into senegenin has not been studied in detail. This report concerns evidence for the presence of homoallylic cations in the conversion.

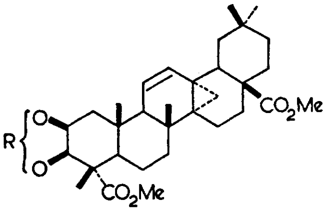
Presenegenin acetonide (V),[3,5] m.p. 158—159°, τ 6·85 (2H, AB-type, CH_2OH), 4·10 (1H, vinyl proton), 5·47 (2H, C-2-*H* and C-3-*H*), with toluene-*p*-sulphonyl chloride in pyridine gave the corresponding toluene-*p*-sulphonate (VI) in 80% yield, m.p. 151—153°, ν_{max} 1632, 1123, 1038, 1012 cm.$^{-1}$ (toluene-*p*-sulphonyl group), τ 2·65 (4H, AB-type, $J = 8$ c./sec., aromatic protons), 7·72 (3H, aromatic-CH_3). Solvolysis of (VI) with sodium acetate in aqueous acetone gave three products: (VII) (20%), m.p. 197—198°, previously reported;[3] (VIII) (50%) m.p. 189—191°, τ 5·68 (3H, C-2-*H*, C-3-*H*, C-12-*H*), 9·92 (2H, cyclopropane protons), ν_{max} 3050 cm.$^{-1}$ (cyclopropane); and (IX) (5%), m.p. 233—235°, τ 5·95 (3H, mult., C-2-*H*, C-3-*H*, C-12-*H*, 9·68 (2H, AB-type, cyclopropane protons).



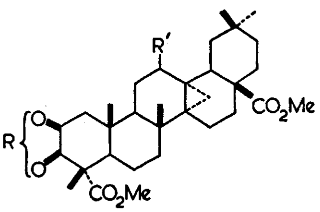
Oxidation of (VIII) with chromium trioxide afforded the ketone (X) in 90% yield, m.p. 179·5—181·5°, λ_{max} (EtOH) 214 mμ (ϵ 4200), ν_{max} 1698



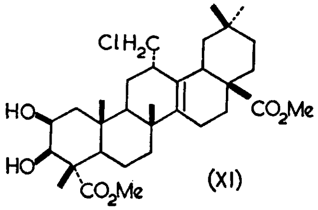
(V) R = Me_2C; R′ = H
(VI) R = Me_2C; R′ = Ts



(VII) R = Me_2C
(VIIa) R = H,H



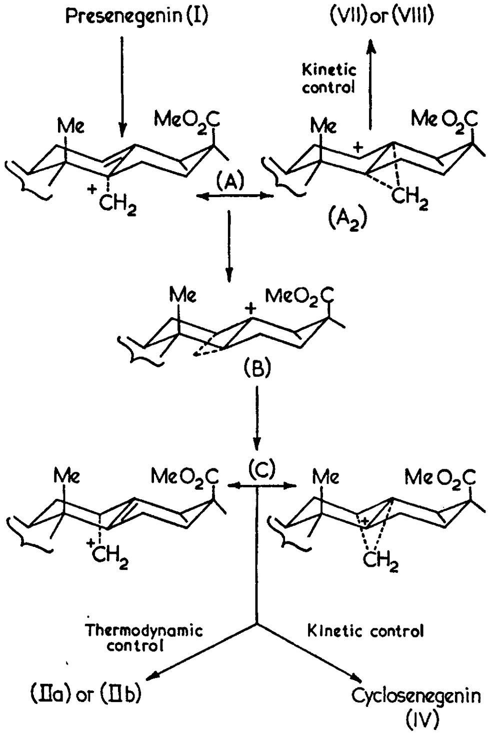
(VIII) R = Me_2C; R′ = OH
(IX) R = H,H; R′ = OH
(X) R = Me_2C; R′ = O



(XI)

$cm.^{-1}$. These facts coupled with analogous reactions in the steroid field[6–8] locate the hydroxyl of (VIII) at C-12. Treatment of (VIII) under the same conditions used for the conversion of presenegenin (I) into senegenin (IIa), gave an essentially quantitative yield of senegenin dimethyl ester (XI).

The reactions described suggest the participation of homoallylic cations[8,9] in these transformations. For purposes of discussion the two resonance hybrids (A) and (C) which are interconnected through the cyclobutonium ion (B), may be considered. Under kinetic control, system (A) would lead to (VII) and (VIII) (in the presence of water). From system (C) under thermodynamic control, senegenin (IIa) or hydroxysenegenin (IIb) would be the expected products. Under kinetic control, the same system would lead to cyclosenegenin (IV). If these relationships are valid, then compounds which correspond to cation (A_2) (such as VIII) should also furnish senegenin (IIa) or hydroxysenegenin (IIb) under thermodynamic control. Thus the quantitative conversion of (VIII) into senegenin dimethyl ester (XI) described above confirms this prediction and also precludes the possibility that presenegenin (I) is an intermediate in this reaction.



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