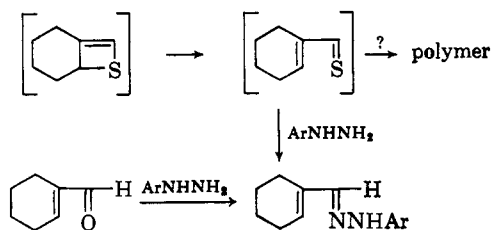


If the pentane solution of **1** is allowed to stand at room temperature for 24 hr., a white, apparently polymeric material is obtained. This polymer has not been characterized although it contains sulfur and no nitrogen and has an infrared absorption at 1600  $\text{cm}^{-1}$  which may indicate the presence of a double bond.

Oxidation as before of half of a pentane solution of **1** gives a 21% yield of the sulfone **3**. Before oxidation, the pentane solution was washed with dilute hydrochloric acid.<sup>7</sup> The other half of the solution is allowed to stand at room temperature for 24 hr., the polymer is removed by filtration, and the solution is oxidized with monoperphthalic acid at  $-10^\circ$  and then at  $70^\circ$  with 30% hydrogen peroxide in acetic acid. No thiete sulfone, **3**, is obtained from this latter solution. This result eliminates the possibility that the thiete sulfone was derived from **2** or from **4** by oxidation of the sulfur and elimination of the amine fragment during or subsequent to the oxidation since **2** and **4** are stable at room temperature. The polymer apparently is derived from the substance (presumably **1**) in the pentane solution which yields sulfone **3** on oxidation since there is no longer any oxidizable product if polymerization is allowed to proceed prior to oxidation.

Treatment of the pentane solution of **1** with 2,4-dinitrophenylhydrazine reagent yields a 2,4-dinitrophenylhydrazone, m.p. 219–220°, whose melting point and infrared and ultraviolet spectra are identical with those of the 2,4-dinitrophenylhydrazone of 1-cyclohexene aldehyde.<sup>8</sup>



Attempts to isolate **1** by carrying out the elimination reaction with potassium *t*-butoxide in dimethyl sulfoxide at 0.5 mm. give a small amount of polymer and 60–65% of *N*-methylpyrrolidine which is identified as its picrate and by its infrared spectrum. The colorless material collected in the traps gives a 2,4-dinitrophenylhydrazone and semicarbazone (m.p. 210–213°, lit.<sup>9</sup> m.p. 212–213°) identical with the same derivatives from 1-cyclohexene aldehyde. Hydrogen sulfide is evolved during formation of the semicarbazone and 2,4-dinitrophenylhydrazone. The colorless material in the traps polymerizes when it is warmed to room temperature; under these conditions cyclohexene aldehyde is stable. It is possible that the colorless material in the traps was, in part, the thiete **1** since thiocarbonyl compounds are usually colored. The intermediacy of an aromatic thiete derivative previously was suggested to account for the formation of a thioaldehyde derivative in the reduction of a naphthothiete sulfone by lithium aluminum hydride.<sup>10</sup>

(7) Compound **4** is removed from the pentane solution by the acid wash. The salt **2** is insoluble in pentane, but any trapped mechanically would be removed in the aqueous acid washings.

(8) I. Heilbron, E. R. H. Jones, R. W. Richardson, and F. Sondheimer, *J. Chem. Soc.*, 737 (1949).

(9) W. Borsche and R. Schmidt, *Ber.*, **43**, 3400 (1910).

(10) D. C. Dittmer and N. Takashina, *Tetrahedron Letters*, 3809 (1964).

Work is in progress on the isolation of **1** and its anion, the latter which might have considerable relative stability.<sup>11</sup>

(11) D. C. Dittmer and M. E. Christy, *J. Am. Chem. Soc.*, **84**, 399 (1962).

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## Cycloesenegenin, a Derivative of Senegenin in *Polygala senega*

Sir:

Recent work on the sapogenins of *Polygala senega* has resulted in the assignment of structures to senegenin ( $\text{C}_{30}\text{H}_{45}\text{ClO}_6$ , I) and senegenic acid ( $\text{C}_{29}\text{H}_{44}\text{O}_6$ , II).<sup>1,2</sup> Since senegenin contains chlorine and senegenic acid has one less carbon than I, it was suspected that both compounds are artifacts produced during the vigorous hydrolysis of senegin by hydrochloric acid.<sup>1,2</sup> We wish to report the isolation and structure of a new sapogenin obtained by the mild hydrolysis of senegin.

The hydrolysis of senegin<sup>3</sup> in aqueous sulfuric acid followed by acetylation and silica gel chromatography furnished two crystalline acids as the acetates. One of these was identified as senegenic acid diacetate (IIb). The other compound<sup>4</sup> (IIIb),  $\text{C}_{38}\text{H}_{52}\text{O}_{10}$ , m.p. 329–332° (with effervescence),  $[\alpha]^{22\text{D}} +21.3^\circ$  (*c* 0.94, EtOH), upon alkaline hydrolysis, gave the acetyl-free compound (IIIa),  $\text{C}_{30}\text{H}_{46}\text{O}_7$ , m.p. 246–253° (with effervescence),  $[\alpha]^{22\text{D}} +5.7^\circ$  (*c* 0.71, EtOH). Acetylation of IIIa regenerated IIIb. Compound IIIb shows no hydroxyl absorption in the infrared and gives an amorphous methyl ester whose p.m.r. spectrum shows the presence of three acetyl groups ( $\tau$  8.07, 7.95, and 7.93), two methyl ester moieties ( $\tau$  6.33 and 6.40), and five C-methyl groups ( $\tau$  9.13, 9.11, 9.00, 8.88, and 8.69). Therefore, the oxygen functions of IIIa are accounted for as two carboxyl and three hydroxyl groups. Moreover, there is an unsharp AB system ( $\tau$  6.10 and 5.65 ( $J = 12$  c.p.s.)), suggesting an acetoxy methylene group connected with an asymmetric center.<sup>5</sup>

Treatment of IIIa with dilute sulfuric acid at reflux for 18 hr. afforded a diene (IV) which proved to be identical with that obtained by dehydrochlorination of I with quinoline.<sup>1</sup> Clearly, this new sapogenin may be assigned structure IIIa and is therefore the "hydroxy-senegenin" proposed by Dugan, de Mayo, and Starratt as the precursor which leads to senegenic acid (IIa) by a reverse Prins reaction.<sup>1</sup>

The solvolysis of the chlorine in I led to interesting results. Treatment of I with 2 *N* NaOH solution followed by careful acidification and repeated crystalliza-

(1) J. J. Dugan, P. de Mayo, and A. N. Starratt, *Can. J. Chem.*, **42**, 491 (1964); *Tetrahedron Letters*, 2567 (1964); *Proc. Chem. Soc.*, 264 (1964).

(2) S. W. Pelletier, N. Adityachaudhury, M. Tomasz, J. J. Reynolds, and R. Mechoulam, *Tetrahedron Letters*, 3065 (1964).

(3) W. A. Jacobs and O. Isler, *J. Biol. Chem.*, **119**, 155 (1937).

(4) Satisfactory analyses were obtained for all compounds cited in this paper. P.m.r. spectra were taken in  $\text{CDCl}_3$  unless specified.

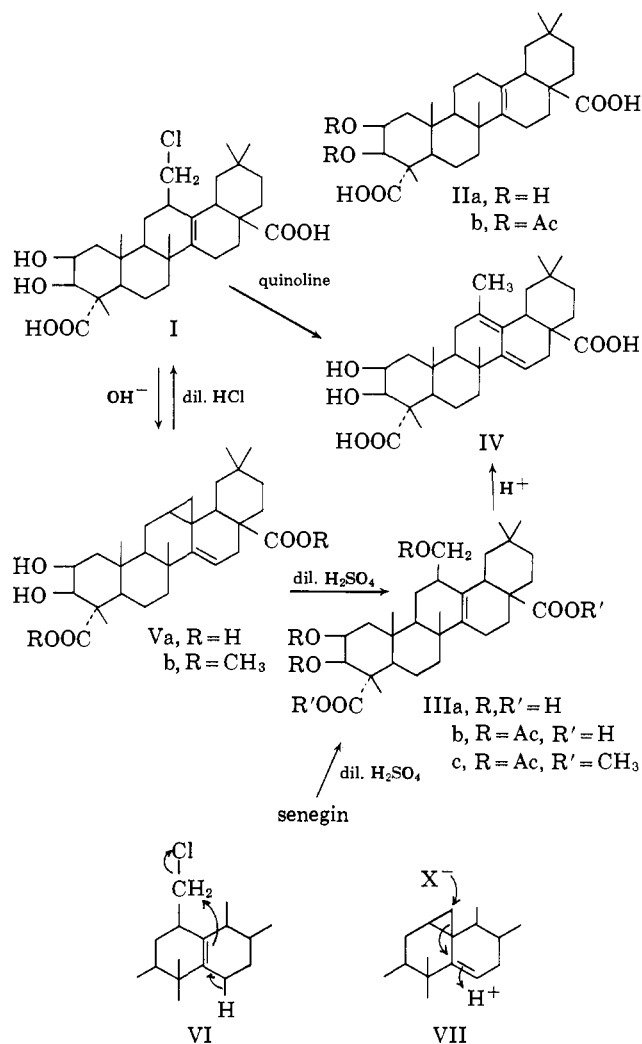
(5) L. M. Jackmann, "Nuclear Magnetic Resonance Spectroscopy," Pergamon Press, New York, N. Y., 1959, p. 102.

tion from aqueous alcohol gave in 30% yield<sup>6</sup> a chlorine-free compound, C<sub>30</sub>H<sub>44</sub>O<sub>6</sub>, designated as *cyclosenegenin*, m.p. 302–305° (with effervescence), [α]<sub>D</sub><sup>22</sup> +57.8° (c 0.81, EtOH).

Surprisingly, when the compound was warmed briefly with dilute hydrochloric acid re-introduction of chlorine occurred to give senegenin (I) in almost quantitative yields. Furthermore, when treated with dilute sulfuric acid, it gave the previously described triol IIIa and a small amount of the diene IV. The following spectral data lead to the assignment of structure Va to this compound. The ultraviolet spectrum of Va has no diene absorption but a maximum at 209 mμ (ε 6780, EtOH), consistent with the presence of a conjugated cyclopropane.<sup>7</sup>

The p.m.r. spectra of Va taken in pyridine shows two complex signals at τ 9.94 and 9.47.<sup>8</sup> The noncrystalline methyl ester Vb shows one spot on a thin-layer chromatograph, has also two complex peaks centered at τ 10.11 and 9.61,<sup>8</sup> besides a broad signal at τ 4.47 for one vinylic proton and others at τ 9.09 (9 H), 8.76 (3 H), and 8.67 (3 H) for five methyl groups and at τ 6.39 (3 H) and 6.30 (3 H) for two methyl esters. Those signals at high field near τ 10.00 are characteristic of a cyclopropane hydrogen.<sup>9</sup> The infrared spectrum of Vb shows a weak absorption at 3050 cm.<sup>-1</sup> with an inflection at 3070 cm.<sup>-1</sup>.<sup>10</sup> These data can be explained reasonably by assuming a 12,13-methylen-14-ene structure for V, which results from the solvolytic removal of chlorine with the concomitant formation of the cyclopropane ring and abstraction of a hydrogen at C-15<sup>11</sup> (see VI).

The reaction from Va to I or IIIa involves non-Markovnikov cleavage of the cyclopropane ring caused by the protonation on the double bond as shown in VII.<sup>12</sup> These results suggest that cyclosenegenin (Va) may be the primary sapogenin which gives rise to senegenin on treatment with alcoholic HCl. Also the



(6) The mother liquors contain a crystalline mixture, whose ultraviolet spectrum shows a composite of the diene (IV) ( $\lambda_{\max}$  249 mμ) and Va ( $\lambda_{\max}$  209 mμ, *vide infra*). An approximate calculation from the relative intensities gives a ratio of about 1:2 (IV:Va).

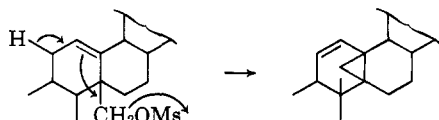
(7) 3α,5-Cyclo-Δ<sup>6</sup>-cholestene absorbs at  $\lambda_{\max}$  207.5 mμ [R. A. Micheli and T. H. Applewhite, *J. Org. Chem.*, **27**, 245 (1962)], and many other vinylcyclopropanes are reported to have maxima around 210 mμ with extinction between 5300 and 12,000. Cf. A. I. Scott, "Interpretation of the Ultraviolet Spectra of Natural Products," The Macmillan Co., New York, N. Y., 1964, p. 49, and also O. L. Chapman, G. W. Borden, R. W. King, and B. Winkler, *J. Am. Chem. Soc.*, **86**, 2660 (1964).

(8) The measurement was done with and without tetramethylsilane as an internal standard.

(9) There are many examples. Among them, 20-methylamino-12β,18-cyclopregnan-3β-ol was reported to have two complex peaks at τ 10.08 and 9.67 by V. Georgian, J. F. Kerwin, M. E. Wolff, and F. F. Owings [*J. Am. Chem. Soc.*, **84**, 3954 (1962)], and 4α,5-methylenecholestane a complex peak at τ 10.00 by K. Kocsis, P. G. Ferrini, D. Arigoni, and O. Jeger [*Helv. Chim. Acta*, **43**, 2178 (1960)].

(10) A. R. H. Cole [*J. Chem. Soc.*, 3807, 3810 (1954)] reported 3042–3058 cm.<sup>-1</sup> for the cyclopropane C–H stretching, e.g., i-cholestane shows a peak at 3050 cm.<sup>-1</sup>.

(11) A similar reaction was utilized in the synthesis of phyllanthol [A. Zürcher, O. Jeger, and L. Ruzicka, *Helv. Chim. Acta*, **37**, 2145 (1954)].



The *i*-steroid rearrangement is also an analogous case, but here the attack of hydroxyl ion, instead of proton abstraction, usually takes place.

(12) Cyclopropanes usually open according to Markovnikov's rule [D. H. R. Barton, J. E. Page, and E. W. Warnhoff, *J. Chem. Soc.*, 2715 (1954)], but with a conjugated cyclopropane protonation takes place first on the double bond, which leads to non-Markovnikov opening [cf. V. Georgian, J. F. Kerwin, M. E. Wolff, and F. F. Owings, ref. 9].

interconversion of I and Va explains the contradictory reports concerning the recovery of senegenin when boiled with alkali.<sup>13</sup>

**Acknowledgment.** This work was supported in part by Grant GM 10966 from the National Institutes of Health, U. S. Public Health Service.

(13) Although Jacobs and Isler reported that senegenin was not recovered after consumption of three equivalents of alkali,<sup>3</sup> in some unpublished experiments in our laboratory it was recovered.

(14) To whom correspondence regarding this paper should be addressed.

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## Structure of Piericidin A

Sir:

Piericidin A (PA) is a new insecticidal metabolite of *Streptomyces mobaraensis* and its isolation,<sup>1</sup> physiological activity, functional groups,<sup>2</sup> and partial structure<sup>3</sup> Ia or Ib have been presented in previous papers. We wish now to report evidence which allows the assign-

(1) S. Tamura, N. Takahashi, S. Miyamoto, R. Mori, S. Suzuki, and J. Nagatsu, *Agr. Biol. Chem.* (Tokyo), **27**, 576 (1963).

(2) N. Takahashi, A. Suzuki, S. Miyamoto, R. Mori, and S. Tamura, *ibid.*, **27**, 583 (1963).

(3) N. Takahashi, A. Suzuki, and S. Tamura, *ibid.*, **27**, 798 (1963).