Acetate 4c.—From sulfoxide **2c** as described for **4b**. The crude crystalline product was obtained in 70% yield and showed two spots on tlc. It was recrystallized from ethyl acetate to give an analytical sample, mp 157–160°, which showed one spot and ν_{max}^{Nujol} 1730, 1755, 3600 cm^{-1}.

Anal. Calcd for $C_{22}H_{29}NO_5$: C, 68.19; H, 7.54; N, 3.62. Found: C, 68.39; H, 7.78; N, 3.38.

Chromatography of the mother liquors afforded a very small amount of another solid which was not investigated further.

Bromo Salt 5b.—Seventy grams of ester **5a** was converted into its free base and brominated as described previously.[1] Crude salt **5b** was used directly for preparation of **5c**. A sample was recrystallized from methanol for analysis: mp 182–185°; ν_{max}^{Nujol} 1560, 1600, 1610, 1730, 3200 cm^{-1}.

Anal. Calcd for $C_{20}H_{25}NO_4Br_2$: Br, 31.76. Found: Br, 31.94.

Keto Salt 5c.—The crude salt from the above preparation was treated with silver nitrate in acetonitrile as previously described.[1] Crude salt **5c** was used directly for preparation of ester **1d**. A sample was recrystallized from methanol for analysis: mp 140–143°; ν_{max}^{Nujol} 1550, 1590, 1610, 1725, 1740, 3500 cm^{-1}.

Anal. Calcd for $C_{20}H_{24}NO_9Cl$: C, 52.47; H, 5.78; Cl, 7.74. Found: C, 52.33; H, 5.54; Cl, 7.77.

Ester 1d.—The crude salt **5c** from the above preparation was reduced with potassium borohydride as previously described.[1] The crude base **1d** was used directly for preparation of sulfoxide **2d**. A sample was recrystallized from ethyl acetate–hexane for analysis: mp 158–160°; ν_{max}^{Nujol} 1710, 3350, 3475 cm^{-1}.

Anal. Calcd for $C_{20}H_{27}NO_5$: C, 66.46; H, 7.53; N, 3.88. Found: C, 66.56; H, 7.70; N, 4.01.

Sulfoxide 2d.—Prepared from ester **1d** in 70% yield. The product was recrystallized from acetonitrile: mp 204–206°; ν_{max}^{Nujol} 1705, 3300, 3600 cm^{-1}.

Anal. Calcd for $C_{21}H_{29}NO_5S$: C, 61.89; H, 7.17; S, 7.87. Found: C, 61.84; H, 7.43; S, 7.79.

Tlc [methanol–chloroform (20:80)] showed two sharp spots of R_f *ca.* 0.6.

Acetate 4d.—Carried out as described for **4c**. The crude residue from the Raney nickel treatment (55%) crystallized readily and was recrystallized from ethyl acetate for analysis: mp 191–193°; ν_{max}^{Nujol} 1730, 1755, 3400, 3450 cm^{-1}.

Anal. Calcd for $C_{22}H_{29}NO_6$: C, 65.49; H, 7.25; N, 3.47. Found: C, 65.69; H, 7.31; N, 3.76.

Registry No.—**1d**, 21273-53-0; **2c**, 21273-54-1; **2d**, 21273-55-2; **4a**, 21273-56-3; **4b**, 21273-57-4; **4c**, 21273-58-5; **4d**, 21273-59-6; **5b**, 21273-60-9; **5c**, 21273-62-1; **6a** acetate, 21273-61-0.

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Synthesis of 3,5α-Dichloro-3,5-seco-A-norcholestane

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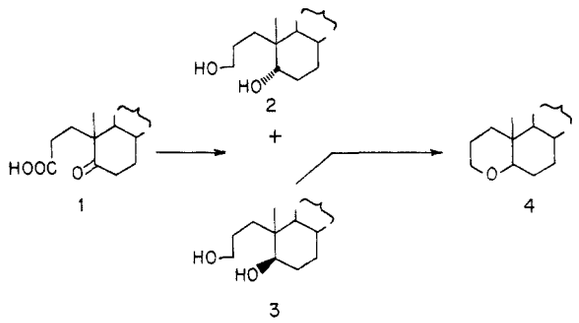
For use as a precursor in the synthesis of organometal substituted steroids, it became necessary to prepare 3,5α-dichloro-3,5-seco-A-norcholestane (**8**). The desired compound has the chlorines in 1,5 positions relative to each other, and possibly could be treated in a number of ways with ring closure to give cholestanes containing a heteroatom in the 4 position.

Reduction of Windaus' keto acid (**1**)[2,3] with lithium aluminum hydride led to a mixture of diols, 3,5-seco-A-norcholestane-3,5α-diol (**2**) and 3,5-seco-A-norcholestane-3,5β-diol (**3**) (Scheme I). These were separated

SCHEME I

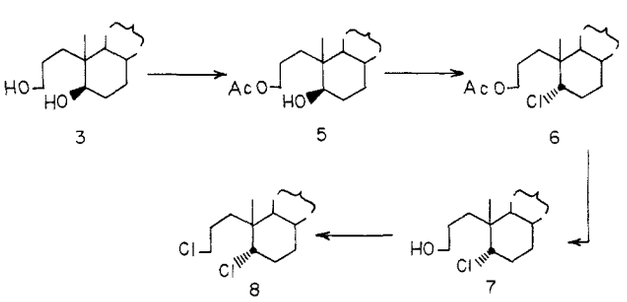


by column chromatography and identified by comparison of their optical rotations with those reported by Edward and Morand[4] for the known epimeric diols.

Initial attempts to react the 3,5α-diol (**2**) with thionyl chloride, a reaction which should proceed with retention of configuration to give the desired 3,5α dichloride, yielded only an oily mixture of unidentified composition. Reactions of the 3,5β-diol (**3**) with (1) phosphorus pentachloride, (2) triphenylphosphine and carbon tetrachloride or carbon tetrabromide,[5] (3) benzenesulfonyl chloride followed by reaction with bromide ion, or (4) phosphorus oxychloride,[6] all which would normally result in inversion of configuration, yielded only the known[7] cyclic ether 4-oxa-5 α-cholestane (**4**).[8,9]

The desired dichloride (**8**) was finally obtained by a sequence of reactions in which the diol monoacetate **5** was converted into the 5α chloride **6** with triphenylphosphine in carbon tetrachloride,[5,11] followed by hydrolysis to the carbinol **7** (Scheme II). Repetition of the chlorination reaction gave 3,5α-dichloro-3,5-seco-A-norcholestane (**8**) in an over-all yield of 32% from the diol **3**.

SCHEME II



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(9) An attempt to convert **3** into 3,5-α-dibromo-3,5-seco-A-norcholestane with triphenyldibromophosphorane[10] was unsatisfactory.

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Experimental Section

The melting points were determined on a Mel-Temp apparatus and are uncorrected. Most of the reactions were run under an inert atmosphere and anhydrous conditions. Analyses were performed by A. Bernhardt, Mülheim, Ruhr (Germany), and Galbraith Laboratories, Knoxville, Tenn.

3,5-Seco-A-norcholestane-3,5-diol Epimers (2 and 3).—A suspension of 97.0 g (0.24 mol) of 5-oxo-3,5-seco-A-norcholestan-3-oic acid (1) in 1 l. of anhydrous ether was added over a period of 40 min to 27.0 g (0.71 mol, a fourfold excess) of $LiAlH_4$ suspended in 400 ml of anhydrous ether and cooled in an ice bath. After stirring overnight the excess $LiAlH_4$ was destroyed by cautious addition of ethanol and then water. A precipitate was filtered off, washed, and dried; the ether was then evaporated to yield 89 g (94%) of solid. There was no carbonyl peak in its ir spectrum. Tlc of the product (ethanol–chloroform, 1:12, on silica gel) showed two major spots with R_f values of 0.29 and 0.37. Attempts to separate these by recrystallization from benzene or acetone were unsuccessful.

The epimers were separated by chromatography on a 2 × 20 in. silica gel column employing chloroform as the initial solvent. Tlc was used to check the fractions. The faster migrating epimer started coming off after several liters of solvent had passed through the column. A small amount (2–3% of the sample) of a fast moving side product was discarded with the forerun. After several more liters of solvent had passed through, the eluate contained a mixture of the two epimers. At this point an ether–chloroform mixture (1:10) was used until the last of the faster epimer had been eluted. The column was then washed with tetrahydrofuran, the slower epimer coming off in the first 300 ml. It was found that the best procedure was to overload the column with the epimeric mixture (about 40 g) and to simply rechromatograph the middle, mixed fractions.

3-Acetoxy-3,5-seco-A-norcholestan-5β-ol (5).—A solution of 17.50 g (0.045 mol) of 3 in 200 ml of pyridine was cooled in an ice–salt bath. To this was added dropwise 3.8 ml (a 5% excess) of acetyl chloride over a 5-min period. The reaction was cooled and vigorously stirred during and after addition. It was continued for 11 hr while the bath gradually warmed to room temperature.

The solution was poured into ice water and extracted with ether. The extract was washed with ice-cold 5% HCl until the wash remained acidic, and then with saturated NaCl solution. The extract was dryed over anhydrous Na_2SO_4 and the ether was removed to yield an oil. This was chromatographed with chloroform on a 2 × 20 in. silica gel column to yield 1.58 g of material which tlc showed to be mostly the monoacetate. The column was washed with tetrahydrofuran to give 3.7 g of solid. Since this contained a considerable amount of the starting diol, it was processed a second time as above.

All of the monoacetate fractions were combined and recrystallized from acetone–water to yield 15.04 g (83%) of 6, mp 84–86°. A small portion was recrystallized again, leading to a product melting at 85–87° with $[\alpha]^{28}D$ + 17.5° ($CHCl_3$). *Anal.* Calcd for $C_{28}H_{50}O_3$: C, 77.36; H, 11.59. Found: C, 77.83; H, 11.75.

5α-Chloro-3,5-seco-A-norcholestan-3-ol (7).—To a solution of 16.53 g (0.038 mol) of 5 in 150 ml of CCl_4 was added 50.0 g (0.19 mol) of Ph_3P. The reaction was carried out in a flamed-out flask under argon. The steroid had been dried overnight in a vacuum desiccator over Drierite and the Ph_3P was dried in an oven at 65°. The CCl_4 had been freshly distilled from P_2O_5.

The reaction mixture was magnetically stirred and kept in a 95° bath. The mixture soon became cloudy and a white precipitate started to form. After reacting for 1.75 hr it gradually turned yellow. Some ethanol was then added (the solution turned colorless) and the reaction was heated for an additional 0.75 hr. After the reaction mixture was concentrated to about one-half its original volume, 50 ml of 5% HCl was added along with about 100 ml of 95% ethanol to yield a homogeneous solution. This was refluxed for 7 hr and then stirred at room temperature for an additional 10-hr period. The solution was poured into water and extracted twice with ether. The extract was washed with water, dilute $NaHCO_3$ solution, and saturated NaCl solution, filtered through anhydrous Na_2SO_4, and brought to dryness. The residue was extracted with 40–60° ligroin and filtered to remove insoluble Ph_3PO. The filtrate was twice more concentrated and filtered, then evaporated to dryness to yield a yellow oil. The first fractions to come off contained the unhydrolized ester (tlc), and this was collected and refluxed in a solvent mixture consisting of 100 ml of ethanol, 4 ml of concentrated HCl, and 25 ml of water for 17 hr and then processed as above to purify it.

The fractions from all of the above operations that contained the desired product were combined to yield 11.68 g of oil which slowly solidified. On tlc the crude product showed three connected spots, with R_f values ($CHCl_3$ on silica gel) of 0.30, 0.35, and 0.39. From a previous run it was known that the spot with R_f 0.30 was caused by the desired product.

The crude material was recrystallized twice from acetone–water to give 7.10 g (45%) of 7 as white needles, mp 102–110°. A small amount was recrystallized further to give the analytical sample, mp 108–110°.

Anal. Calcd for $C_{26}H_{47}ClO$: C, 75.96; H, 11.53. Found: C, 76.61; H, 11.79.

3,5-α-Dichloro-3,5-seco-A-norcholestane (8).—A solution of 7.10 g (0.0173 mol) of 7 in 50 ml of CCl_4 was prepared in a flamed-out flask under argon. To this was added 21.0 g (0.08 mol) of Ph_3P and the reaction was stirred while immersed in a bath kept at 100°. A white precipitate soon formed and after 60 min the solution suddenly turned yellow. Ethanol (40 ml) and dilute HCl (1 ml of concentrated HCl + 3 ml of water) were then added (the solution became colorless) and the mixture was refluxed for an additional hour. It was poured into water and worked up as above. Tlc (40–60° ligroin on silica gel) of the resulting crude oil showed two major spots with R_f values of 0.60 and 0.83 plus several much smaller spots.

The oil was chromatographed on a 2 × 20 in. silica gel column using 40–60° ligroin. All fractions yielded oils, but the one containing only the spot with R_f 0.60 crystallized on standing overnight. Using seed crystals, this fraction and all other fractions containing that spot were crystallized from acetone as prisms. The total yield of 6.39 g (86%) of 8 was obtained, melting between 90 and 93°. The highest melting crops melted at 91–93° with $[\alpha]^{29}D$ +33.8° ($CHCl_3$).

Anal. Calcd for $C_{26}H_{46}Cl_2$: C, 72.70; H, 10,80. Found: C, 72.64; H, 10.47.

Registry No.—**5**, 21273-50-7; **7**, 21273-51-8; **8**, 21273-52-9.

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(+)-β-Eudesmol O-α-L-Arabopyranoside. A New Sesquiterpene Glycoside from *Machaeranthera tanacetifolia* (H.B.K.) Nees (Compositae)[1]

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We report the isolation and structure determination of the first glycoside of β-eudesmol. Chloroform extraction of air-dried plants of *Machaeranthera tanacetifolia* collected near Gail, Texas, afforded in 0.43% yield the new glycoside, $C_{20}H_{34}O_5$, mp 129–130°. The evidence presented below established that the compound is (+)-β-eudesmol O-α-L-arabopyranoside (1).

The new glycoside afforded (+)-β-eudesmol[2] upon periodic acid oxidation and β-L-arabinose upon hydrolysis with 0.1 *N* sulfuric acid; both products were identical with authentic samples. Nmr data for both the glycoside and its triacetate indicated that the sugar

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