A fraction with R_f 0.25 contained **4-bromo-5-methyltropone** (2), yield 90 mg (45%), m.p. 80 °C (after recrystallization from benzene). IR (Nujol), ν/cm^{-1}: 1650 (C=O). UV (EtOH), λ_{max}/nm (ε): 237 (16980), 328 (7580). ^1H NMR ($CDCl_3$), δ: 2.47 (s, 3 H, Me); 6.68 (dd, H(2), $^3J_{H(2),H(3)}$ = 12.5 Hz, $^4J_{H(2),H(7)}$ = 3 Hz); 6.86 (dd, H(7), $^3J_{H(7),H(6)}$ = 12.5 Hz, $^4J_{H(7),H(2)}$ = 3 Hz); 7.05 (d, H(6), $^3J_{H(6),H(7)}$ = 12.5 Hz); 7.48 (d, H(3), $^3J_{H(3),H(2)}$ = 12.5 Hz). The compound obtained is similar to that earlier reported.[5]

A fraction with R_f 0.12 contained **4-methyltropone** (3) that was isolated as a yellow light oil; yield 24 mg (20%). ^1H NMR ($CDCl_3$), δ: 2.27 (H(4), $^4J_{H(4),H(5)}$ = 1.3 Hz, $^6J_{H(4),H(7)}$ = 0.7 Hz); 6.82 (H(5), $^3J_{H(5),H(6)}$ = 8.3 Hz, $^4J_{H(5),H(7)}$ = 1.2 Hz); 6.91 (H(7), $J_{H(7),H(6)}$ = 12.0 Hz); 6.95 (H(3), $^4J_{H(3),H(5)}$ = 1.7 Hz); 6.99 (H(2), $^3J_{H(2),H(3)}$ = 12.6 Hz, $^5J_{H(2),H(5)}$ = 0.5 Hz, $^4J_{H(2),H(7)}$ = 1.9 Hz); 7.01 (H(6), $J_{H(6),H(5)}$ = 8.3 Hz). MS, m/z: 120 [M^+]. The compound obtained is similar to that earlier reported.[1]

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Germylated steroids
1. Hydrogermylation of conjugated steroid enones

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Steroids germylated in position 16 were prepared for the first time by hydrogermylation of conjugated steroid enones. The addition of trichlorogermane to a conjugated Δ^{16}-double bond leads not only to an α-isomer, which is typical of steroids, but to a β-isomer as well. The isolated Δ^5-double bond is not involved in this reaction.

Key words: organogermanium compounds, germylated steroids.

Significant interest has been drawn in recent years to the biological effects of organogermanium compounds.[1] We might consider 1968, when the biological activity of 2-carboxyethylgermaniumsesquioxide was discovered,[2] as the beginning of the use of organogermanium compounds in medicine. Since that time, intense studies into the synthesis and biological action of organogermanium compounds have been carried out, and over a thousand papers and patents, including reviews and monographs, have been published. As a result, a lot of organogermanium compounds have been synthesized that possess antitumor and antiviral properties, serve as inductors of interferon and activators of macrophages, display the immuno-modulating effect, *etc.* At the same time, organogermanium compounds, unlike organosilicon and organotin compounds, are virtually nontoxic.

The compound that has been studied most thoroughly and used most widely is 2-carboxyethylgermaniumsesquioxide (trademark Ge-132), already mentioned above. This compound is synthesized by the hydrogermylation of acrylic acid with trichlorogermane followed by hydrolysis. This procedure was first suggested in Russia.[3]

There are no germanium-substituted natural compounds, steroids in particular, among the organogermanium compounds obtained to date. Although ste-

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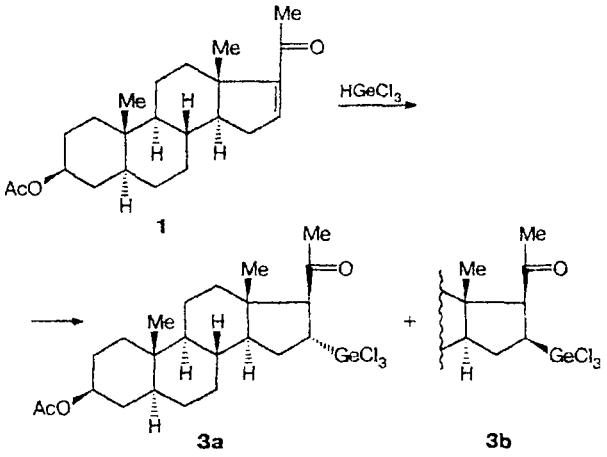
roids themselves have high biological activity, their spectrum of action is usually limited, mainly to hormonal effects. Antitumor, immuno-modulating, and other types of activity are usually not characteristic of them. It therefore seemed interesting to synthesize germanium-modified steroids and find out how such a modification affects their biological action.

We chose conjugated natural enones, 3β-acetoxy-5α*H*-pregn-16-en-20-one (**1**) and 3β-acetoxypregna-5,16-dien-20-one (**2**), that serve as the main starting material in the production of steroid drugs, as objects of this study.

The hydrogermylation of compound **1** with trichlorogermane etherate in CH_2Cl_2 occurs rapidly and regioselectively both at room temperature and at lower temperatures, to give a mixture of the 16α- and 16β-isomers of 3β-acetoxy-16-trichlorogermyl-5α*H*-pregnan-20-one (**3a** and **3b**, respectively). The configuration of the 16β-isomer **3b** was established by X-ray diffraction analysis, whose results will be reported separately.

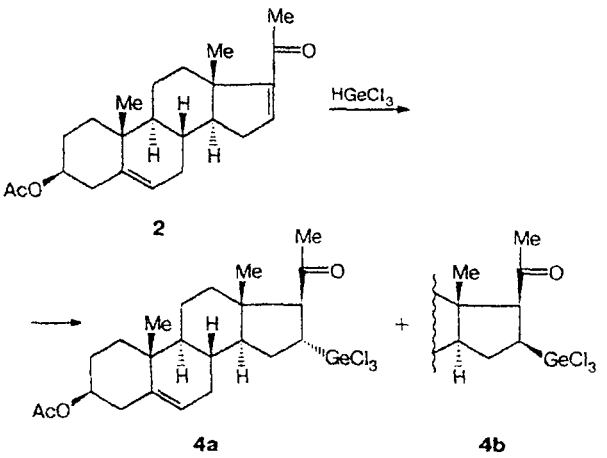


The ratio of the resulting 16α-/16β-isomers depends on the reaction temperature and varies from 7 : 3 at −25 °C to 6 : 4 at −20 °C. The subsequent boiling of the reaction mixture for 3 h results in a further increase in the content of the 16β-isomer **3b** to give a 4.5 : 5.5 ratio.

The hydrogermylation of enone **2** occurs in a similar way. The isolated Δ^5-double bond is not affected by hydrogermylation. The configurations of the isomers were suggested on the basis of comparing the ^{1}H NMR spectra of compounds **4a,b** and **3a,b**.

The ^{1}H NMR spectra of compounds **3** and **4** do not contain signals of vinyl protons at C(16) atom, which are typical of enones **1** and **2**, but do contain signals of vicinal protons at C(16) and C(17). The distinctive feature of the spectra of 16β-isomers **3b** and **4b** is also a stronger downfield shift of the signals of methyl group protons at positions 18 and 21 in comparison with the shift for similar groups in the 16α-isomers.

Thus, the hydrogermylation of conjugated steroid 16-en-20-ones afforded 16α- and 16β-trichlorogermyl-



substituted steroids that can be transformed into germanium analogs of known drugs by modifications of the steroid skeleton. The high reactivity of the Ge—Cl bonds makes it possible to modify the trichlorogermyl group to give germatrans, sesquioxides, and other derivatives. Studies along these directions will be continued.

Experimental

^{1}H NMR spectra were recorded on a Bruker WM-250 spectrometer (250 MHz) in $CDCl_3$. The completion of the reactions was monitored by TLC on Silufol plates. The isomer ratios were determined from the ratios of intensities of signals of the Me groups at position 21 in the ^{1}H NMR spectra.

3β-Acetoxy-16α- and -16β-trichlorgermyl-5α*H*-pregnan-20-ones (3a,b). Trichlorogermane etherate (0.84 g, 2.5 mmol) was added to a solution of 3β-acetoxy-5α*H*-pregn-16-en-20-one (**1**) (0.72 g, 2 mmol) in CH_2Cl_2 (3 mL). The reaction mixture was kept for ~1 h at −20 °C and then refluxed for 3 h. The solvent, ether, and excess trichlorogermane were removed *in vacuo*. This procedure was repeated three times, with the addition of CH_2Cl_2 (1—2 mL) every time. The oily residue was dissolved in ether (2 mL). The precipitate that formed after 1—2 days was filtered off to give 0.5 g (46%) of 3β-acetoxy-16β-trichlorogermyl-5α*H*-pregnan-20-one (**3b**), m.p. 178—190 °C (from ether). ^{1}H NMR, δ: 0.70 (s, 3 H, 18-Me); 0.83 (s, 3 H, 19-Me); 2.03 (s, 3 H, AcO); 2.31 (s, 3 H, 21-Me); 2.60 (m, 1 H, H(16)); 3.10 (d, 1 H, H(17), J = 10 Hz); 4.70 (m, 1 H, H(3)). After the isomer **3b** was isolated, 0.3 g (28%) of 3β-acetoxy-16α-trichlorogermyl-5α*H*-pregnan-20-one (**3a**), m.p. 170—175 °C (from ether), was precipitated with hexane from the mother liquor. ^{1}H NMR, δ: 0.63 (s, 3 H, 18-Me); 0.83 (s, 3 H, 19-Me); 2.03 (s, 3 H, AcO); 2.20 (s, 3 H, 21-Me); 2.85 (d, 1 H, H(17), J = 10 Hz); 3.33 (m, 1 H, H(16)); 4.70 (m, 1 H, H(3)).

3β-Acetoxy-16α- and -16β-trichlorogermylpregn-5-en-20-ones (4a,b). A similar procedure, starting from 3β-acetoxypregna-5,16-dien-20-one (**2**), afforded a mixture of isomers **4a** and **4b**. Separation performed as described above yielded 0.47 g (28%) of 3β-acetoxy-16α-trichlorogermylpregn-5-en-20-one (**4a**), m.p. 126—133 °C (from ether), and 0.36 g (22%) of 3β-acetoxy-16β-trichlorogermylpregn-5-en-20-one (**4b**), m.p. 175—182 °C (from ether). ^{1}H NMR, δ: for 16α-isomer (**4a**),

0.67 (s, 3 H, 18-Me); 1.03 (s, 3 H, 19-Me); 2.04 (s, 3 H, AcO); 2.22 (s, 3 H, 21-Me); 2.86 (d, 1 H, H(17), J = 10 Hz); 3.36 (m, 1 H, H(16)); 4.61 (m, 1 H, H(3)); 5.40 (m, 1 H, H(6)); for 16β-isomer (**4b**), 0.73 (s, 3 H, 18-Me); 1.03 (s, 3 H, 19-Me); 2.04 (s, 3 H, AcO); 2.34 (s, 3 H, 21-Me); 2.62 (m, 1 H, H(16)); 3.12 (d, 1 H, H(17), J = 10 Hz); 4.61 (m, 1 H, H(3)); 5.40 (m, 1 H, H(6)).

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X-ray diffraction study of 1-[1-benzoyl-2-(2-furyl)vinyl]-2-dicyanomethylene-1,2-dihydropyridine

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1-[1-Benzoyl-2-(2-furyl)vinyl]-2-dicyanomethylene-1,2-dihydropyridine was studied by X-ray structural analysis. The compound under study occurs as a Z isomer with respect to the central vinyl fragment.

Key words: 2-dicyanomethylene-1-vinyl-1,2-dihydropyridine, X-ray structural analysis.

As part of continuing studies of the structures of 1,2-dihydropyridines,[1] which contain a strong electron-withdrawing dicyanomethylene substituent at position 2 of the pyridine ring, in this work we studied the molecular geometry of 1-[1-benzoyl-2-(2-furyl)vinyl]-2-dicyanomethylene-1,2-dihydropyridine (**1**) by X-ray structural analysis. The overall view of molecule **1** is shown in Fig. 1. The bond lengths and bond angles are given in Tables 1 and 2, respectively.

As in the case of 1-[1-(4-chlorobenzoyl)-2-ethoxyvinyl]-2-dicyanomethylene-1,2-dihydropyridine (**2**) studied previously,[1] compound **1** occurs as a Z isomer with respect to the virtually planar vinyl fragment (the N(1)—C(7)—C(15)—C(16) torsion angle is −2.1°). In molecule **1**, the 1,2-dihydropyridine ring is planar (the deviations of the atoms from the mean plane are no more than ±0.009 Å), whereas in molecule **2**, this ring adopts a substantially flattened half-chair conformation. The observed π,π-conjugation between the planar

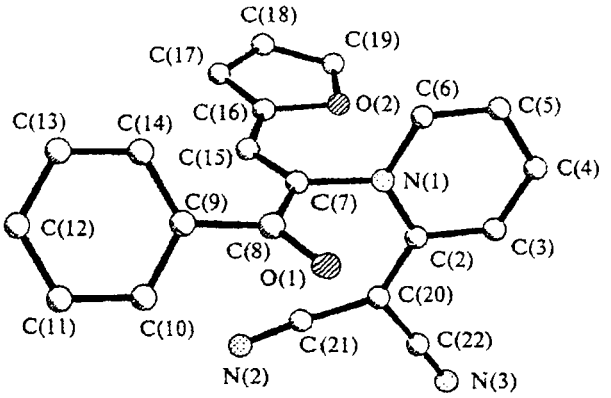

Fig. 1. Overall view of molecule **1**.

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