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STEROL 5,8-ENDOPEROXIDES

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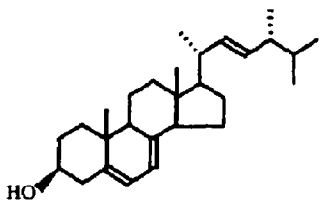
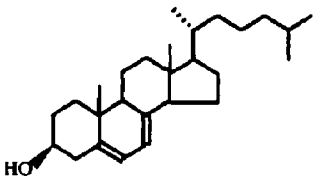
In this review the structures and properties of sterol 5,8-endoperoxides and methods for synthesizing them are discussed.

Among natural steroids, a special place is occupied by those the reasons for the existence of which and their fine biological roles in plants and animals have so far remained unexplained. Since the biosynthesis of steroids requires a large expenditure of energy and the presence of a considerable number of special enzymes, it is difficult to expect that living organisms would produce substances that are not at all necessary to them. For this reason, an elucidation of the exact purpose of the so-called substances of the secondary metabolism, including steroids, is one of the necessary conditions for understanding the mechanisms of the functioning of biological systems.

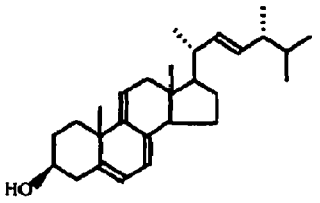
One of the groups of natural steroids with unexplained biological functions consists of steroid 5,8-endoperoxides. These substances belong to the group of oxidized steroid derivatives and contain a 5,8-endoperoxide grouping in addition to the fragments characteristic of such derivatives. This structural element arises as the result of the real or formal addition of an oxygen molecule to a 5,7-diene system in the molecule of the initial steroid, for example, ergosterol, 7-dehydrocholesterol, and 9(11)-dehydroergosterol.



Ergosterol



7-Dehydrocholesterol



9(11)-Dehydroergosterol

Table 1 brings together information on the structures and some properties of the natural 5,8-endoperoxides known at the present time. In the scientific literature such terms as "steroid peroxides" or "5,8-epidioxysteroids," in addition to those given above, are used for naming these compounds, and, therefore, in the Table wherever possible we have tried to take these variant names into account. The compounds themselves are arranged in order of increasing size of the carbon skeleton.

The best-known representative of the group of compounds under discussion is ergosterol 5,8-endoperoxide (**8**), first isolated from the mycelium of the fungus *Aspergillus fumigatus* [1]. The proof of the structure of this compound caused no difficulties since it proved to be identical with a specimen obtained earlier in the photooxidation of ergosterol in the presence of the sensitizer eosin [2—4]. It was later found that peroxide (**8**) is represented extremely widely in the plant and animal kingdoms [5—42].

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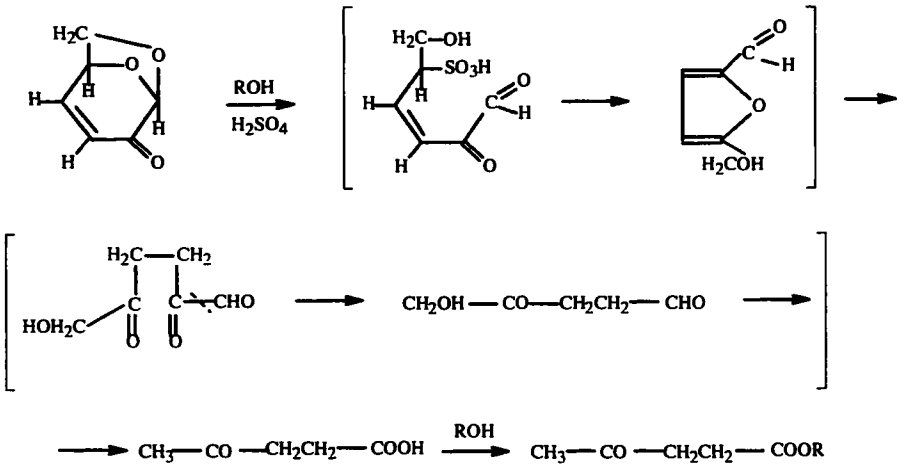
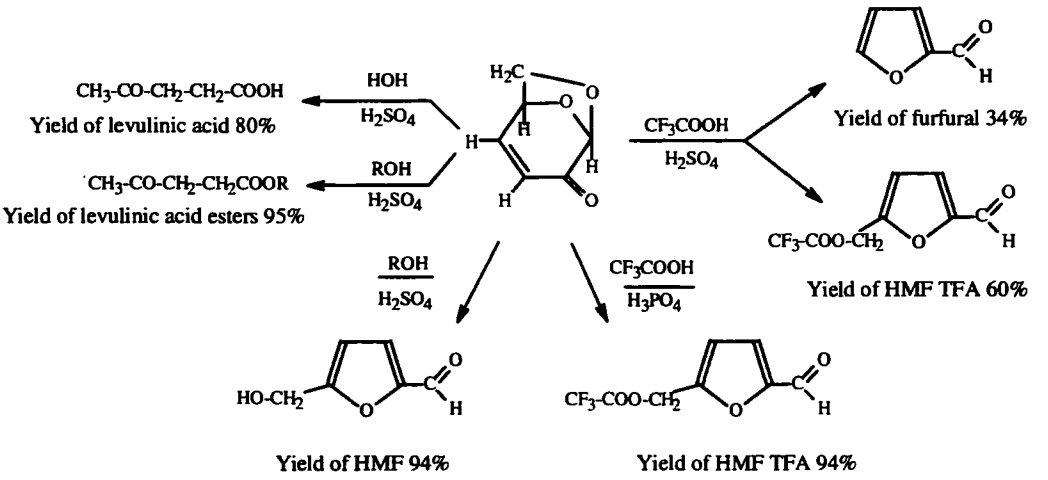


Scheme 2

We have established that in an acid medium levoglucosenone is capable of undergoing conversion into hydroxymethylfurfural, the further transformation of which depends on the nature of the solvent and the conditions of the process. The possibility has been shown of the quantitative production from levoglucosenone of levulinic acid, hydroxymethylfurfural derivatives, and levulinic acid derivatives, the yields of some products reaching 94—95%.

The experimental results obtained on the transformation of levoglucosenone at the anhydroglucose bond in the presence of catalysts of the acid type permit us to give general scheme of the processes then taking place:



Scheme 3

It must be mentioned that the reactions of levoglucosenone at the anhydroglucose bond are not apparently exhausted by these transformations, and this explains the interest of researchers in the chemical transformations of levoglucosenone.

EXPERIMENTAL

Levoglucosenone was obtained as in [21] by the thermolysis of cellulose in the presence of 5% of $CuSO_4$ in a current of superheated steam, and it was extracted from the resulting aqueous solutions with diethyl ketone and purified by vacuum distillation. After two distillations the purity of the levoglucosenone amounted to 99.7% according to GLC and ^{1}H NMR. The

GLC of levoglucosenone and its transformation product was conducted on a Chrom-5 chromatograph with columns having dimensions of 0.4 × 100 cm (5% of PEGA on Chromaton N-AW-HMDS, 0.20—0.25 mm fraction) and 0.4 × 200 cm (5% of XE-60 on Chromaton N-AW-HMDS, 0.20—0.25 mm fraction), using a flame-ionization detector. The temperature of the column thermostat was 100—200°C, that of the evaporator and detector 230°C, and the carrier gas was helium; hydrogen—oxygen flame.

Quantitative determinations of the reaction products were made by the absolute calibration of all the individual substances, 1-5 μl of specimen being injected in the evaporator of the chromatograph. ^{1}H, ^{13}C, ^{19}F, and ^{17}O NMR spectra were recorded on a Tesla BS-567 A instrument with working frequencies of 100 and 94 MHz (^{1}H and ^{19}F) and on a Bruker CXP-300 instrument with working frequencies of 25.14 an 40.69 MHz (^{13}C and ^{17}O).

The chromato-mass spectrometric investigations of the products were carried out in a capillary column, 0.25 mm × 40 m, with OV-1, connected to a Finnigan 4023 Automated GC/MS System (the investigations were conducted by V. N. Sidel'nikov of the G. K. Boreskov Institute of Catalysis, Novosibirsk). Analytical conditions: programmed rise in temperature from 20 to 250°C (5 degrees per minute), isometric regime for 30 min, sample volume 0.3—0.5 μl at a split of 1/50.

The reactions of levoglucosenone in various media were conducted in a sealed glass reactor with a capacity of 3 ml permitting samples to be taken for GLC under hermetic conditions, or in sealed ampuls.

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