THE REACTION OF 3-ACETYL-2,2-DIMETHYLOXIRANE WITH PHENOLS UNDER CONDITIONS OF ACID CATALYSIS

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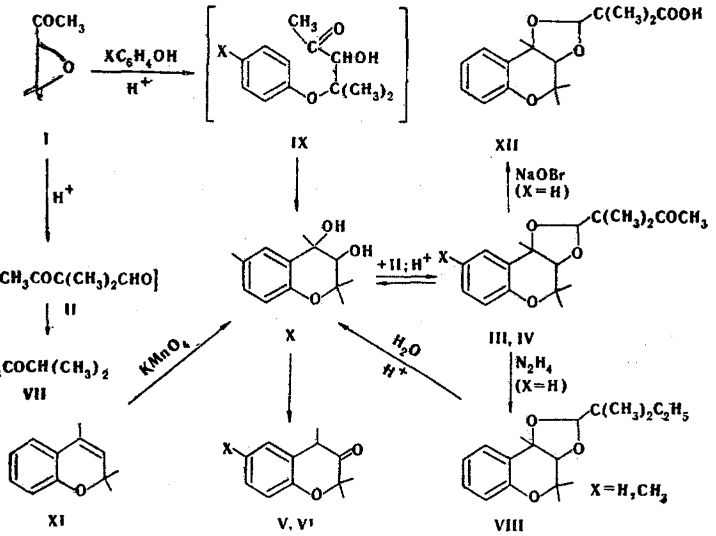
The reaction of 3-acetyl-2,2-dimethyloxirane with phenol and p-cresol in the presence of sulfuric acid at 70-90°C forms derivatives of 3a,9b-dihydro-4H-1,3-dioxolo[4,5-c]chromene, and also 2,2,4-trimethyl- and 2,2,4,6-tetramethylchroman-3-ones.

In the presence of basic catalysts, 3-acetyl-2,2-dimethyloxirane (I) reacts with phenols to form 2-hydroxy-1-phenoxy ketones, which decompose under the experimental conditions into phenoxyacetones and acetone [1].

In the present work it has been established that the reaction of the oxirane (I) with phenol and p-cresol in the presence of catalytic amounts of sulfuric acid at 70-90°C takes place with the formation of 1-hydroxy-2-phenoxy ketones which cyclize under the conditions of the experiment to the corresponding chromandiols which, with the product of the isomerization of the oxirane (I) – the oxo aldehyde (II) [2] – form the dioxolanes (III) and (IV). In addition, very small amounts of the corresponding chroman-3-ones (V) and (VI), and also methyl isopropyl ketone (VII), which is the product of the ketonic decomposition of the oxo aldehyde (II), have been isolated.



The ketone (III) was reduced by the Kizhner–Wolf [Wolf–Kishner] method to the 1,3-dioxolane (VIII), the hydrolysis of which led to 2,2-dimethylbutanal (XIII) and the chromanone (V). In its turn, the structure of the latter was shown by independent synthesis – by the dehydration of cis-2,2,4-trimethylchroman-3,4-diol (X), which was obtained by the hydroxylation of 2,2,4-trimethyl-2H-chromene (XI) [4].

The hydrolysis of the 1,3-dioxolane (III) also gave the chromanone (V) and methyl isopropyl ketone (VII). The oxidation of compound (III) with sodium hypobromite gave the acid (XII), which confirms the presence of an acetyl group in the molecule of the 1,3-dioxolane (III).

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Thus, all these facts permit us with complete justification to consider that compounds (III) and (VIII) are 1,3-dioxolanes in which the chromandiol (X) acts as the glycol component and the oxo aldehyde (II) in the case of compound (III) or the aldehyde (XIII) in the case of the 1,3-dioxolane (VIII) acts as the carbonyl component and, consequently, compounds (III, VIII, and XII) have the respective structures of 2-(2-methyl-3-oxo-2-butyl)-, 2-tert-pentyl- and 2-(2-carboxy-2-propyl)-4,4,9b-trimethyl-3a,9b-dihydro-1,3-dioxolo-[4,5-c]chromenes.

The chemical structure of compounds (III, V, VIII, and XIII) is also completely confirmed by their IR and PMR spectra. The structures of the 1,3-dioxolo[4,5-c]chromene (IV) and the chromanone (VI) were determined unambiguously by a comparison of their IR and PMR spectra with the spectra of the chroman (III) and the chromanone (V).

EXPERIMENTAL

The PMR spectra were recorded on an HA-100-D-15 spectrometer with TMS as internal standard. The IR spectra of solutions of the substances in carbon tetrachloride were recorded on a UR-20 instrument. The end of the reactions and the individualities of the substances were determined by TLC in a nonfixed layer of alumina of activity grade II.

2-(2-Methyl-3-oxo-2-butyl)-4,4,9b-trimethyl-3a,9b-dihydro-1,3-dioxolo[4,5-c]chromene (III). With stirring and cooling, 0.01 ml of concentrated sulfuric acid was added to a mixture of 29 g (0.31 mole) of phenol and 11.4 g (0.1 mole) of the oxirane (I) [5]. The temperature of the mixture was raised rapidly to 70-90°C and was then allowed to fall to that of the room over 2 h. The reaction product was poured into a cooled 15% aqueous solution of caustic potash. The colorless crystals that deposited were filtered off and washed with water to give 9.1 g (60%) of (III). mp 105-106°C (from methanol). IR spectra, cm^{-1}: 1718 (CO), 1134, 1161, 1080 (–O–CH–O–), 1230 (–O–Ar), 3050, 1620, 1590, 1490, 760 (o-C_6H_4). PMR spectrum* (60 MHz, solution in CCl_4, internal standard HMDS), δ, ppm: 0.98 [s, $C(CH_3)_2$], 1.16 (s, CH_3), 1.44 (s, CH_3), 1.69 (s, CH_3), 1.97 (s, $COCH_3$), 3.5 (s, O–CH–C), 4.54 (s, O–CH–O), 6.8-7.2 (m, o-C_6H_4). Found: C 70.9; 71.1; H 8.1; 8.1%; mol. wt. 301; 296 (cryoscopically in benzene). $C_{18}H_{24}O_4$. Calculated: C 70.0; H 7.9%; mol. wt. 304. 2,4-Dinitrophenylhydrazone (DNPH), mp 149-150°C (from methanol). Found: N 11.1; 11.4%. $C_{24}H_{28}N_4O_7$. Calculated: N 11.5%.

The filtrate was extracted repeatedly with pentane, and the extracts were washed with water and dried with sodium sulfate. After the removal of the solvent, distillation of the residue gave 1.1 g of methyl isopropyl ketone (VII) (bp 92-94°C, n_D^{20} 1.3860; DNPH, mp 118-119°C [6]) and 1.6 g of 2,2,4-trimethylchroman-3-one (V) (colorless liquid with a smell of camphor, bp 103-104°C (12 mm); n_D^{20} 1.5200; d_4^{20} 1.0771). IR spectrum, cm^{-1}: 1738 (CO), 1260, 1171 (O–C_6H_5), 3070, 3050, 1620, 1595, 1490, 950, 770 (o-C_6H_4). PMR spectrum (CCl_4): δ, ppm: 1.24 (s, CH_3), 1.35 (s, CH_3), 1.38 (d, CH_3, J = 7 Hz), 3.48 (q, CH, J = 7 Hz), 6,8-7.2 (m C_6H_4). Found: C 75.4; 75.7; H 7.5; 7.3%; MR_D 53.62. $C_{12}H_{14}O_2$. Calculated: C 75.4; H 7.4%; MR_D 53.47.

2-(2-Methyl-3-oxo-2-butyl)-4,4,8,9b-tetramethyl-3a,9b-dihydro-1,3-dioxolo[4,5-c]chromene (IV) was obtained in a similar manner to the preceding compound with a yield of 29%. mp 92-93°C (from methanol). IR spectrum, cm^{-1}: 1720 (CO), 1155, 1140, 1101, 1080 (O–CH–O), 1230 (O–Ar), 3030, 1622, 1505 (substituted aromatic nucleus). PMR spectrum, δ, ppm: 0.96 (s, CH_3), 0.98 (s, CH_3), 1.11 (s, CH_3), 1.38 (s, CH_3), 1.62 (s, CH_3), 1.97 (s, $COCH_3$), 2.23 (s, CH_3–Ar), 3.47 (s, O–CH–C), 4.53 (s, O–CH–O), 6.53-7.06 (m, three aromatic protons). Found: C 71.6; 71.7; H 8.0; 8.2%. $C_{19}H_{26}O_4$. Calculated: C 71.8; H 8.2%. Also isolated was 1.4 g of 2,2,4,6-tetramethylchroman-3-one (VI), bp 135-136°C (17 mm); n_D^{20} 1.5175; d_4^{20} 1.0582. IR spectrum, cm^{-1}: 1738 (CO), 1265, 1173 (O–C_6H_3), 3040, 1630, 1622, 1501, 953, 840 (substituted aromatic nucleus). PMR spectrum (CCl_4), δ, ppm: 1.20 (s, CH_3), 1.36 (s, CH_3), 1.40 (d, CH_3, J = 7 Hz), 2.26 (s, CH_3–Ar), 3.46 (q, CH, J = 7 Hz), 6.8 (m, three aromatic protons). Found: C 76.4; 76.3; H 7.8; 7.8%; MR_D 58.38. $C_{13}H_{16}O_2$. Calculated: C 76.42; H 7.9%; MR_D 58.09. DNPH, mp 175-176°C (from methanol). Found: N 14.8; 15.1%. $C_{19}H_{20}N_4O_5$. Calculated: N 14.8%.

2-tert-Pentyl-4,4,9b-trimethyl-3a,9b-dihydro-1,3-dioxolo[4,5-c]chromene (VIII). A mixture of 30.4 g of the chromene (III), 15 ml of 85% hydrazine hydrate, and 22.4 g of finely ground caustic potash in 100 ml of diethyleneglycol was boiled for two hours and then a mixture of hydrazine and water was slowly distilled off until the temperature of the reaction mixture reached 195°C. This temperature was maintained until the evolution of nitrogen ceased. Then the reaction mixture was diluted with water and extracted with ether,

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*Abbreviations here and below: s – singlet; d – doublet; t – triplet; q – quartet, m – multiplet.

the extract was dried with calcium chloride, the solvent was driven off, and the residue was recrystallized to give 24.0 g (78%) of (VIII) with mp 63-64°C (from methanol). IR spectrum, cm^{-1}: 1160, 1172, 1115, 1075 (O−CH−O), 3050, 1618, 1593, 1490, 760 (o-C_6H_4), 1230 (O−C_6H_4). PMR spectrum (60 MHz, solution in CCl_4), δ, ppm: 0.76 [s, $C(CH_3)_2$], 1.15 (s, CH_3), 1.43 (s, CH_3), 1.65 (s, CH_3), 0.71 (t, CH_3, J=6.7 Hz), 1.16 (q, CH_2, J=6.7 Hz), 3.44 (s, O−CH−C), 4.14 (s, O−CH−O), 6.8-7.2 (m, o-C_6H_4). Found: C 74.3; 74.2; H 8.9; 8.8%. $C_{18}H_{26}O_3$. Calculated: C 74.5; H 9.0%.

2-(2-Carboxy-2-propyl)-4,4,9b-trimethyl-3a,9b-dihydro-1,3-dioxolo[4,5-c]chromene (XII). With cooling to −2°C and stirring, 1.7 ml of bromine and then a solution of 1.02 g of compound (III) in 10 ml of dioxane were added to a solution of 4 g of caustic soda in 20 ml of water at such a rate that the temperature of the reaction mixture did not exceed 10°C. The mixture was stirred for another 1 h at room temperature. The bromoform was distilled off with steam and the aqueous solution was mixed with a solution of 1 g of sodium pyrosulfite in 15 ml of water and acidified with hydrochloric acid, which gave 0.78 g (77%) of the acid (XIII), mp 198-200°C. Found: C 66.4; 66.5; H 7.5; 7.4%; equiv. 306; 305. $C_{17}H_{18}O_5$. Calculated: C 66.5; H 7.2%; equiv. 306.

Hydrolysis of the Chromene (III). A mixture of 15.2 g of (III) and 23 ml of 80% formic acid was boiled for 13 h. The solution was diluted with water, neutralized with sodium bicarbonate, and extracted with ether, the extract was dried with sodium sulfate, the solvent was driven off, and the residue was fractionated through a Vigreux column (30 cm), giving 2.3 g of methyl isopropyl ketone and 7.5 g (79%) of 2,2,4-trimethylchroman-3-one (V) [bp 102-104°C (12 mm); n_D^{20} 1.5195].

Hydrolysis of the 1,3-Dioxolane (VIII). The reaction was performed similarly to the preceding experiment (the reaction mixture was heated for 1 h 30 min). From 15 g of (VIII) was obtained 3.8 g (73%) of 2,2-dimethylbutanal (XIII) (bp 102-104°C; n_D^{20} 1.3974; DNPH, mp 144-145°C [3]). PMR spectrum (CCl_4), δ, ppm: 0.98 [s, $C(CH_3)_2$], 0.50 (t, CH_3), 1.61 (q, CH_2), 9.8 (s, CHO). Also obtained was 7.9 g (80%) of 2,2,4-trimethylchroman-3-one with bp 102-103°C (11 mm); n_D^{20} 1.5196; DNPH, mp 163-164°C.

cis-2,2-4-Trimethylchroman-3,4-diol (X). With cooling to −18°C and stirring, a solution of 10.9 g (0.07 mole) of potassium permanganate and 9.4 g (0.08 mole) of magnesium sulfate in 218 ml of water was added by drops over 2 h 30 min to a solution of 15.1 g (0.09 mole) of 2,2,4-trimethyl-2H-chromene (XI) obtained by the thermal decomposition of 4-(4-hydroxyphenyl)-2,2,4-trimethylchroman (mp 165-166°C [7]) in ethanol. The manganese dioxide was filtered off and the residue was washed with 250 ml of boiling water. The filtrate was evaporated in vacuum with the aid of a rotary evaporator. The dry residue was boiled with 50 ml of anhydrous methanol, and elimination of the solvent from the extract gave 7.4 g (42%) of the diol (X) with mp 136-137°C (from carbon tetrachloride). Found: C 68.9; 68.9; H 7.0; 7.1; 1,2-diol 99.6, 99.2%. $C_{12}H_{16}O_3$. Calculated: C 69.2; H 7.1%.

Dehydration of the Chromandiol (X). This was performed in a similar manner to the hydrolysis of the chromene (VIII). From 6.4 g of (X) was obtained 4.9 g (84%) of 2,2,4-trimethylchroman-3-one, bp 106-107°C (15 mm), n_D^{20} 1.5197; DNPH, mp 163-164°C (from a mixture of chloroform and methanol); a mixture with the DNPH of the chromanone (V) gave no depression of the melting point. The identity of the chromanone (V) and the sample obtained by independent synthesis was also confirmed by the complete coincidence of their IR and PMR spectra.

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