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UNEXPECTED FORMATION OF THE 6,7,13,13a-TETRAHYDRO-15H-1,4-DIAZEPINO[1,7-*a*:4,5-*a*']DIINDOLE SYSTEM IN THE REACTION OF 2,3,3-TRIMETHYL-3H-INDOLE WITH CHLOROACETONITRILE

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It has been found that reaction of 2,3,3-trimethyl-3H-indole (**1a**) with diiodomethane in the presence of sodium hydroxide leads to the formation of the fused pentacyclic system of pyrimido[1,6-*a*:3,4-*a*']diindole [1]. Alkylation of the mentioned 3H-indole with 1,2-dibromoethane afforded the derivative of 13,13,13a,15,15-pentamethyl-6,7,13,13a-tetrahydro-15H-1,4-diazepino[1,7-*a*:4,5-*a*']diindole [2]. Herein, we wish to report that the pentacyclic system of 6,7,13,13a-tetrahydro-15H-1,4-diazepino[1,7-*a*:4,5-*a*']diindole forms in the reaction of chloroacetonitrile with 2,3,3-trimethyl-3H-indole **1a**,**b**. Alkylation of the latter with chloroacetonitrile was investigated in order to obtain intermediates, which could be applied for generation of reactive methylides [3].

Reaction of compound **1a** with chloroacetonitrile was carried out in boiling toluene. The stepwise workup of the reaction mixture with acids and bases afforded 1-cyanomethyl-2,3,3-trimethyl-3H-indolium perchlorate (**2a**) and 13,13,13a,15,15-pentamethyl-6,7,13,13a-tetrahydro-15H-1,4-diazepino[1,7-*a*:4,5-*a*']-diindol-6-one (**3a**) (Scheme 1).

The ^{1}H NMR spectrum of **3a** showed the presence of five methyl group singlets in the area of 1.22-1.43, the AB-quadruplet of diastereotopic methylene protons in the area of 4.24-4.37, and a singlet of 14-H at 5.10 ppm. In the ^{13}C NMR spectrum the signal of sp^3-hybridized α-carbon (C-13a) of indole ring systems is situated at 71.9, while the signal of sp^2-hybridized C-14a is present at 145.7 pm. The β-carbon of the enamine moiety (C-14) resonates at 112.7 and the carbon of C=O group at 171.7 ppm. These data together with the observation in the IR spectrum of absorption bands at 1672 (C=O) and 1634 cm^{-1} ($C_{(14)}$=C) confirm the structure of the obtained compound **3a**.

It can be assumed that in the first stage of this annulation reaction the addition of the nitrogen atom of the starting 3H-indole **1a** molecule to the nitrile group of the formed 1-cyanomethyl-2,3,3-trimethyl-3H-indolium derivative takes place. Further intramolecular addition of the nucleophilic β-carbon atom of the enamine moiety to the α-carbon of the indole ring system generates the fused pentacyclic system. The presence of the carbonyl group in the molecules of **3a** is a result of the acid hydrolysis of the iminoether moiety.

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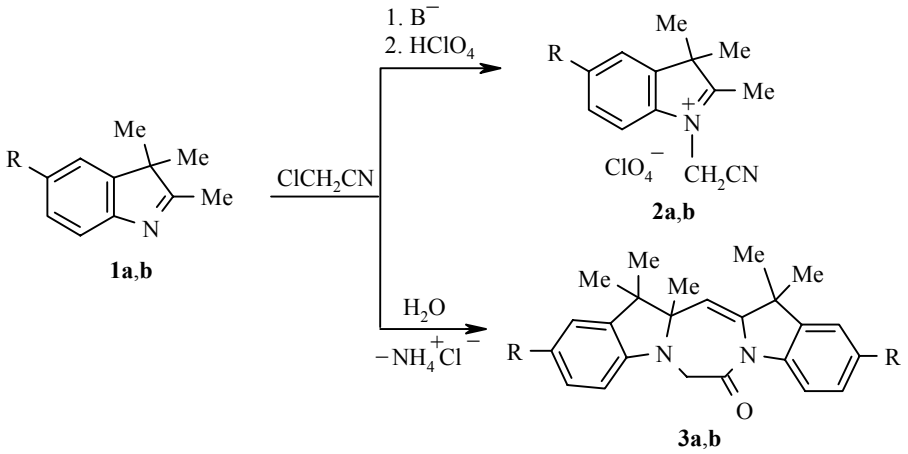
Scheme 1



1-3 a R = H, **b** R = Me

Reaction of 2,3,3,5-tetramethyl-3H-indole **1b** with chloroacetonitrile afforded the salt **2b** and diazepino[1,7-*a*:4,5-*a*']diindol-6-one **3b**, correspondingly.

1-Cyanomethyl-2,3,3-trimethyl-3H-indolium Perchlorate (2a) and 13,13,13a,15,15-Pentamethyl-6,7,13,13a-tetrahydro-15H-1,4-diazepino[1,7-*a*:4,5-*a*']diindol-6-one (3a). A mixture of compound **1a** (9.55 g, 60 mmol), chloroacetonitrile (6.79 g, 5.68 ml, 90 mmol), and toluene (10 ml) is heated 20 h at 115°C. The reaction mixture was poured into 3% hydrochloric acid (100 ml) and extracted with ether (2 × 30 ml). The organic layer was separated, washed with water (20 ml), and dried with calcium chloride, the solvent was evaporated, and the residue crystallized from ethanol to yield 1.30 g (12 %) of compound **3a**; mp 196-197°C. ^{1}H NMR spectrum ($CDCl_3$): 1.22 (3H, s, CH_3); 1.36 (3H, s, 2 × CH_3); 1.39 (3H, s, CH_3); 1.43 (3H, s, CH_3); 4.24-4.37 (2H, AB-quadruplet, J = 16.0 Hz, CH_2); 5.10 (1H, s, 14-H); 6.67-7.24 (7H, m, HAr); 8.11 ppm (d, J = 7.5 Hz, 4-H). ^{13}C NMR spectrum ($CDCl_3$): 20.6 (13a-CH_3); 23.4; 26.1 (13,13-CH_3); 27.8; 32.3 (15,15-CH_3); 45.2 (C-13), 47.3 (C-15); 49.5 (CH_2); 71.9 (C-13a); 107.0 (C-9); 112.7 (C-14); 117.8 (C-11); 118.6 (C-4); 121.5 (C-12); 121.8 (C-2); 124.5 (C-1); 127.4 (C-10); 127.5 (C-3); 137.7 (C-12a); 138.5 (C-15a); 140.7 (C-4a); 145.7 (C-14a); 147.4 (C-8a); 171.7 ppm (C=O). Mass spectrum, *m/z* (%): 358 (M^+, 25), 343 (100), 328 (8), 315 (14), 313 (13), 300 (4), 285 (15), 269 (5), 196 (4), 182 (3), 167 (7), 158 (9), 144 (11), 130 (9), 115 (10), 103 (6), 91 (8), 77 (10). Found, %: C 80.1; H 7.4. $C_{24}H_{26}N_2O$. Calculated, %: C 80.4; H 7.3.

The aqueous solution obtained after separation of the organic layer was treated with sodium carbonate. The liberated substance was extracted with ether (2 × 15 ml) and the extract washed with water (15 ml) and dried with calcium chloride. The solvent was removed and the residue dissolved in ethanol (3 ml), and to the solution 40% perchloric acid was added until pH 2. The mixture was kept at 0°C for 18 h, and the crystalline substance removed by filtration. Yield of perchlorate **2a** 2.55 g (14 %); mp 236-237°C (ethanol). ^{1}H NMR spectrum (CF_3COOH): 1.26 (6H, s, 3,3-CH_3); 2.62 (3H, s, 2-CH_3); 5.36 (2H, s, CH_2); 7.28-7.49 ppm (4H, m, H_{Ar}). Found, %: C 51.9; H 5.1; Cl 11.5. $C_{13}H_{15}ClN_2O_4$. Calculated, %: C 52.3; H 5.1; Cl 11.9.

Perchlorate 2b and Diazepino[1,7-*a*:4,5-*a*']diindol-6-one 3b were obtained from **1b** in a similar way. Yield of perchlorate **2b** 15 %; mp 190-191°C (ethanol). ^{1}H NMR spectrum (CF_3COOH): 1.25 (6H, s, 3,3-CH_3); 2.13 (3H, s, 5-CH_3); 2.59 (3H, s, 2-CH_3); 5.33 (2H, s, CH_2); 7.03-7.48 ppm (3H, m, H_{Ar}). Found, %: C 53.4; H 5.6; N 8.8; Cl 11.5. $C_{14}H_{17}ClN_2O_4$. Calculated, %: C 53.8; H 5.5; N 9.0; Cl 11.3.

Yield of compound **3b** 8%; mp 195-196°C (ethanol). IR spectrum: 1672 (C=O), 1638 cm^{-1} ($C_{(14)}$=C). ^1H NMR spectrum ($CDCl_3$): 1.13 (3H, s, CH_3); 1.34 (9H, s, 3 × CH_3); 1.39 (3H, s, CH_3); 2.22 (3H, s, CH_3); 2.37 (3H, s, CH_3); 4.18-4.36 (2H, AB-quadruplet, J = 16.0 Hz, CH_2); 5.07 (1H, s, 14-H); 6.57 (1H, d, J = 7.54 Hz, 9-H); 6.77-7.02 (4H, m, 1-H, 3-H, 10-H, 12-H); 7.97 ppm (1H, d, J = 8.0 Hz, 4-H). Found, %: C 80.3; H 8.0; N 7.0. $C_{26}H_{30}N_2O$. Calculated, %: C 80.8; H 7.8; N 7.2.

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