ANTHRA[1,2-b]FURAN AND 1H-NAPHTH[2,3-g]INDOLE DERIVATIVES

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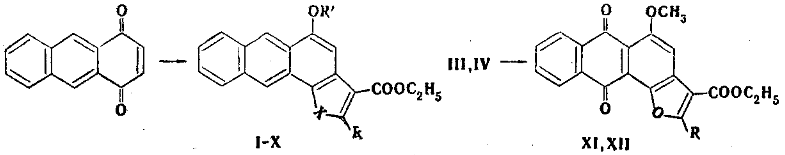
A number of previously inaccessible anthra[1,2-b]furan and 1H-naphth[2,3-g]indole derivatives were obtained by condensation of 1,4-anthraquinone with acetoacetic ester and its analogs. Quinones of the anthra[1,2-b]furan series were obtained by oxidation of the methoxy derivatives of anthra[1,2-b]furan.

The literature contains fragmentary information concerning the synthesis of several representatives of the anthra[1,2-b]furan and 1H-naphth[2,3-g]indole classes [1-3]. However, there are no indications of the synthesis of functional derivatives and compounds with substituents in the 2 and 3 positions.

We have found that 2-methyl- (I) and 2-phenyl-3-ethoxycarbonyl-5-hydroxyanthra[1,2-b]furan (II) are formed in the condensation of 1,4-anthraquinone [4] with acetoacetic and benzoylacetic esters. Methylation of the products gives 5-methoxy derivatives III and IV. Similarly, 1-methyl- (V), 1-phenyl- (VI), and 1-benzyl-2-methyl-3-ethoxycarbonyl-5-hydroxy-1H-naphth[2,3-g]indole (VII) are obtained from 1,4-anthraquinone and nitrogen-substituted β-aminocrotonic esters via the method in [5]. Methylation of the products gives the corresponding methoxy derivatives (VIII-X).

Oxidation of III and IV with sodium dichromate in acid media gave quinones of the anthra[1,2-b]furan series – 2-methyl- (XI) and 2-phenyl-3-ethoxycarbonyl-5-methoxy-6,11-dioxoanthra[1,2-b]furan (XII). As was observed previously for the corresponding naphthofuran derivatives [6], the methoxy group is not involved in the oxidation. The presence of a methoxy group in XI and XII was confirmed by the PMR spectra, in which there are singlets of the CH_3O groups at 3.85 and 3.90 ppm. In addition, the following signals are noted in the PMR spectrum of XI: an ethyl group with δ 1.38 ppm (CH_3, triplet), and 4.32 ppm (CH_2, quartet), a methyl group with 2.73 ppm, and the aromatic portion of the molecule with δ 7.70-7.99 ppm. Similarly, the PMR spectrum of XII contains signals of an ethyl group at 1.29 ppm (CH_3, triplet) and 4.27 ppm (CH_2, quartet) and the aromatic portion of the molecule at 7.30-8.05 ppm.



I X=O,. R=CH_3; R'=H; II X=O, R=C_6H_5, R'=H; III X=O, R=R'=CH_3; IV X=O, R=C_6H_5, R'=CH_3; V X=NCH_3, R=CH_3, R'=H; VI X=NC_6H_5, R=CH_3, R'=H; VII X=$NCH_2C_6H_5$, R=CH_3, R'=H; VIII X=NCH_3, R=R'=CH_3; IX X=NC_6H_5, R=R'=CH_3; X X=$NCH_2C_6H_5$, R=R'=CH_3.

EXPERIMENTAL

The UV spectra of dioxane solutions of the compounds were obtained with an EPS-3 spectrophotometer. The PMR spectra of d_6-dimethyl sulfoxide solutions of the compounds were recorded with a JNM-4H-100 spectrometer with tetramethylsilane as the internal standard.

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TABLE 1. Anthra[1,2-b]furan Derivatives

Comp.	mp, °C	Empirical formula	Found, %		Calc., %		Yield, %
			C	H	C	H	
I	243—244	$C_{20}H_{16}O_4$	74,9	5,2	75,0	5,0	55
II	206—208	$C_{25}H_{18}O_4$	78,3	4,7	78,5	4,7	45
III	182—183	$C_{21}H_{18}O_4$	75,0	5,6	75,4	5,4	63
IV	158—160	$C_{26}H_{20}O_4$	78,9	5,3	78,8	5,1	84

TABLE 2. 1H-Naphth[2,3-g]indole Derivatives

Comp.	mp, °C	Empirical formula	Found, %			Calc., %			Yield,%
			C	H	N	C	H	N	
V	250—253 (dec.)	$C_{21}H_{19}NO_3$	75,9	5,9	4,2	75,6	5,8	4,2	51
VI	223—225	$C_{26}H_{21}NO_3$	78,8	5,2	3,6	79,0	5,3	3,5	36
VII	293—295	$C_{27}H_{23}NO_3$	79,1	5,6	3,5	79,2	5,7	3,4	44
VIII	208—209	$C_{22}H_{21}NO_3$	75,7	6,2	4,0	76,0	6,1	4,0	69
IX	164—165	$C_{27}H_{23}NO_3$	78,9	5,8	3,5	79,2	5,7	3,4	65
X	197,5—198,5	$C_{28}H_{25}NO_3$	79,8	5,9	3,4	79,5	5,9	3,3	60

2-Methyl(phenyl)-3-ethoxycarbonyl-5-hydroxyanthra[1,2-b]furans (I, II) (Table 1). A 0.033-mole sample of 1,4-anthraquinone was added with stirring to a heated (to 70°) mixture of 0.033 mole of anhydrous zinc chloride in 6 ml of absolute alcohol and 15 ml of acetoacetic ester, and the reaction mixture was stirred at 70-80° for 25 min. The precipitate was separated, washed with ether, and recrystallized from dimethylformamide.

2-Methyl(phenyl)-3-ethoxycarbonyl-5-methoxyanthra[1,2-b]furans (III, IV) (Table 1). A 15-ml sample of dimethyl sulfate was added with stirring at 30-35° to a solution of 0.048 mole of 5-hydroxyanthra[1,2-b]-furan (I, II) in 360 ml of dioxane and 240 ml of 2 N NaOH solution, and the mixture was stirred for 2 h and cooled. The precipitate was removed by filtration and recrystallized from acetone.

1-Alkyl(aryl)-2-methyl-3-ethoxycarbonyl-5-hydroxy-1H-naphth[2,3-g]indoles (V-VII) (Table 2). A 0.01-mole sample of ethyl β-(methylamino)crotonate was added to a refluxing solution of 0.01 mole of 1,4-anthraquinone in 60 ml of glacial acetic acid, and the mixture was refluxed for 30 min and cooled. The precipitate was separated, washed with ether, and recrystallized from nitrobenzene.

1-Alkyl(aryl)-2-methyl-3-ethoxycarbonyl-5-methoxy-1H-naphth[2,3-g]indoles (VIII)-X) (Table 2). A 0.024-mole sample of 5-hydroxynaphth[2,3-g]indole (V-VII) in 180 ml of dioxane and 120 ml of 2 N NaOH solution was methylated with 7.5 ml of dimethyl sulfate. The reaction and isolation of the products were carried out under the conditions of the synthesis of III and IV. The products (VIII-X) were recrystallized from dioxane.

2-Methyl-3-ethoxycarbonyl-5-methoxy-6,11-dioxoanthra[1,2-b]furan (XI). A solution of 11.92 g of sodium dichromate in 120 ml of 90% acetic acid was added with stirring to a heated (to 70°) suspension of 0.01 mole of anthra[1,2-b]furan III in 100 ml of glacial acetic acid, and the resulting solution was stirred at 70-80° for 4 h, cooled to room temperature, and poured into water. The resulting precipitate was separated and recrystallized from acetic acid to give 1.65 g (45%) of XI with mp 214-216°. UV spectrum: λ_{max} 252, 397 nm (log ε 4.96, 3.87). Found: C 69.3; H 4.5%. $C_{21}H_{16}O_6$. Calculated: C 69.2; H 4.4%.

2-Phenyl-3-ethoxycarbonyl-5-methoxy-6,11-dioxoanthra[1,2-b]furan (XII). This compound was obtained in 64% yield by the method used to obtain XI and had mp 237-239° (from acetic acid). UV spectrum: λ_{max} 262, 412 nm (log ε 4.49, 4.09). Found: C 73.0; H 4.3%. $C_{26}H_{18}O_6$. Calculated: C 73.2; H 4.2%.

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