SYNTHESIS OF 1-AMINOANTHRAPYRIDONES AND THEIR DERIVATIVES

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UDC 547.837.6.07

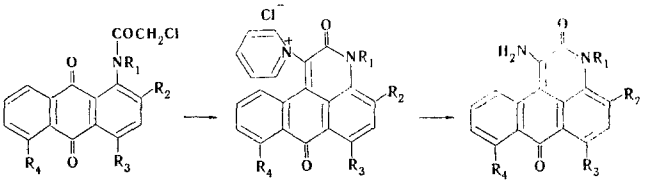
1-Aminoanthrapyridones are obtained when 1-anthrapyridonylpyridinium chlorides are heated in high-boiling amines. The synthesis of a number of substituted N-chloroacetyl-1-aminoanthraquinones, 1-anthrapyridonylpyridinium chlorides, and 1-aminoanthrapyridones is described.

1-Alkylaminoanthrapyridones are of interest for use as luminophores [1]. In the present study, we undertook the synthesis of 1-aminoanthrapyridones that do not contain substituents in the amino group, give intense luminescence in solutions during irradiation with UV light, and can be used as effective luminophores in daylight fluorescent pigments [2]. Only one compound – 1-amino-6-isopropylamino-N-isopropylanthrapyridone, obtained by ammonolysis of the corresponding 1-chloro derivative – is described in the literature [3]. We investigated the possibility of obtaining 1-aminoanthrapyridones by cleavage of the pyridine ring in 1-anthrapyridonylpyridinium salts; this reaction has not been studied in this series of compounds.

It is known that the action of basic reagents on pyridinium salts containing electron-acceptor groupings attached to the nitrogen atom may lead to complete cleavage of the pyridine ring to give the corresponding primary amines [4]. 1-Anthrapyridonylpyridinium chlorides are obtained by the action of pyridine on N-chloroacetyl-1-aminoanthraquinones [5,6]; owing to the ease of reductive elimination of the pyridinium group, they are used as intermediates in the synthesis of anthrapyridones that do not contain substituents in the 1 position [7]. It was found that 1-anthrapyridonylpyridinium chloride and its N-methyl analog (XV and XVI, Table 2) undergo quantitative cleavage of the pyridine ring to give 1-aminoanthrapyridones (XXVIII and XXIX, Table 3), which crystallize directly out of the reaction mass in 98-99% yields with a high degree of purity [8], when they are heated in high-boiling aromatic and aliphatic amines (for example, aniline, toluidines, morpholine, hexylamine, and cyclohexylamine). The use of other basic reagents (alkalis, for example) in this reaction gives poor results: the intermediately formed products of cleavage of the pyridine ring undergo ambiguous transformations in this case.

The R_1-R_4 values are presented in Tables 1-3.

This method makes it possible to obtain 1-aminoanthrapyridone derivatives that contain various substituents attached to both the heterocyclic nitrogen atom and the anthrone ring. Acylation of the substituted 1-amino-, 1-alkylamino-, or 1-arylaminoanthraquinones with acetyl chloride gives N-chloroacetylamino-



I-XIV XV-XXVII XXVIII-XLI

Scientific-Research Institute of Organic Intermediates and Dyes, Moscow. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 12, pp. 1651-1655, December, 1972. Original article submitted July 26, 1971.

TABLE 1. N-Chloroacetyl-1-aminoanthraquinones

Comp.	R_1	R_2	R_3	R_4	Mp, °C[a]	Empirical formula	Found, %		Calc., %		Yield, %
							Cl	N	Cl	N	
I	H	H	H	H	218—219[b]	$C_{16}H_{10}ClNO_3$	11,7	4,6	11,8	4,7	91
II	CH_3	H	H	H	170—171[c]	$C_{17}H_{12}ClNO_3$	11,4	4,3	11,3	4,5	86
III	H	CH_3	H	H	211—212	$C_{17}H_{12}ClNO_3$	11,6	4,4	11,3	4,5	92
IV	H	H	OH	H	197—198[d]	$C_{16}H_{10}ClNO_4$	11,2	4,3	11,3	4,4	91
V	H	C_6H_{11}	H	H	151—152	$C_{22}H_{20}ClNO_3$	—	3,6	—	3,7	96
VI	$C_6H_4CH_3$-*p*	H	H	H	183—184	$C_{23}H_{16}ClNO_3$	9,2	3,5	9,1	3,6	86
VII	H	H	$NHC_6H_4CH_3$-*p*	H	236—237	$C_{28}H_{17}ClN_2O_3$	8,8	6,8	8,8	6,9	78
VIII	H	H	$NHC_6H_2(CH_3)_3$-2,4,6	H	259—260	$C_{25}H_{21}ClN_2O_3$	8,6	6,4	8,3	6,5	79
IX	H	H	$NHCOC_6H_5$	H	139—140	$C_{23}H_{15}ClN_2O_4$	8,6	6,8	8,5	6,7	88
X	H	H	H	$NHCOC_6H_5$	292—293	$C_{23}H_{15}ClN_2O_4$	8,5	6,7	8,5	6,7	82
XI	CH_3	H	Br	H	237—238[e]	$C_{17}H_{11}ClBrNO_3$	9,2	3,5	9,0	3,6	86
XII	H	CH_3	Br	H	244—245	$C_{17}H_{11}ClBrNO_3$	9,1	3,5	9,0	3,6	91
XIII	CH_3	H	NHC_6H_5	H	209—210	$C_{23}H_{17}ClN_2O_3$	8,6	6,8	8,8	6,9	94
XIV	$C_6H_4CH_3$-*p*	H	$NHC_6H_4CH_3$-*p*	H	205—206	$C_{30}H_{23}ClN_2O_3$	7,1	5,6	7,2	5,7	95

[a]Compounds III and XI were crystallized from chlorobenzene, V was crystallized from cyclohexane, and the remaining compounds were crystallized from aqueous acetic acid. [b]According to [9], mp 222°. [c]According to [9], mp 170-171.5°. [d]According to [7], mp 197°. [e]According to [9], mp 239°.

TABLE 2. 1-Anthrapyridonylpyridinium Chlorides

Comp.	R_1	R_2	R_3	R_4	Mp, °C	Empircal formula	Found, %		Calc., %		Yield, %
							Cl	N	Cl	N	
XV	H	H	H	H	* †	$C_{21}H_{13}ClN_2O_2$	9,7	7,7	9,8	7,8	89
XVI	CH_3	H	H	H	256—257	$C_{22}H_{15}ClN_2O_2$	9,3	7,4	9,3	7,5	82
XVII	H	CH_3	H	H	*	$C_{22}H_{15}ClN_2O_2$	9,2	7,5	9,3	7,5	78
XVIII	H	H	OH	H	310—311	$C_{21}H_{13}ClN_2O_3$	9,2	7,5	9,4	7,4	78
XIX	$C_6H_4CH_3$-*p*	H	H	H	255—256	$C_{28}H_{19}ClN_2O_2$	7,8	6,2	7,8	6,2	88
XX	H	H	$NHC_6H_4CH_3$-*p*	H	*	$C_{28}H_{20}ClN_3O_2$	7,8	9,1	7,6	9,0	94
XXI	H	H	$NHC_6H_2(CH_3)_3$-2,4,6	H	*	$C_{30}H_{24}ClN_3O_2$	6,9	8,6	6,9	8,5	86
XXII	H	H	$NHCOC_6H_5$	H	*	$C_{28}H_{18}ClN_3O_3$	7,3	8,8	7,4	8,8	98
XXIII	H	H	H	$NHCOC_6H_5$	*	$C_{28}H_{18}ClN_3O_3$	7,2	8,7	7,4	8,8	81
XXIV	CH_3	H	Br	H	291—292	$C_{22}H_{14}ClBrN_2O_2$	—	6,1	—	6,2	84
XXV	H	CH_3	Br	H	*	$C_{22}H_{14}ClBrN_2O_2$	—	6,1	—	6,2	92
XXVI	CH_3	H	NHC_6H_5	H	292—293	$C_{28}H_{20}ClN_3O_2$	7,6	8,9	7,6	9,0	91
XXVII	$C_6H_4CH_3$-*p*	H	$NHC_6H_4CH_3$-*p*	H	200—201	$C_{35}H_{26}ClN_3O_2$	6,4	7,5	6,4	7,6	96

*This compound melts above 350°.

†According to [6], mp 412°.

TABLE 3. 1-Aminoanthrapyridones

Comp.	R_1	R_2	R_3	R_4	Mp, °C	Empirical formula	Found, %			Calc., %			Yield, %
							C	H	N	C	H	N	
XXVIII	H	H	H	H	*	$C_{16}H_{10}N_6O_2$	73,3	3,7	10,8	73,2	3,8	10,7	99
XXIX	CH_3	H	H	H	271—272	$C_{17}H_{12}N_6O_2$	73,9	4,3	10,0	73,9	4,4	10,1	98
XXX	H	CH_3	H	H	*	$C_{17}H_{12}N_6O_2$	73,8	4,1	10,2	73,9	4,4	10,1	99
XXXI	H	H	OH	H	*	$C_{16}H_{10}N_6O_3$	69,1	3,9	10,3	69,1	3,6	10,1	93
XXXII	H	C_6H_{11}	H	H	330—331	$C_{22}H_{20}N_6O_2$	75,4	6,3	8,4	75,6	6,5	8,3	92
XXXIII	$C_6H_4CH_3$-*p*	H	H	H	250—251	$C_{23}H_{16}N_6O_2$	78,3	4,5	7,8	78,4	4,6	7,9	89
XXXIV	H	H	$NHC_6H_4CH_3$-*p*	H	*	$C_{23}H_{17}N_7O_2$	75,3	4,8	11,6	75,2	4,7	11,4	91
XXXV	H	H	$NHC_6H_2(CH_3)_3$-2,4,6	H	180—181	$C_{25}H_{21}N_7O_2$	75,7	5,3	10,8	75,9	5,4	10,6	91
XXXVI	H	H	H	$NHCOC_6H_5$	*	$C_{28}H_{15}N_7O_3$	72,3	4,1	11,1	72,4	3,9	11,0	99
XXXVII	H	H	$NHCOC_6H_5$	H	†	$C_{28}H_{15}N_7O_2$	72,5	4,0	10,9	72,4	3,9	11,0	97
XXXVIII	H	CH_3	Br	H	*	$C_{17}H_{11}N_6O_2Br$	57,2	3,0	7,8	57,3	3,1	7,9	89
XXXIX	CH_3	H	Br	H	293—294	$C_{17}H_{11}N_6O_2Br$	57,3	3,2	7,9	57,3	3,1	7,9	96
XL	CH_3	H	NHC_6H_5	H	232—233	$C_{23}H_{17}N_7O_2$	75,2	4,7	11,5	75,2	4,7	11,4	97
XLI	$C_6H_4CH_3$-*p*	H	$NHC_6H_4CH_3$-*p*	H	151—152	$C_{30}H_{23}N_8O_2$	79,0	5,2	9,1	78,8	5,1	9,2	91

* This compound melts above 350°.

† This compound was crystallized from chlorobenzene; the remaining compounds were crystallized from aqueous dimethylformamide.

anthraquinones (I-XIV, Table 1), which are converted to 1-anthrapyridonylpyridinium chlorides (XV-XXVII, Table 2) by the action of pyridine. Heating of the latter in aniline gives 1-aminoanthrapyridones with the corresponding substituents (XXVIII-XLI, Table 3). The reactions give high yields and can be used for the preparative synthesis of 1-aminoanthrapyridone derivatives.

When substituents that are capable of exchange with an amine residue are present in the 1-anthrapyridonylpyridinium chlorides, the preparation of 1-aminoanthrapyridones can be carried out with retention of the original substituent, since the cleavage of the pyridine ring proceeds with much greater ease than nucleophilic substitution in the anthrapyridone. Thus 1-amino-6-bromo-N-methylanthrapyridone (XXXIX) is formed in 96% yield when 6-bromo-N-methyl-1-anthrapyridonylpyridinium chloride (XXIV) is heated in aniline to 100°. Increasing the reaction temperature gives 1-amino-6-anilino-N-methylanthrapyridone (XL).

The introduction of an amino group into the 1 position has virtually no effect on the lability of the bromine atom in 6-bromoanthrapyridones, which react with nucleophilic agents under the same conditions as 1-amino-6-bromoanthrapyridones (XXXVIII and XXXIX). Owing to this, it becomes possible to obtain various 6-substituted 1-aminoanthrapyridones (for example, XL and XLII) starting both from the corresponding substituted 1-aminoanthraquinones (for example, XII and XIII) and from 6-bromo derivatives of 1-aminoanthrapyridones (for example, XXXVIII and XXXIX). Depending on the character and position of the substituent, one of the indicated paths may be more expedient.

N-Methylanthrapyridone has a long-wave absorption band at 405 nm ($\log \varepsilon$ 3.73). The introduction of an amino group into the 1 position leads to an increase in the intensity and a small bathochromic shift of this band: λ_{max} 430 nm ($\log \varepsilon$ 4.18) for 1-amino-N-methylanthrapyridone (XXIX). It is interesting that the band characteristic for XXIX and unsubstituted N-methylanthrapyridone at 412 nm ($\log \varepsilon$ 3.94) is retained along with the appearance of a new long-wave maximum at 512 nm ($\log \varepsilon$ 4.15) in the spectrum of 1-amino-6-anilino-N-methylanthrapyridone (XL), while this band is absent in the spectrum of 6-anilino-N-methylanthrapyridone (Fig. 1).

EXPERIMENTAL

The absorption spectra were recorded with an SF-4 spectrophotometer.

N-Chloroacetyl-1-aminoanthraquinones (I-XIV). A mixture of 10 g of 1-aminoanthraquinone derivative, 50-100 ml of benzene, and 10 ml of chloroacetyl chloride was refluxed for 0.5-1 h until the starting anthraquinone was completely absent on the chromatogram in a thin layer of Al_2O_3 (chloroform). The mixture was

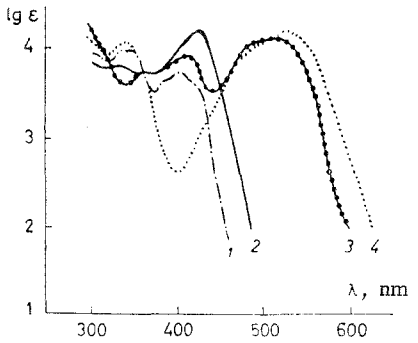


Fig. 1. Absorption spectra (in chlorobenzene): 1) N-methylanthrapyridone; 2) 1-amino-N-methylanthrapyridone (XXIX); 3) 1-amino-6-anilino-N-methylanthrapyridone (XL); 4) 6-anilino-N-methylanthrapyridone.

cooled, and the precipitated needles were removed by filtration and washed with benzene (Table 1).

1-Anthrapyridonylpyridinium Chlorides (XV-XXVII). A solution of N-chloroacetyl-1-aminoanthraquinone in a 20-fold amount of pyridine was refluxed for 20-30 min, during which needles precipitated. The mixture was cooled, and the needles were removed by filtration and washed with benzene and ether (Table 2). When pure N-chloroacetyl-1-aminoanthraquinones were used, the 1-anthrapyridonylpyridinium chlorides were isolated in analytically pure form without additional treatment.

1-Aminoanthrapyridones (XXVIII-XLI). A mixture of the 1-anthrapyridonylpyridinium chloride derivatives (XV-XXVII) and a fivefold amount of aniline was heated to the boiling point and cooled to 80°. A 10-fold quantity of methanol was added, and the precipitated needles were removed by filtration and washed with methanol to give the corresponding 1-aminoanthrapyridone derivative (Table 3). In the preparation of 6-bromo derivatives of 1-aminoanthrapyridones (XXXVIII-XXXIX), the temperature was raised to 100°, the mixture was stirred for 10-15 min, and the products were isolated as indicated above. In the preparation of 1-amino-4-cyclohexylanthrapyridone (XXXII), cyclohexylamine was used in place of aniline, and the reaction mass was diluted with 5% hydrochloric acid, after which the precipitate was removed by filtration and washed.

1-Amino-6-anilino-N-methylanthrapyridone (XL). A. The preparation from XXVI is presented above.

B. A mixture of 1 g of XXIV or XXXIX, 5 ml of aniline, 0.5 g of anhydrous sodium acetate, 0.1 g of copper acetate, and 0.1 g of copper powder was refluxed for 1.5 h, after which the mixture was cooled to 80° and diluted with 15 ml of methanol. The precipitate was removed by filtration, washed with methanol, and crystallized to give XL in 80% yield.

1-Amino-6-anilino-4-methylanthrapyridone (XLII). This compound was obtained in 75% yield from 1-amino-6-bromo-4-methylanthrapyridone (XXXVIII), as in the preparation of XL (by method B). The dark red needles had mp 305-306° (from aqueous dimethylformamide). Found,%: C 75.2; H 4.5; N 11.3. $C_{23}H_{17}N_3O_2$. Calculated,%: C 75.2; H 4.7; N 11.4.

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