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NITROPYRIDINES

11.* RECYCLIZATION OF QUATERNARY NITROPYRIDINIUM SALTS INTO SUBSTITUTED NITROANILINES

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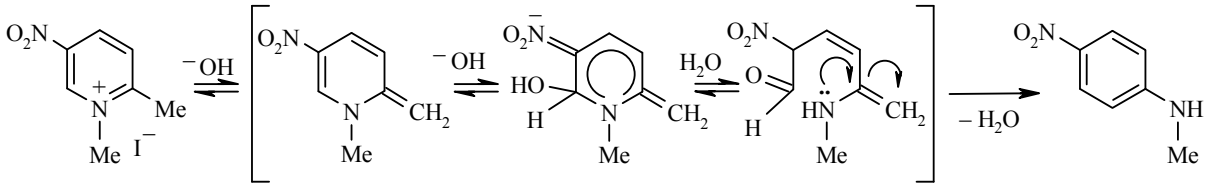
Substituted nitroanilines have been obtained by the recyclization of nitropyridinium quaternary salts under the action of bases.

Keywords: anhydro base, biphenyl, substituted nitroanilines, 3(5)-nitropyridines, 4-nitropyridine, pseudo base, pyridinium quaternary salts, recyclization.

The aim of the present work was to study the synthetic possibilities of the recyclization of nitropyridinium salts. The rearrangement of nitropicoline and nitrolutidine salts into nitroanilines was carried out for the first time in the eighties [2–4].

In the early stages of investigations on drawing up a scheme for the recyclization of nitropyridinium salts the formation of anhydro bases **A** and anionic σ-complexes **B** as intermediates were postulated.



A **B** **C**

Dedicated to bright memories of Professor Reva Safarovich Sagitullin.

* For Communication 10, see [1].

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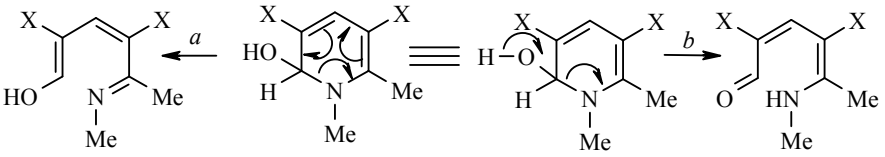
Later, this mechanism was rejected for the following reasons.

1. In a series of cases (recyclization of indolizines, nicotyrinium salts, opening of Zincke salts, etc.) the formation of an anhydro base is impossible in principle [5, 6].

2. Compounds, the anhydro bases of which are readily formed, proved in general to be incapable of recyclization while the formation of an anhydro base was not blocked [7].

So it is more logical to suggest that neutral analogs of anionic σ-complexes act as intermediates in the recyclization of pseudo bases [8].

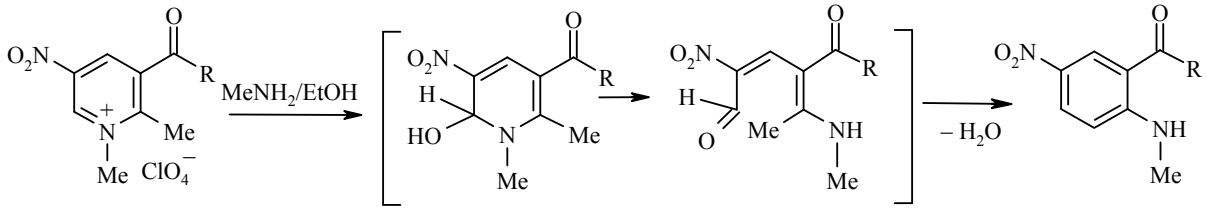


Of the two possible variants of the opening of the ring of the pseudo base, the electrocyclic (a) and the ionic (b), the ionic variant should be preferred since:

1. The formation of the opened forms has never been mentioned for nucleophiles incapable of ionic ring opening (X = Cl^-, Br^-, I^-, CN^-, etc.).

2. The enthalpies of formation of the ionic forms, resulting from electrocyclic opening, are greater than the enthalpies of formation of the enamine forms from ionic opening (ΔH = –14 kcal/mole) [9].

The recyclization of nitropyridinium salts **1a–c** by the action of alcoholic methylamine at room temperature leads to substituted nitroanilines **2a–c**. Hydroxyl anion attacks the spatially more accessible position 6 of the pyridinium salts **1a–c** with the formation of pseudo base **1A**. Ionic opening of pseudo base **1A** leads to the opened form **1B**, the cyclization of which into the substituted nitroanilines **2a–c** occurs by intramolecular aldol–crotonate condensation of the resulting formyl group with the methyl group.



1a–c **1A** **1B** **2a–c**

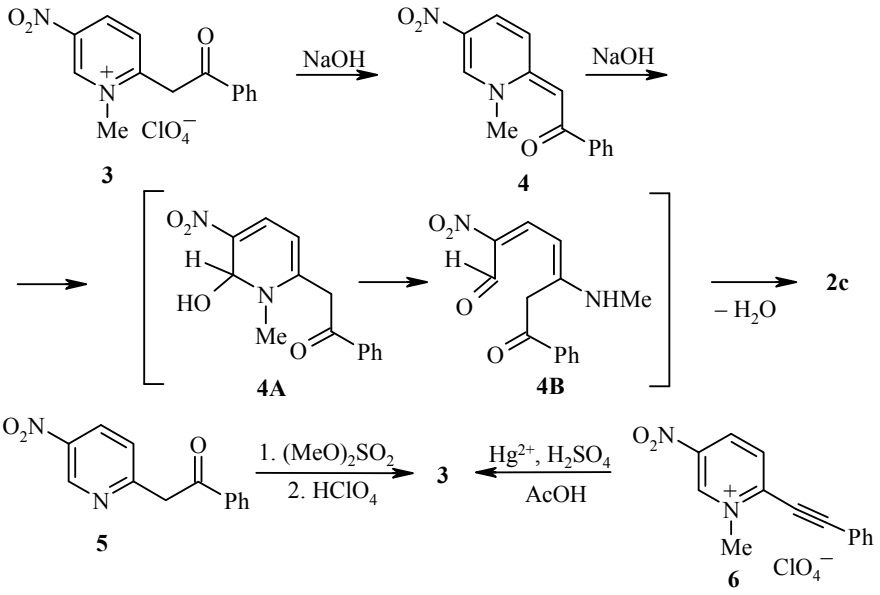
1,2 a R = Me, **b** R = *cyclo*-Pr, **c** R = Ph

The rearrangement product of 5-nitro-2-phenacylpyridinium salt **3** is [2-(methylamino)-5-nitrophenyl]-phenyl methyl ketone (**2c**). On treating a solution of the pyridinium salt **3** with base deprotonation occurs at the CH-acidic methylene group of the phenacyl substituent with the formation of a stable anhydro base **4**. Further conversion of anhydro base **4** into pseudo base **A** occurs by addition of water to it. An analogous equilibrium in the anhydro base–pseudo base system was described by O. Mumm in the example of recyclizing a 3,5-diethoxycarbonylcollidinium salt [10].

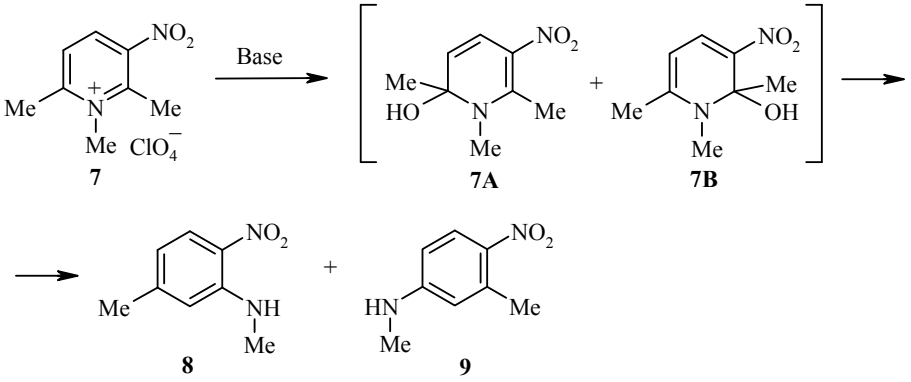
The formation of the benzene ring of compound **2c** occurs as a result of the interaction of the generated formyl group and the methylene unit of the phenacyl group in the opened form **4B**.

5-Nitro-2-phenacylpyridinium perchlorate **3** was synthesized by acidic hydration according to Kucherov of the triple bond of the 1-methyl-5-nitro-2-(phenylethynyl)pyridinium quaternary salt **6** and by alkylation of 5-nitro-2-phenacylpyridine (**5**). A 10% solution of perchloric acid was used to replace the methylsulfate anion

by perchlorate. It was not possible to use the saturated aqueous solution of sodium perchlorate usually used for this purpose since the basicity of water is sufficient to deprotonate the methylene group of pyridinium methylsulfate and form anhydro base **4**.



On rearranging the unsymmetrical quaternary 3-nitrolutidinium salt **7** by the action of an aqueous alcoholic solution of sodium hydroxide the isomeric *o*- and *p*-nitrotoluidine derivatives **8** and **9** were formed in a 2.1:1 ratio, in 56% overall yield. The scheme for the recyclization of salt **7** with the intermediate formation of pseudo bases **7A** and **7B** assumes attack of the hydroxyl anion at positions 2 and 6 of the nucleus. The dominating formation of *o*-toluidine **8** points to the predominant attack of hydroxyl anion at the *para* position in relation to the nitro group of salt **7**, which is sterically more available.



Base: 10% NaOH or $MeNH_2/H_2O$

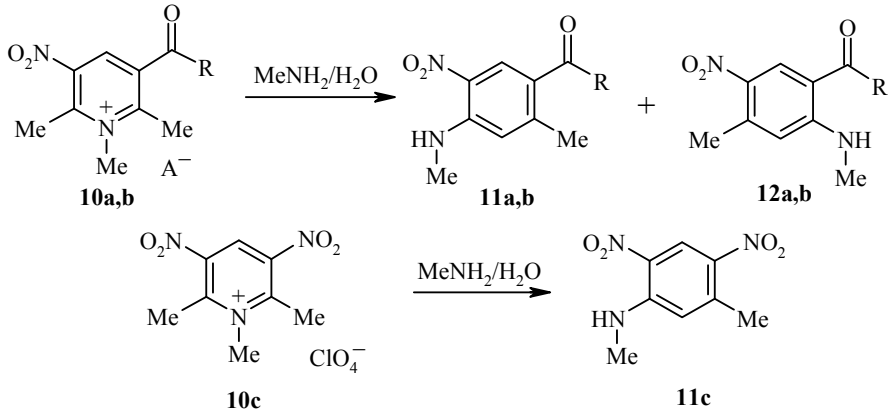
On recyclizing 3-nitrolutidinium perchlorate **7** under the action of 41% aqueous methylamine solution the overall yield of *o*- and *p*-nitrotoluidine derivatives **8** and **9** was 52%, and the *ortho/para* ratio of isomers was 2.5:1. On using 25% aqueous methylamine in the recyclization of salt **7** the overall yield of isomers was the same (51%) but the *ortho/para* ratio of isomers was significantly different and amounted to 4.7:1 [4].

TABLE 1. Physicochemical Characteristics and Preparation Conditions of Pyridinium Quaternary Salts

Compound	Empirical formula	Found, % / Calculated, %			mp, °C*	Time,h / temperature, °C	Yield, %
		C	H	N			
1a	$C_9H_{11}ClN_2O_7$	36.66 / 36.69	3.67 / 3.76	9.25 / 9.51	136–137	3/70	87
1b	$C_{11}H_{13}ClN_2O_7$	41.11 / 41.20	4.01 / 4.09	8.62 / 8.74	150–151	4/80	72
1c	$C_{14}H_{13}ClN_2O_7$	47.37 / 47.14	3.85 / 3.67	8.02 / 7.85	228–229	4/80	81
3	$C_{14}H_{13}ClN_2O_7$	47.08 / 47.14	3.55 / 3.67	7.75 / 7.85	202–203	2/80	64
6	$C_{14}H_{11}ClN_2O_6$	49.72 / 49.65	3.36 / 3.27	8.35 / 8.27	193–194	2/70	78
7	$C_8H_{11}ClN_2O_6$	36.10 / 36.04	4.17 / 4.16	11.08 / 10.51	231–232	8/70	81
10a	$C_{10}H_{13}ClN_2O_7$	39.00 / 38.91	4.26 / 4.25	8.51 / 9.08	145–146	48/70	82
10b	$C_{12}H_{15}FN_2O_6S$	43.07 / 43.11	4.56 / 4.52	8.41 / 8.38	132–133	120/25	83
10c	$C_8H_{10}ClN_3O_8$	30.74 / 30.83	3.25 / 3.23	13.33 / 13.48	>250 (dec.)	120/70	47
10d	$C_{15}H_{15}FN_2O_6S$	48.73 / 48.65	4.06 / 4.08	7.42 / 7.56	196–197	120/25	86
14	$C_7H_9ClN_2O_6$	33.20 / 33.28	3.55 / 3.59	11.01 / 11.09	124–125	5/70	76
16a	$C_8H_{13}ClN_2O_4$	40.27 / 40.60	5.36 / 5.54	11.94 / 11.84	183–184	72/25	52
16b	$C_9H_{15}ClN_2O_4$	43.44 / 43.12	5.92 / 6.03	11.20 / 11.18	163–164	72/25	60

*Solvents for recrystallization: ethanol (compounds **1a–c, 10a,b,d, 14, 16a,b),** 50% acetic acid (compound **3**), water (compound **6**), propanol (compound **7**), 10% perchloric acid (compound **10c**).

5-Nitropyridinium salts **10a,b** were recyclized analogously under the action of 41% aqueous methylamine solution with the formation of the isomeric nitroanilines **11a,b** and **12a,b** in 85–97% overall yield. According to the data of ^{13}C NMR spectra the most electron-deficient is the α-carbon atom in the *p*-position to the nitro group. It is also predominantly attacked by base, which provides a significantly greater yield of

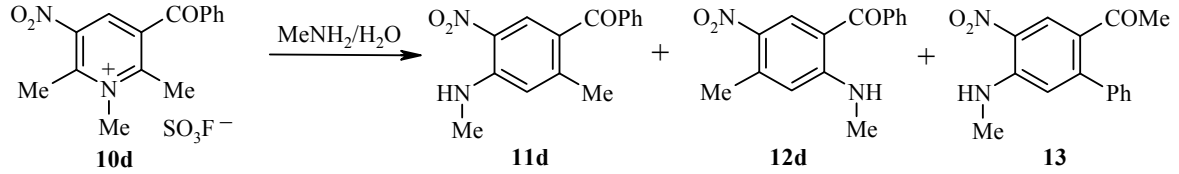


10a,b **11a,b** **12a,b** **10c** **11c**

10–12 a R = Me, A = ClO_4; **b** R = *cyclo*-Pr, A = SO_3F

substituted *o*-nitroanilines **11a,b**. As a result of rearrangement of the symmetrical 3,5-dinitropyridinium salt **10c** only 2,4-dinitrotoluidine **11c** is formed.

Rearrangement of salt **10d** leads to the formation of two isomeric nitroanilines **11d** and **12d** in 55% overall yield in a 1.1:1 and biphenyl **13** in 30% yield. Closure of the benzene ring with the formation of biphenyl **13** occurs with the participation of the benzoyl group in an aldol-crotonate condensation with the methyl group.



10d **11d** **12d** **13**

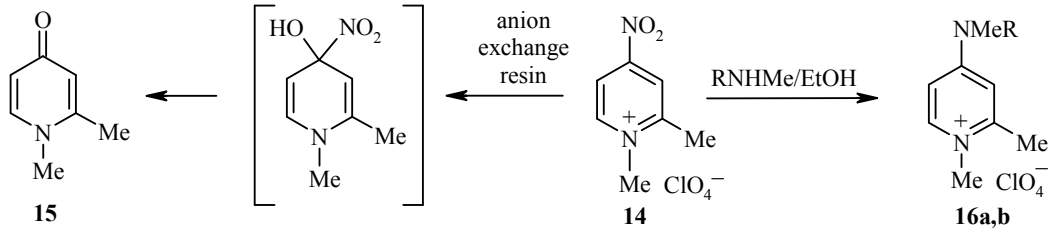
The quaternary 4-nitropicolinium salt **14** is not recyclized by the action of aqueous alcoholic NaOH solution into N-methyl-3-nitroaniline, which was not detected even in trace amounts. The hydroxyl ion attacks the most electron-deficient position 4 of the pyridinium salt which leads to nucleophilic *ipso* substitution of the nitro group [11].

The reaction proceeds under charge control and leads to 1,2-dimethylpyridin-4(1H)-one. On interacting of 4-nitropyridinium salt **14** with alcoholic methylamine and dimethylamine the nitro group is replaced by methylamine and dimethylamine respectively, which leads to the formation of substituted 4-aminopyridinium salts **16a,b**.

TABLE 2. Physicochemical Characteristics and Preparation Conditions of Nitroanilines

Compound	Empirical formula	Found, % / Calculated, %			mp, °C	Method*	Yield, %
		C	H	N			
2a	$C_9H_{10}N_2O_3$	–	–	–	149–150 [12]	A	72
2b	$C_{11}H_{12}N_2O_3$	59.86 / 59.99	5.42 / 5.49	12.64 / 12.72	160–161	A	60
2c	$C_{14}H_{12}N_2O_3$	–	–	–	160–161 [13]	A B B	52 (from **1c**) 40 (from **3**) 60 (from **4**)
8	$C_8H_{10}N_2O_2$	–	–	–	73–74 [14]	B C	38 37
9	$C_8H_{10}N_2O_2$	–	–	–	92–93 [15]	B C	18 15
11a	$C_{10}H_{12}N_2O_3$	57.75 / 57.68	5.72 / 5.81	13.54 / 13.45	213–214	C	58
11b	$C_{12}H_{14}N_2O_3$	61.59 / 61.53	5.82 / 6.02	11.74 / 11.96	148–149	C	47
11c	$C_8H_9N_3O_4$	45.67 / 45.50	4.28 / 4.30	19.75 / 19.90	171–172	C	30
11d	$C_{15}H_{14}N_2O_3$	66.87 / 66.66	5.32 / 5.22	10.50 / 10.36	149–150	C	30
12a	$C_{10}H_{12}N_2O_3$	57.65 / 57.68	5.75 / 5.81	13.43 / 13.45	167–168	C	39
12b	$C_{12}H_{14}N_2O_3$	61.62 / 61.53	5.98 / 6.02	11.93 / 11.96	106–107	C	40
12d	$C_{15}H_{14}N_2O_3$	66.80 / 66.66	5.18 / 5.22	10.45 / 10.36	186–187	C	25
13	$C_{15}H_{14}N_2O_3$	66.74 / 66.66	5.25 / 5.22	10.30 / 10.36	139–140	C	30

*A with alcoholic methylamine, B with aqueous alcoholic alkali, C with aqueous methylamine.



16 a R = H, **b** R = Me

Data of elemental analysis and spectral characteristics are given in Tables 1–7 for compounds synthesized for the first time.

We have therefore established the principal difference in the behavior of quaternary 3-, 4-, and 5-nitropyridinium salts under the action of bases. A nitro group in positions 3 and 5 of the nucleus of the pyridinium salt activates addition of nucleophile at positions 2 and 6 of the nucleus, accompanied by recyclization, but the nitro group in position 4 of the nucleus directs attack of the nucleophile to position 4, which leads to nucleophilic *ipso* substitution of the nitro group.

TABLE 3. ^{1}H NMR Spectra of Pyridinium Salts

Compound	Chemical shifts, δ, ppm (*J*, Hz)*	
	N–CH_3 (s)	Other protons
1a	4.44	2.75 (3H, s, $COCH_3$); 2.86 (3H, s, 2-CH_3); 9.52 (1H, d, ^4J = 2.4, H-4); 10.21 (1H, d, ^4J = 2.4, H-6)
1b	4.44	1.27–1.35 (4H, m, $2CH_2$); 2.57–2.88 (1H, m, CH); 2.88 (3H, s, 2-CH_3); 9.43 (1H, d, ^4J = 2.2, H-4); 10.22 (1H, d, ^4J = 2.2, H-6)
1c	4.39	2.73 (3H, s, 2-CH_3); 7.61–7.90 (5H, m, C_6H_5); 9.12 (1H, d, ^4J = 2.2, H-4); 9.68 (1H, d, ^4J = 2.2, H-6)
3	4.34	5.22 (2H, s, CH_2); 7.58–7.73 (3H, m, C_6H_5); 8.08–8.13 (2H, m, C_6H_5); 8.24 (1H, d, ^3J = 8.8, H-3); 9.14 (1H, dd, ^3J = 8.8, ^4J = 2.4, H-4); 9.69 (1H, d, ^4J = 2.4, H-6)
6	4.54	7.53–7.72 (3H, m, C_6H_5); 7.83–7.88 (2H, m, C_6H_5); 8.39 (1H, d, ^3J = 8.8, H-3); 9.10 (1H, dd, ^3J = 8.8, ^4J = 1.8, H-4); 9.65 (1H, d, ^4J = 1.8, H-6)
7	4.15	2.88 (3H, s, 6-CH_3); 2.91 (3H, s, 2-CH_3); 8.15 (1H, d, ^3J = 8.7, H-5); 8.96 (1H, d, ^3J = 8.7, H-4)
10a	4.21	2.71 (3H, s, $COCH_3$); 2.88 (3H, s, 2-CH_3); 2.93 (3H, s, 6-CH_3); 9.31 (1H, s, H-4)
10b	4.21	1.23–1.37 (4H, m, $2CH_2$); 2.53–2.62 (1H, m, CH); 2.89 (3H, s, 2-CH_3); 2.94 (3H, s, 6-CH_3); 9.23 (1H, s, H-4)
10c	4.26	3.00 (6H, s, 2,6-CH_3); 9.28 (1H, s, H-4)
10d	4.24	2.73 (3H, s, 2-CH_3); 2.99 (3H, s, 6-CH_3); 7.61–7.68 (2H, m, C_6H_5); 7.80–7.87 (3H, m, C_6H_5); 9.20 (1H, s, H-4)
14	3.97	2.60 (3H, s, 2-CH_3); 7.12 (1H, dd, ^3J = 7.1, ^4J = 2.9, H-5); 7.19 (1H, d, ^4J = 2.9, H-3); 8.55 (1H, d, ^3J = 7.1, H-6)
16a	3.78	2.51 (3H, s, 2-CH_3); 2.86 (3H, d, *J* = 5.0, NHC<u>H</u>$_3$); 6.76 (1H, dd, ^3J = 7.2, ^4J = 2.8, H-5); 6.82 (1H, d, ^4J = 2.8, H-3); 8.24 (1H, d, ^3J = 7.2, H-6); 8.34 (1H, br. s, N<u>H</u>CH_3)
16b	3.83	2.53 (3H, s, 2-CH_3); 3.16 (6H, s, $N(CH_3)_2$); 6.90 (1H, dd, ^3J = 7.8, ^4J = 2.4, H-5); 6.96 (1H, d, ^4J = 2.4, H-3); 8.18 (1H, d, ^3J = 7.8, H-6)

*The ^{1}H NMR spectra were taken in DMSO-d_6 (compounds **1a–c, 7, 10a,b,d, 14** and **16a,b**) and CD_3CN (compounds **3**, **6**, and **10c**).

TABLE 4. ^{13}C NMR Spectra of Compounds **1a–c, 10a–d, 14**, and **16b**

Compound	Chemical shifts (DMSO-d_6), δ, ppm*								
	2-CH_3	6-CH_3	N–CH_3	C-2	C-3	C-4	C-5	C-6	Signals of other groups
1a	18.40	–	47.36	160.41	138.84	137.05	143.52	144.74	30.57 ($CO\underline{C}H_3$); 197.85 ($\underline{C}OCH_3$)
1b	18.69	–	47.27	159.94	139.37	137.06	143.70	144.66	14.18 (CH_2)$_2$; 22.21 (CH); 199.81 (CO)
1c	18.88	–	47.13	159.47	138.68	137.58	144.00	144.48	129.22 (C-2',6'); 130.48 (C-3',5'); 133.50 (C-4'); 134.66 (C-1'); 190.60 ($\underline{C}$OPh)
7	22.27	17.92	42.08	161.22	127.18	138.80	147.45	151.97	–
10a	18.54	19.82	42.81	159.74	136.49	137.28	146.69	153.58	27.96 ($CO\underline{C}H_3$); 196.28 ($\underline{C}OCH_3$)
10b	18.75	20.17	42.77	159.13	137.16	137.04	147.60	153.47	14.05 (CH_2)$_2$; 22.15 (CH); 199.89 ($\underline{C}$O-*c*-Pr)
10c	19.61	19.61	41.75	158.82	148.05	136.00	148.05	158.82	–
10d	18.46	20.57	42.71	158.56	136.39	137.38	147.02	153.59	129.27 (C-2',6'); 130.41 (C-3',5'); 135.49 (C-4'); 134.68 (C-1'); 190.79 ($\underline{C}$OPh)
14	19.63	–	43.16	169.88	112.41	156.34	114.67	147.25	–
16b	19.38	–	41.48	151.48	105.97	156.05	107.73	143.70	39.48 (N(CH_3)$_2$)

*The ^{13}C NMR spectrum of compound **10c** was taken in CD_3CN.

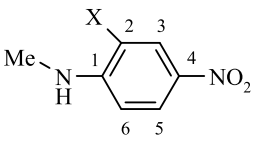
TABLE 5. IR Spectra of Nitroanilines

Compound	ν, см$^{-1}$		
	NO_2	NH	C=O
2a	1582, 1321	3301	1632, 1612
2b	1584, 1323	3241	1630, 1618
2c	1580, 1321	3281	1626, 1611
8	1580, 1330	3371	–
9	1528, 1357	3357	–
11a	1555, 1391	3366	1661, 1613
11b	1560, 1384	3373	1658, 1627
11c	1580, 1536, 1357, 1322	3359	–
11d	1562, 1351	3339	1680, 1614
12a	1566, 1348	3308	1638, 1612
12b	1567, 1345	3282	1627, 1606
12d	1552, 1352	3318	1621, 1610
13	1569, 1351	3367	1648, 1615

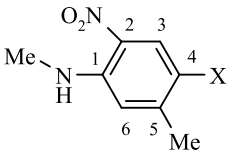
TABLE 6. ^{1}H NMR Spectra of Nitroanilines

Com-pound	Chemical shifts ($CDCl_3$), δ, ppm (J, Hz)	
	$N\underline{H}CH_3$ (br. s)	Other protons
2b	9.55	1.03–1.25 (4H, m, $2CH_2$); 2.65–2.78 (1H, m, CH); 3.00 (3H, d, J = 5.1, $NHC\underline{H}_3$); 6.69 (1H, d, ^3J = 9.3, H-3); 8.24 (1H, dd, ^3J = 9.3, ^4J = 2.4, H-4); 8.98 (1H, d, ^4J = 2.4, H-6)
2c	9.30	3.10 (3H, d, J = 5.0, $NHC\underline{H}_3$); 6.80 (1H, d, ^3J = 9.6, H-3); 7.49–7.56 (2H, m, C_6H_5); 7.58–7.67 (3H, m, C_6H_5); 8.29 (1H, dd, ^3J = 9.6, ^4J = 2.5, H-4); 8.52 (1H, d, ^4J = 2.5, H-6)
8	8.09	2.37 (3H, s, 5-CH_3); 3.03 (3H, d, J = 5.3, $NHC\underline{H}_3$); 6.47 (1H, dd, ^3J = 8.7, ^4J = 1.5, H-4); 6.62 (1H, br s, H-6); 8.07 (1H, d, ^3J = 8.7, H-3)
9	8.89	2.61 (3H, s, 3-CH_3); 2.98 (3H, br s, $NHC\underline{H}_3$); 6.96 (1H, m, H-2); 7.00 (1H, m, H-6); 8.04 (1H, d, ^3J = 8.7, H-5)
11a	8.34	2.59 (3H, s, 2-CH_3); 2.64 (3H, s, $COCH_3$); 3.10 (3H, d, J = 5.1, $NHC\underline{H}_3$); 6.64 (1H, s, H-3); 8.72 (1H, s, H-6)
11b	8.31	1.01–1.06 (2H, m, CH_2); 1.17–1.22 (2H, m, CH_2); 2.48–2.55 (1H, m, CH); 2.57 (3H, s, 2-CH_3); 3.09 (3H, d, J = 5.2, $NHC\underline{H}_3$); 6.65 (1H, s, H-3); 8.83 (1H, s, H-6)
11c	8.41	2.72 (3H, s, 5-CH_3); 3.14 (3H, d, J = 5.3, $NHC\underline{H}_3$); 6.70 (1H, s, H-6); 9.11 (1H, s, H-3)
11d	8.31	2.10 (3H, s, 2-CH_3); 3.08 (3H, d, J = 5.1, $NHC\underline{H}_3$); 6.72 (1H, s, H-3); 7.29–7.35 (2H, m, C_6H_5); 7.42−7.47 (3H, m, C_6H_5); 8.63 (1H, s, H-6)
12a	9.36	2.63 (3H, s, 4-CH_3); 2.68 (3H, s, $COCH_3$); 3.00 (3H, d, J = 5.3, $NHC\underline{H}_3$); 6.48 (1H, s, H-3); 8.71 (1H, s, H-6)
12b	9.34	1.03–1.10 (2H, m, CH_2); 1.16–1.22 (2H, m, CH_2); 2.67–2.74 (4H, m, CH, 4-CH_3); 2.98 (3H, d, J = 5.1, $NHC\underline{H}_3$); 6.48 (1H, s, H-3); 8.98 (1H, s, H-6)
12d	9.10	2.72 (3H, s, 4-CH_3); 3.06 (3H, d, J = 4.7, $NHC\underline{H}_3$); 6.57 (1H, s, H-3); 7.46–7.67 (5H, m, C_6H_5); 8.49 (1H, s, H-6)
13	8.31	2.53 (3H, s, $COCH_3$); 3.10 (3H, d, J = 5.3, $NHC\underline{H}_3$); 6.73 (1H, s, H-3); 7.44–7.51 (2H, m, C_6H_5); 7.55−7.62 (1H, m, C_6H_5); 7.73−7.78 (2H, m, C_6H_5); 8.29 (1H, s, H-6)

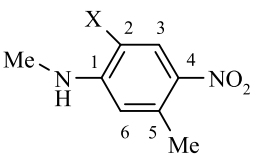
TABLE 7. ^{13}C NMR Spectra ($CDCl_3$) of Nitroanilines



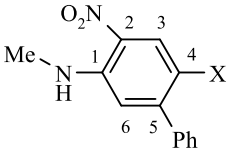
2a–c



8, 12a,b,d



9, 11a–d



13

Compound	Chemical shifts, δ, ppm							
	N–CH_3	C-1	C-2	C-3	C-4	C-5	C-6	Signals of other groups
2a	29.65	155.44	115.87	129.87	135.22	130.03	111.11	27.74 ($CO\underline{C}H_3$); 200.43 ($\underline{C}OCH_3$)
2b	29.61	155.20	116.62	129.10	135.46	129.70	110.92	11.69 (CH_2); 17.26 (CH); 201.62 ($\underline{C}O$-*c*-Pr)
2c	29.79	156.05	115.54	129.96	135.24	132.24	111.00	128.53 (C-2',6'); 129.04 (C-3',5'); 131.89 (C-4'); 138.78 (C-1'); 198.47 ($\underline{C}O$Ph)
8	29.62	147.81	129.97	126.68	116.89	146.34	112.91	22.14 (5-CH_3)
9	33.63	147.06	119.98	137.20	143.46	127.52	114.92	21.51 (3-CH_3)
11a	29.78	149.24	128.91	115.76	124.55	147.40	130.76	23.33 (5-CH_3); 28.35 ($CO\underline{C}H_3$); 197.38 ($\underline{C}OCH_3$)
11b	29.74	148.18	129.10	115.43	126.23	147.13	129.49	11.44 (CH_2); 18.89 (CH); 22.47 (5-CH_3); 200.03 ($\underline{C}O$-*c*-Pr)
11c	30.06	147.50	129.18	115.82	143.13	136.87	125.98	22.46 (5-CH_3)
11d	29.91	149.53	130.34	115.30	127.20	146.85	128.13	29.47 (5-CH_3); 128.13 (C-2',6'); 128.58 (C-3',5'); 129.16 (C-4'); 140.19 (C-1'); 198.97 ($\underline{C}O$Ph)
12a	29.48	154.12	115.08	131.98	135.90	142.45	113.73	28.86 (5-CH_3); 27.60 ($CO\underline{C}H_3$); 200.06 ($\underline{C}OCH_3$)
12b	29.48	153.95	115.80	131.26	136.11	142.13	113.62	11.54 (CH_2); 17.11 (CH); 22.88 (5-CH_3); 201.27 ($\underline{C}O$-*c*-Pr)
12d	29.63	154.74	114.61	131.75	135.99	142.38	113.68	22.84 (5-CH_3); 128.43 (C-2',6'); 128.98 (C-3',5'); 134.39 (C-4'); 138.90 (C-1'); 198.09 ($\underline{C}O$Ph)
13	29.80	148.45	128.78	115.38	125.22	138.25	130.49	21.68 ($CO\underline{C}H_3$); 128.46 (C-2',6'); 129.89 (C-3',5'); 132.75 (C-4'); 147.09 (C-1'); 195.40 ($\underline{C}OCH_3$)

EXPERIMENTAL

The IR spectra were obtained on a Simex FT-801 instrument (with an attachment for a single broken internal reflection). The ^{1}H NMR spectra of compounds **1a–c, 2b, 3**, and **6** were recorded on a Bruker AC-200 (at 200 MHz) spectrometer, internal standard was TMS, of compounds **4, 7–16** on a Bruker Advance DRX-400 (at 400 MHz), internal standard was the residual protons of the deuterated solvent. The ^{13}C NMR spectra were recorded on a Bruker Advance DRX-400 (at 100 MHz) using the solvent as internal standard. Elemental analysis was carried out on a Perkin-Elmer CHN Analyzer. Silica gel Merck 60A, 0.060–0.200 mm was used for column chromatography. A check on the progress of reactions and the purity of the obtained compounds was effected by TLC on Silufol UV-254 plates.

Preparation of Quaternary Pyridinium Salts 1a–c, 6, 7, 10a, 14 (General Method). A mixture of the corresponding pyridine (5-nitro-2-(phenylethynyl)pyridine [1], 3-acyl-2-methyl-5-nitropyridine [16], 3-acetyl-2,6-dimethyl-5-nitropyridine [17], 2,6-dimethyl-3-nitropyridine [18], or 2-methyl-4-nitropyridine [19]) (5 mmol), and dimethyl sulfate (1.9 g, 15 mmol) was heated (reaction conditions are shown in Table 1). The reaction mixture was cooled, washed with dry ether (3×10 ml), and the ether decanted. The residue was dissolved in water (5 ml) and a saturated aqueous solution of sodium perchlorate (0.64 g, 5.3 mmol) was added. The precipitated pyridinium perchlorate was filtered off, dried, and recrystallized.

1-Methyl-5-nitro-2-(2-oxo-2-phenylethyl)pyridinium Perchlorate (3). A mixture of salt **6** (1.69 g, 5 mmol), conc. H_2SO_4 (0.4 ml), and mercury(II) sulfate (1.56 g, 5.2 mmol) in 90% acetic acid solution (17.5 ml) was heated for 2 h at 80°C. The reaction mixture was filtered and concentrated perchloric acid was added with cooling. The precipitated crystals were filtered off and washed with 10% perchloric acid solution.

[2-Methyl-5-nitropyrid-2(1H)-ylidene]acetophenone (4). A mixture of (5-nitropyrid-2-yl)acetophenone [1] (0.24 g, 1 mmol) and dimethyl sulfate (0.38 g, 3 mmol) was heated for 6 h at 100°C. The mixture was cooled, washed with dry ether (3×10 ml), and the ether decanted. The residue was triturated with water and the precipitated red crystals filtered off. Yield 90%; mp 208–209°C (ethanol). IR spectrum, ν, cm^{-1}: 1699 (C=O), 1541, 1362 (NO_2). ^{1}H NMR spectrum (DMSO-d_6), δ, ppm (*J*, Hz): 3.76 (3H, s, NCH_3); 6.10 (1H, s, =CH–); 7.44–7.54 (3H, m, C_6H_5); 7.85 (1H, dd, ^3J = 10.3, ^4J = 2.0, H-4); 7.93–7.98 (2H, m, C_6H_5); 8.77 (1H, d, ^3J = 10.3, H-3); 9.12 (1H, d, ^4J = 2.0, H-6). Found, %: C 65.47; H 4.63; N 11.15. $C_{14}H_{12}N_2O_3$. Calculated, %: C 65.62; H 4.72; N 10.93.

Preparation of Quaternary Pyridinium Salts 10b,c,d (General Method). A solution of methyl fluorosulfonate (1.71 g, 15 mmol) in 1,2-dichloroethane (3 ml) was added dropwise with stirring to a solution of the corresponding pyridine (5 mmol) (3-(cyclopropylcarbonyl)-2,6-dimethyl-5-nitropyridine [17], 3-benzoyl-2,6-dimethyl-5-nitropyridine [17], or 2,6-dimethyl-3,5-dinitropyridine [17]) in 1,2-dichloroethane (15 ml) with cooling to 0°C. The mixture was stirred for 30 min with cooling and 5 days at room temperature, diluted with ether, and the precipitated solid filtered off.

1,2,6-Trimethyl-3,5-dinitropyridinium Perchlorate (10c). After heating, the mixture was cooled, washed with dry ether (3×20 ml), and the ether decanted. The residue was dissolved with heating in 10% perchloric acid (10 ml), cooled, and the precipitated crystals filtered off.

Preparation of Nitroanilines 2a–c (General Method). A. A 30% alcoholic methylamine solution (30 ml) was added to a solution of the corresponding salt **1a–c** (3 mmol) in DMF (2.3 ml) and the mixture stirred for 20 h. The reaction mixture was diluted with water and neutralized with 50% acetic acid solution. The precipitated solid was filtered off and purified by column chromatography (eluent chloroform). Compounds **2a–c** were recrystallized from ethanol.

[2-(Methylamino)-5-nitrobenzo]phenone (2c). B. From quaternary salt **3**. A 10% sodium hydroxide solution (6 ml) was added to a solution of salt **3** (1.07 g, 3 mmol) in ethanol (6 ml). The mixture was stirred at room temperature for 24 h, diluted with water, and neutralized with 50% acetic acid solution. The precipitated solid was filtered off.

C. From anhydro base **4**. A 10% sodium hydroxide solution (6 ml) was added to a solution of anhydro base **4** (0.77 g, 3 mmol) in ethanol (6 ml). The reaction was carried out analogously to the previous reaction.

Methyl(5-methyl-2-nitrophenyl)amine (8) and Methyl(3-methyl-4-nitrophenyl)amine (9). B. A 10% sodium hydroxide solution (4 ml) was added to a suspension of salt **7** (0.54 g, 2 mmol) in ethanol (8 ml). The reaction mixture was stirred for 48 h at room temperature, diluted with water, and neutralized with 50% acetic acid solution. The precipitated oil was extracted with benzene and dried over $MgSO_4$. After removing the solvent the product was isolated by column chromatography (eluent chloroform).

C. A mixture of salt **7** (0.54 g, 2 mmol) and 41% aqueous methylamine solution (40 ml) was stirred at room temperature for 48 h. The mixture was neutralized with 50% acetic acid solution, the precipitated oil was extracted with benzene and the extract dried over $MgSO_4$. After removing the solvent the product was isolated by column chromatography and recrystallized from ethanol.

Preparation of Nitroanilines 11a–d, 12a,b,d, and 13 (General Method). C. A 41% aqueous solution of methylamine (40 ml) was added to a solution of the corresponding salt **10a–d** (2 mmol) in DMF (4 ml) and the mixture was stirred at room temperature for 2 h. After neutralization with 50% acetic acid the precipitated solid was filtered off (in the case of compound **10c** after neutralization the mixture was extracted with ethyl acetate, the extract was dried, and after removal of the solvent was purified by column chromatography). Separation of the isomers was carried out by column chromatography (eluent chloroform). The product was recrystallized from ethanol.

1,2-Dimethylpyridin-4(1H)-one (15). A mixture of pyridinium salt **14** (0.25 g, 1 mmol) and anion exchange resin (OH^- form) (1.84 g) in ethanol (14 ml) was boiled for 2 h. The resin was filtered from the reaction mixture and the filtrate evaporated. The product was purified by column chromatography (eluent ethanol). Yield 48%; mp 50–55°C (toluene) (lit. mp 50–55°C [20]). ^{1}H NMR spectrum (DMSO-d_6), δ, ppm (*J*, Hz): 2.21 (3H, s, 2-CH_3); 3.52 (3H, s, NCH_3); 5.96 (1H, dd, ^3J = 7.5, ^4J = 2.4, H-5); 6.02 (1H, d, ^4J = 2.4, H-3); 7.59 (1H, d, ^3J = 7.5, H-6). ^{13}C NMR spectrum (DMSO-d_6), δ, ppm: 178.12 (C-4); 149.64 (C-2): 143.15 (C-6); 117.92 (C-5); 116.38 (C-3); 40.42 (NCH_3); 19.48 (2-CH_3).

Preparation of 4-Alkylamino-1,2-dimethylpyridinium Perchlorates 16a,b (General Method). A solution of salt **14** (0.25 g, 1 mmol) in a 30% alcoholic solution of methylamine or dimethylamine (30 ml) was stirred for 3 days. After removing the solvent, the residue was recrystallized from ethanol.

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REFERENCES

1. G. P. Sagitullina, M. A. Vorontsova, A. K. Garkushenko, N. V. Poendaev, and R. S. Sagitullin, *Zh. Org. Khim.*, **46**, 1820 (2010).
2. A. N. Kost, D. V. Yashunskii, S. P. Gromov, and R. S. Sagitullin, *Khim. Geterotsikl. Soedin.*, 1268 (1980). [*Chem. Heterocycl. Comp.*, **16**, 962 (1980)].
3. A. N. Kost, R. S. Sagitullin, and S. P. Gromov, *Khim. Geterotsikl. Soedin.*, 98 (1979). [*Chem. Heterocycl. Comp.*, **15**, 87 (1979)].
4 R. S. Sagitullin, S. P. Gromov, and A. N. Kost, *Dokl. Akad. Nauk*, **236**, 634 (1977).
5. A. N. Kost, L. G. Yudin, R. S. Sagitullin, and A. Muminov, *Khim. Geterotsikl. Soedin.*, 1566 (1978). [*Chem. Heterocycl., Comp.*, **14**, 1278 (1978)].
6. A. N. Kost, R. S. Sagitullin, and S. P. Gromov, *Dokl. Akad. Nauk*, **230**, 1106 (1976).
7. T. V. Stupnikova, B. P. Zemskii, R. S. Sagitullin, and A. N. Kost, *Khim. Geterotsikl. Soedin.*, 291 (1982). [*Chem. Heterocycl. Comp.*, **18**, 217 (1982)].
8. J. W. Bunting, in: A. R. Katritzky and A. J. Boulton (editors), *Advances in Heterocyclic Chemistry*, Vol. 25, Academic Press, New York (1979), p. 2.
9. E. G. Atavin, V. O. Tikhonenko, and R. S. Sagitullin, *Khim. Geterotsikl. Soedin.*, 923 (2001). [*Chem. Heterocycl. Comp.*, **37**, 850 (2001)].

10. O. Mumm and G. Hingst, *Ber.*, **56**, 2301 (1923).
11. O. N. Chupakhin and D. G. Beresnev, *Usp. Khim.*, **71**, 803 (2002).
12. J. F. K. Wilshire, *Aust. J. Chem.*, **35**, 2497 (1982).
13. L. H. Sternbach, R. Ian Fryer, O. Keller, W. Metlesics, G. Sach, and N. Steiger, *J. Med. Chem.*, **6**, 261 (1963).
14. O. Fischer and M. Rigaud, *Ber.*, **35**, 1258 (1902).
15. R. Stroermer, *Ber.*, **31**, 2523 (1898).
16. G. P. Sagitullina, A. K. Garkushenko, E. O. Silina, and R. S. Sagitullin, *Khim. Geterotsikl. Soedin.*, 1193 (2009). [*Chem. Heterocycl. Comp.*, **45**, 948 (2009)].
17. G. P. Sagitullina, A. K. Garkushenko, E. G. Atavin, and R. S. Sagitullin, *Mendeleev Commun.*, **19**, 155 (2009).
18. E. Plazek, *Ber.*, **72**, 577 (1939).
19. A. N. Kost, R. S. Sagitullin, and S. P. Gromov, *Khim. Geterotsikl. Soedin.*, 922 (1976). [*Chem. Heterocycl. Comp.,* **12**, 766 (1976)].
20. P. Patel and J. A. Joule, *J. Chem. Soc., Chem. Commun.*, 1021 (1985).