Chemistry of Heterocyclic Compounds, Vol. 38, No. 3, 2002

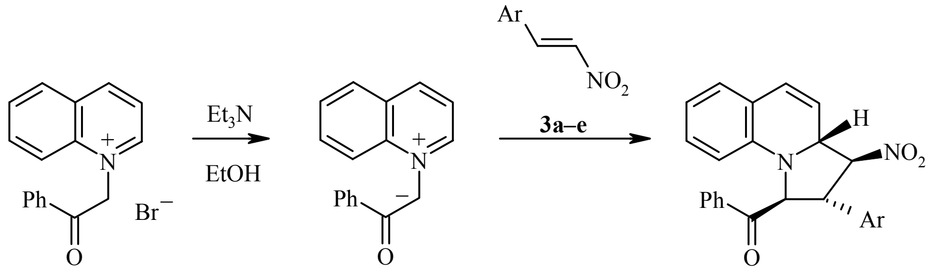
INVESTIGATION OF THE REACTIONS OF QUINOLINIUM YLIDE WITH NITROSTYRENES

A. M. Shestopalov, K. S. Chunikhin, and L. A. Rodinovskaya

The reactions of nitrostyrenes with quinolinium ylide have been investigated. Previously unknown 2-aryl-1-benzoyl-3-nitro-1,2,3,3a-tetrahydropyrrolo[1,2-a]quinolines have been obtained and their stereochemistry has been established.

Keywords: quinolinium ylides, nitrostyrenes, 1,2,3,3a-tetrahydropyrrolo[1,2-*a*]quinolines.

The reactions of azinium ylides with unsaturated compound containing nucleofugal group, 1,1-dimethylthio-2-nitroethylene, have been investigated previously [1-5]. It was established that these reactions can proceed both by synchronous mechanism of 1,3-dipolar cycloaddition and by asynchronous mechanism with the formation of indolizines. Up to the present time the reactions of azinium ylides with unsaturated nitro compounds containing no nucleofugal group have not been studied. For the first time we studied [6] the interaction of quinolinium ylide with nitrostyrenes and established its regioselectivity and stereoselectivity. Reactions were carried out in ethanol at 40-45°C, generating ylide **1** by the action of triethylamine on the quinolinium salt **2**.



2 **1** **4a–e**

3, 4 a Ar = Ph; **b** Ar = 2-$NO_2C_6H_4$; **c** Ar = 4-ClC_6H_4; **d** Ar = 4-$CH_3OC_6H_4$; **e** Ar = 2-C_4H_3S

We obtained substituted *trans-trans-trans*-1,2,3,3a-tetrahydropyrrolo[1,2-*a*]quinolines **4a-e** (Table 1) under these conditions, the structures of which were confirmed by data of physicochemical investigations. In the IR spectra of compounds **4a-e** there were characteristic signals of keto group and bands for the stretching vibrations of NO_2 group (see Table 2). The mass spectra contained molecular ion peaks, peaks characteristic of nitro compounds arising from fission of the NO_2 group (*m/z* M-46), quinoline mass peak (*m/z* 129), and a peak for the benzoyl fragment (*m/z* 107) (Table 2).

N. D. Zelinsky Institute of Organic Chemistry, Russian Academy of Sciences, Moscow 117913, Russia; e-mail: shchem@dol.ru. Translated from Khimiya Geterotsiklicheskikh Soedineii, No. 3, pp. 346-349, March, 2002. Original article submitted March 14, 2001; revision submitted May 30, 2001.

TABLE 1. Characteristics of Compounds **4a-e**

Compound	Empirical formula	Found, % Calculated, % C	H	N	mp, °C (ethanol)	Yield, %
4a	$C_{25}H_{20}N_2O_3$	76.02 75.75	5.25 5.05	6.78 7.07	176-178	75
4b	$C_{25}H_{19}N_3O_5$	67.81 68.02	4.09 4.31	9.31 9.52	166-167	50
4c	$C_{25}H_{19}ClN_2O_3$	69.43 69.76	4.25 4.41	6.77 6.51	174-176	56
4d	$C_{26}H_{22}N_2O_4$	72.90 73.23	5.32 5.16	6.81 6.57	154-156	57
4e	$C_{23}H_{18}N_2O_3S$	68.85 68.65	4.61 4.47	7.11 6.96	167-168	75

According to the data of ^{1}H NMR spectra compounds **4a-e** were pure substances (Table 3). Assignment of the signals was made from analysis of the coupling constants and the data of difference double resonance experiment for compound **4d**, i.e. from the changes in the spectrum on quenching the signals at 4.57, 5.38, and 5.91 ppm. An alternative assignment is possible, *viz*. 4.57 ppm for 4-H, 5.38 for 3a-H, 5.56 for 2-H, 5.9 for 5-H, 5.97 for 3-H, and 6.53 ppm for 2-H. However this is less probable since the signal for the 2-H proton adjacent to the aromatic nucleus must appear in the higher field region, at 4.4-4.7 ppm [7-10].

According to the data of difference double resonance the proton at 6.06 ppm is vicinal in relation to the proton at 6.86 ppm and both probably belong to the benzene ring of the quinoline fragment. The torsion angle $\phi_{2,3}$ calculated by the Karplus–Conroy equation with regard to the steric factors from the value of the coupling constant $J_{2,3} \sim 9.7$ Hz, is equal to 140°, which indicates that protons 2 and 1 are disposed *trans* pseudodiaxially. The protons 3 and 3a with coupling constant $J_{3,3a} \sim 7$ Hz may have both *cis* and *trans* mutual disposition. Since quinolinium ylides react in the *anti* form [7-10], and proton 3a and proton 1 are disposed *trans* pseudodiaxially, it follows that protons 3a and 3 are also disposed *trans* pseudodiaxially. It may therefore be concluded that compound **4d** has a *trans-trans-trans* pseudodiaxial configuration. These data are in good agreement with the correlation data of ^{1}H NMR and X-ray structural analysis obtained previously for 1,2,3,3a-tetrahydropyrrolo[1,2-*b*]quinoline [7-10].

TABLE 2. Data of IR and Mass Spectra of Compounds **4a-e**

Compound	Mass spectrum, *m/z* (*I*, %)	IR spectrum, ν, cm^{-1} CO	NO$_2$
4a	396 [M$^+$] (9.7), 364 [M$^+$ - O$_2$] (15.0), 350 [M$^+$ - NO$_2$] (23.1), 319 (34.3), 291 (23.4), 188 (45.6), 149 (67.9), 144 (56.9), 131 (89.0), 105 (74.7)	1688	1548 (*as*), 1384 (*s*)
4b	441 [M$^+$] (12.3), 409 [M$^+$ - O$_2$] (14.4), 395 [M$^+$ - NO$_2$] (24.5), 319 (32.1), 336 (2.0), 188 (42.1), 194 (23.7), 144 (58.4), 131 (90.1), 105 (75.2)	1680	1544 (*as*), 1380 (*s*)
4c	430 [M$^+$] (11.7), 398 [M$^+$ - O$_2$] (16.8), 384 [M$^+$ - NO$_2$] (21.5), 325 (27.0), 319 (39.0), 278 (17.0), 188 (28.0), 183 (24.8), 144 (45.3), 131 (92.2), 105 (79.0)	1688	1548 (*as*), 1384 (*s*)
4d	427 [M$^+$] (12.0), 395 [M$^+$ - O$_2$] (12.3), 381 [M$^+$ - NO$_2$] (31.0), 322 (30.0), 319 [M$^+$ - 4-CH$_3$O - C$_6$H$_4$] (21.0), 275 (10.0), 188 (32.1), 179 (45.0), 144 (64.0), 131 (95.0), 105 (80.0)	1684	1548 (*as*), 1384 (*s*)
4e	402 [M$^+$], 370 [M$^+$ - O$_2$], 356 [M$^+$ - NO$_2$], 325 (7.0), 319 (34.7), 297 (3.0), 188 (32.0), 156 (57.0), 144 (57.9), 131 (100.0), 105 (77.0)	1688	1548 (*as*), 1380 (*s*)

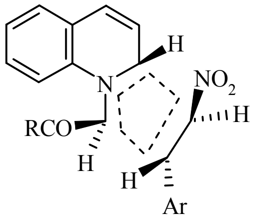
TABLE 3. ^{1}H NMR Spectral Characteristics of Compounds **4a-e**

Compound	δ, ppm, coupling constant (*J*), Hz						
	1-H, d	2-H, dd	3-H, dd	3a-H, dd	4-H, dd	5-H, d	6-H – 9-H, H_{Ph}, H_{Ar}
4a	5.91	4.63	5.38	5.97	5.56	6.53	6.05 (1H, d); 6.59-7.85 (13H, m)
	$J_{1,2} = J_{2,1} = 9.75$; $J_{2,3} = J_{3,2} = 2.42$		$J_{3,3a} = J_{3a,3} = 7.01$; $J_{3a,4} = J_{4,3a} = 2.53$		$J_{4,5} = J_{5,4} = 10.05$		
4b	6.16	5.34	5.72	6.01	5.65	6.56	6.27 (1H, d); 6.59-7.85 (12H, m)
	$J_{1,2} = J_{2,1} = 9.57$; $J_{2,3} = J_{3,2} = 2.2$		$J_{3,3a} = J_{3a,3} = 7.10$; $J_{3a,4} = J_{4,3a} = 2.25$		$J_{4,5} = J_{5,4} = 10.05$		
4c	5.91	4.84	5.63	5.85	5.56	6.53	6.15 (1H, d); 6.59-7.85 (12H, m)
	$J_{1,2} = J_{2,1} = 9.87$; $J_{2,3} = J_{3,2} = 1.42$		$J_{3,3a} = J_{3a,3} = 7.01$; $J_{3a,4} = J_{4,3a} = 2.53$		$J_{4,5} = J_{5,4} = 10.07$		
4d*	5.91	4.57	5.38	5.97	5.56	6.53	6.05 (1H, d); 6.59-7.85 (12H, m)
	$J_{1,2} = J_{2,1} = 2.42$; $J_{2,3} = J_{3,2} = 9.75$		$J_{3,3a} = J_{3a,3} = 7.02$; $J_{3a,4} = J_{4,3a} = 2.53$		$J_{4,5} = J_{5,4} = 10.05$		
4e	5.93	5.16	5.51	5.81	5.64	6.53	6.05 (1H, d); 6.59-7.85 (11H, m)
	$J_{1,2} = J_{2,1} = 9.75$; $J_{2,3} = J_{3,2} = 2.42$		$J_{3,3a} = J_{3a,3} = 7.01$; $J_{3a,4} = J_{4,3a} = 1.93$		$J_{4,5} = J_{5,4} = 9.90$		

---

* The singlet signal of the CH_3O group is found at 3.65 ppm.

Such a high stereoselectivity indicates that the reaction proceeds by the route of synchronous [$\pi_S4 + \pi_S2$] cycloaddition of ylide. In the five-center transition state **A**, characteristic of synchronous 1,3-dipolar cycloaddition, quinolinium ylide is found to exist in the *anti* form, but the *trans* disposition of the substituents in nitrostyrene is retained.



A

Obviously if this reaction took place according to asynchronous mechanism, such as through Michael adduct, the stereochemistry would be different.

EXPERIMENTAL

Melting points were determined on a Kofler stage. The IR spectra were recorded on a Perkin–Elmer 577 instrument in KBr disks, ^{1}H NMR spectra – on a Bruker WM 250 (250 MHz) spectrometer in DMSO-d_6, and mass spectra – on a Finnigan MAT INCOS 50 mass spectrometer (ionizing energy 70 eV). Elemental analysis was carried out on a Perkin–Elmer C, H, N analyzer.

2-Aryl-1-benzoyl-3-nitro-1,2,3,3a-tetrahydropyrrolo[1,2-*b*]quinolines (4a-e) (General Method). Suspension of N-phenacylquinolinium bromide **2** (0.17 g, 0.52 mmol) and *trans*-2-nitrostyrene **3a-e** (0.5 mmol) in ethanol (2 ml) was maintained at 40-45°C until solution was formed. Triethylamine (0.08 ml, 0.6 mmol) was added to the solution. A transient reddening of the reaction mixture was observed, orange solid product separated after 3-4 min, and was filtered off, washed sequentially with water, ethanol, and hexane, and crystallized from ethanol. The characteristics of compounds **4a-e** are given in Tables 1-3.

REFERENCES

1. V. P. Litvinov and A. M. Shestopalov, *Zh. Org. Khim.*, **33**, 975 (1997).
2. Y. Tominaga, Y. Miyake, H. Fujito, K. Kurata, H. Awaya, H. Matsuda, and G. Kabayashi, *Chem. Pharm. Bull.*, **25**, 1528 (1977).
3. Y. Tominaga and Y. Matsuda, *J. Heterocycl. Chem.*, **22**, 937 (1985).
4. Y. Tominaga, Y. Shiroshita, and A. Hosomi, *J. Heterocycl. Chem.*, **25**, 1745 (1988).
5. Y. Tominaga, Y. Shiroshita, T. Kurokava, H. Gotou, Y. Matsuda, and A. Hosomi, *J. Heterocycl. Chem.*, **26**, 477 (1989).
6. K. S. Chunikhin, L. A. Rodinovskaya, and A. M. Shestopalov, in: *Young People's Scientific School on Organic Chemistry, Abstracts of the All-Russian Scientific Conference*, Ekaterinburg (2000), p. 132.
7. A. M. Shestopalov, V. P. Litvinov, Yu. A. Sharanin, and G. E. Khoroshilov, *Dokl. Akad. Nauk*, **312**, 1156 (1990).
8. A. M. Shestopalov, Yu. A. Sharanin, V. N. Nesterov, G. E. Khoroshilov, V. E. Shklover, Yu. T. Struchkov, and V. P. Litvinov, *Khim. Geterotsikl. Soedin.*, 1354 (1991).
9. A. M. Shestopalov, Dissertation for Doctor of Chemical Sciences, Moscow, 1991.
10. V. P. Litvinov, *Zh. Org. Khim.*, **31**, 1441 (1995).