82010-11-5; (*Z*,*X*)-farnesol, 82010-12-6; (*E*,*X*)-farnesal, 80442-43-9; (*Z*,*X*)-farnesal, 80442-44-0; (*E*,*X*)-farnesal *O*-trimethylsilyl cyanohydrin, 82025-98-7; (*Z*,*X*)-farnesal *O*-trimethylsilyl cyanohydrin, 82025-99-8.

200-MHz Proton Nuclear Magnetic Resonance Study of the Naphtho[2,1-*e*]tetrazolo[5,1-*c*]-*as*-triazine/3-Azidonaphtho[2,1-*e*]-*as*-triazine/Naphtho[2,1-*e*]tetrazolo[1,5-*b*]-*as*-triazine Equilibrium

Sergio Castillón

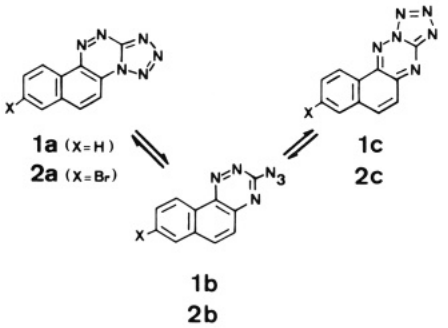
Departamento de Quimica Orgânica, Facultad de Ciencias, Universidad de Zaragoza, Spain

Jaume Vilarrasa*

Departament de Quimica Orgânica, Facultat de Quimica, Universitat de Barcelona, Barcelona-28, Spain

Received December 1, 1981

In the first paper of this series[1] the cyclization of several (2-hydroxynaphthalenyl)-1-azoazoles to naphtho[2,1-*e*]-azolo-*as*-triazines was reviewed and investigated, the structure of most of these tetracyclic compounds being firmly established on the basis of the common spectroscopic techniques. However, with regard to the corresponding tetrazole derivative, naphtho[2,1-*e*]tetrazolo-[5,1-*c*]-*as*-triazine (**1a**), which may tautomerize to 3-azi-



donaphtho[2,1-*e*]-*as*-triazine (**1b**) and naphtho[2,1-*e*]tetrazolo[1,5-*b*]-*as*-triazine (**1c**),[2,3] doubt still remained: whereas, as shown by IR spectroscopy, the azide form (**1b**) seemed to predominate in $CHCl_3$, we had inconclusive proof concerning the true structure (**1a**, **1c**, or a mixture of both) of the cyclic, major product(s) in the solid state and in Me_2SO solution at room temperature. An easy approach to the question would have been to perform an NMR study of **1** in suitable solvents at about 20 °C, but the low solubility of **1** precluded it at that moment.

We report here a 200-MHz FT ^1H NMR study of the 8-bromo derivative of **1** (**2**), a more appropriate compound than **1** for analytical purposes, in Me_2SO-d_6 and in $CDCl_3$, which establishes without doubt that in the former solvent the only tautomer present is **2c** while in the latter there is an equilibrium between **2b** and **2c**.

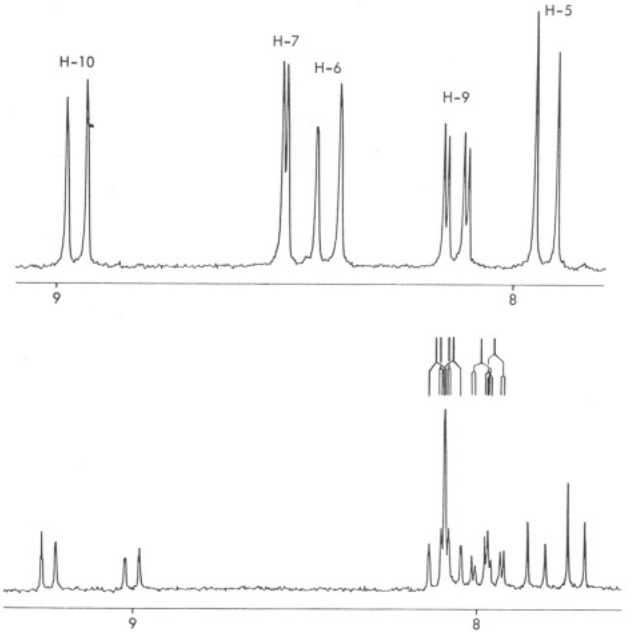
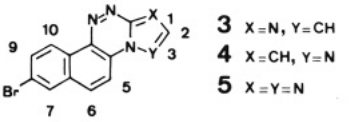


Figure 1. 200-MHz ^1H NMR spectrum of **2** in Me_2SO-d_6 (top) and in $CDCl_3$ (bottom).

The preparation of **2** was accomplished as in the case of **1**,[1] i.e., by coupling diazotetrazole with the corresponding 2-naphthol and refluxing the azo derivative under acidic conditions. For the sake of comparison, 8-bromonaphtho[2,1-*e*]imidazo[2,1-*c*]-*as*-triazine (**3**), 8-bromonaphtho[2,1-*e*]pyrazolo[5,1-*c*]-*as*-triazine (**4**), and 8-bromonaphtho[2,1-*e*]-*s*-triazolo[5,1-*c*]-*as*-triazine (**5**) were similarly obtained.



The ^1H NMR spectrum of **2** in Me_2SO-d_6 at 20 °C, practically a first-order spectrum, is shown in Figure 1 (top). It is obvious that a single tautomer is present. Furthermore, if the observed chemical shifts are compared with those of the protons of **3**–**5** in the same solvent (see Table I), it will be noted that H-5 of **2** appears at higher field than the analogous protons of **3**–**5** (the complex signal including H-5, H-6, and H-7 lies at ca. δ 8.5 in all cases), and the δ value for H-10 of **2** is lower than expected. Therefore, it can be deduced that the tautomer of **2** that largely predominates under those conditions is not **2a**.[4] Taking into account that the azide band is absent from the IR spectrum of **2** in Me_2SO (and in the solid state[5]), we can conclude that the "true structure" of **2** must be **2c**.

The ^1H NMR spectrum of **2** in $CDCl_3$ at 20 °C, shown in Figure 1 (bottom), affords an indirect confirmation of the above statement. Two sets of signals are apparent, which can be attributed to **2b** (57%) and **2c** (43%)[6] in view of the strong azide bands present in the IR spectrum in $CHCl_3$ and the δ values observed for the H-5 and H-10

(1) Vilarrasa, J.; Granados, R. *J. Heterocycl. Chem.* **1974**, *11*, 867.
(2) For reviews on the azide–tetrazole equilibrium, see, e.g.: (a) Butler, R. N. *Adv. Heterocycl. Chem.* **1977**, *21*, 323. (b) Tisler, M. *Synthesis* **1973**, 123.
(3) The existence of a similar ternary equilibrium in the benzo-*as*-triazine series has been recently demonstrated: (a) Messmer, A.; Hajós, G.; Tamás, J.; Neszmélyi, A. *J. Org. Chem.* **1979**, *44*, 1823. (b) Castillón, S.; Meléndez, E.; Pascual, C.; Vilarrasa, J., *J. Org. Chem.*, in press.
(4) The low δ value for H-5 agrees with structures **2b** and **2c**, in which no azole ring is close to that proton, as observed in naphtho[2,1-*e*]-*v*-triazolo[1,5-*b*]-*as*-triazine.[1] Protons H-5, H-6, and H-10 of a related compound, naphtho[2,1-*e*]-*as*-triazin-3-one, appear at δ 7.20, 8.16, and 8.52, respectively, in Me_2SO-d_6 (Lalor, F. J.; Scott, F. L.; Ferguson, G.; Marsh, W. C. *J. Chem. Soc., Perkin Trans. 1* **1978**, 789).
(5) Attempts to obtain crystals of **2** good enough for a X-ray analysis have been unsuccessful.
(6) On addition of TFA to this solution the **2b**/**2c** ratio increases, as expected.[2]

0022-3263/82/1947-3168$01.25/0

Table I. ^{1}H NMR Spectral Data in Me_2SO-d_6

	chemical shift, δ								coupling constant, Hz				
compd	H-1	H-2	H-3	H-5	H-6	H-7	H-9	H-10	$J_{1,2}$	$J_{2,3}$	$J_{5,6}$	$J_{7,9}$	$J_{9,10}$
2				7.94	8.40	8.49	8.12	8.94			9.5	2.0	8.6
3		8.20	8.84		8.3–8.5		7.94	9.15		1.3		2.0	8.6
4	7.70	8.56			8.4–8.5		8.04	9.22	2.6			2.0	8.6
5		9.12			8.6–8.7		8.18	9.38				2.2	8.6

protons (the two high-field doublets and the two downfield doublets, respectively). There is no evidence for **2a**.

A last point to consider is whether the bromo substituent plays an important role in the stability of **2c**. As the 200-MHz ^{1}H NMR spectrum of **1** in Me_2SO-d_6 at 20 °C does agree with that of **2** under the same conditions, i.e., since the only tautomer detected is **1c**, it may be thought that its role is not significant.

In conclusion we can remark, correcting the previous suggestions on the subject, that the tetrazolo[1,5-*b*]-*as*-triazine system (as in **1c** and **2c**) is largely favored with respect to the tetrazolo[5,1-*c*]-*as*-triazine arrangement (as in **1a** and **2a**) in the naphtho series considered here. Indeed, this agrees with what is observed in simple *as*-triazine systems, in which the compounds cyclized on N-2 (tetrazolo[1,5-*b*]-*as*-triazines) usually predominate over those cyclized on N-4 (tetrazolo[5,1-*c*]-as-triazines),[2,7] but partially disagrees with what occurs in the benzo-*as*-triazine series.[3] A general explanation for all these facts could be as follows: the cyclization of the azide on N-2 seems to be favored as a rule,[7] probably because the lone-pair repulsion between N-1 and N-2 disappears after such a cyclization, but may give more quinone-like or less aromatic polycyclic structures than the cyclization on N-4; the relative importance of this last factor may in some cases, particularly in the benzo series, invert the stability order.

Experimental Section

Melting points are uncorrected. ^{1}H NMR spectra were recorded on Varian XL-200 (200 MHz) and Perkin-Elmer R-24 or R-12B spectrometers; chemical shifts are reported in parts per million with respect to internal Me_4Si in all the cases, and *J* values are given in hertz. IR spectra were obtained on a Perkin-Elmer 283 instrument.

Azo derivatives [(6-bromo-2-hydroxynaphthalen-1-yl)-1-azoazoles] were prepared by standard procedures,[1] from 6-bromo-2-naphthol and the diazo derivatives arising from 5-aminotetrazole hydrate, 2-aminoimidazolium sulfate, 3(5)-aminopyrazole, and 3(5)-amino-*s*-triazole and were used in the next step without further purification. Dehydration of 2-(2-hydroxynaphthalen-1-yl)-1-azo-5-tetrazole to naphtho[2,1-*e*]tetrazolo[5,1-*c*]-*as*-triazine and/or related tautomers (**1**) was carried out as reported.[1]

8-Bromonaphtho[2,1-*e*]tetrazolo[1,5-*b*]-*as*-triazine (2c). 2-(6-Bromo-2-hydroxy-naphthalen-1-yl)-1-azo-5-tetrazole (5.0 g, 15.7 mmol) was heated at reflux in 2 M aqueous H_2SO_4 for 2 h. The resulting solution was basified with 2 M aqueous NaOH and then continuously extracted with CH_2Cl_2. The organic extracts were dried over anhydrous Na_2SO_4, filtered, and evaporated under vacuum to afford 3.8 g (80% yield) of almost pure **2**, which was recrystallized in ethanol to give a yellow amorphous solid: mp 202–204 °C; IR (KBr) 3060, 1585, 1525, 1425, 1345, 1295, 1275, 1125, 1110, 1030, 970, 885, 835 cm^{-1}; IR ($CHCl_3$) 3030, 2130, 2110, 1595, 1520, 1465, 1400, 1365, 1300, 1230, 1070 cm^{-1}; 200 MHz ^{1}H NMR ($CDCl_3$) δ 7.75 (d, *J* = 9.2 Hz, H-5), 7.96 (dd, *J* = 2.2 Hz, *J* = 8.6 Hz, H-9), 8.07 (d, *J* = 9.2 Hz, H-6), 8.09 (d, *J* = 2.2 Hz, H-7), and 9.24 (d, *J* = 8.6 Hz, H-10), corresponding to **2b**, and δ 7.86 (d, *J* = 9.6 Hz, H-5), 8.01 (dd, *J* = 2.2 Hz, *J* = 8.6 Hz, H-9), 8.11 (d, *J* = 2.2 Hz, H-7), 8.13 (d, *J* = 9.6 Hz, H-6), and 9.00 (d, *J* = 8.6 Hz, H-10), corresponding to **2c**. Anal. Calcd for $C_{11}H_7N_6OBr$: C, 41.40; H, 2.21; N, 26.34. Found: C, 41.17; H, 2.48; N, 26.01.

8-Bromonaphtho[2,1-*e*]azolo-*as*-triazines 3–5. Solutions of 4–5 g of crude 2-(8-bromo-2-hydroxynaphthalen-1-yl)-1-azoazoles in ca. 100 mL of acetic acid were refluxed for 30 min (imidazole derivative), 24 h (pyrazole derivative), and 48 h (*s*-triazole derivative). Elimination of the solvent under vacuum and recrystallization of the residues from absolute EtOH gave **3–5**, respectively.

8-Bromonaphtho[2,1-*e*]imidazo[2,1-*c*]-*as*-triazine (**3**): 58% yield (from the starting amine); mp >300 °C; IR (KBr) 3140, 3060, 1585, 1520, 1465, 1440, 1395, 1340, 1300, 1170, 1120, 1100, 1060, 890, 870, 820, 780, 730 cm^{-1}.

8-Bromonaphtho[2,1-*e*]pyrazolo[5,1-*c*]-*as*-triazine (**4**): 85% overall yield; mp 234–236 °C; IR(KBr) 3060, 2920, 1585, 1530, 1510, 1465, 1420, 1400, 1335, 1320, 1275, 1140, 1065, 895, 830, 820, 750, 720 cm^{-1}.

8-Bromonaphtho[2,1-*e*]-*s*-triazolo[5,1-*c*]-*as*-triazine (**5**): 87% overall yield; mp 287–288 °C; IR (KBr) 3060, 1585, 1530, 1460, 1400, 1315, 1290, 1240, 1200, 1170, 1130, 910, 895, 825 cm^{-1}.

Registry No. 2b, 81940-10-5; **2c**, 81940-11-6; **3**, 81940-12-7; **4**, 81940-13-8; **5**, 81940-14-9; 6-bromo-2-hydroxynaphthalene-1-azo-5′-tetrazole, 81940-15-0.

(7) (a) Weissberger, A.; Taylor, E. C. *Chem. Heterocycl. Compd.* **1977**, *30*, 179. (b) Goodman, M. M.; Atwood, J. L.; Carlin, R.; Hunter, W.; Paudler, W. W. *J. Org. Chem.* **1976**, *41*, 2860. (c) Goodman, M. M.; Paudler, W. W. *Ibid.* **1977**, *42*, 1866.

Active Heteromethylene Compounds. 2.[1a,b] A New Synthesis of *N*-(Halomethyl)acylamides

John P. Chupp,* Kindrick L. Leschinsky, and Deborah A. Mischke

Monsanto Agricultural Products Company, Research Department, St. Louis, Missouri 63166

Received March 9, 1982

Although a number of reports relate to the preparation of *N*-(halomethyl)acylamides, including some quite recent references,[2] known methods still possess severe limitations in gaining access to these desirable intermediates. Thus, *N*-(chloromethylation) with combinations of formaldehyde and HCl[3] is narrowly confined to simple aliphatic amides, and even here mixtures and disappointing yields are most often encountered. Although the conversion of *N*-(hydroxymethyl) amides with phosphorus pentachloride, thionyl chloride, or halogen acids is convenient, this method is largely limited to substrates derived from reaction of formaldehyde with imides or primary amides, owing to incomplete reaction and side products when secondary amides or anilides are methylolated.[4] Similarly, the addition of acid chlorides to monomeric[5,6] or trimeric[2a,7]

(1) (a) Part I: K. W. Ratts and J. P. Chupp, *J. Org. Chem.*, **39**, 3745 (1974); (b) presented at the 183rd National Meeting of the American Chemical Society, Las Vegas, NV, April 1, 1982; ORGN 195.

(2) (a) S. Gronowitz and Z. Lidert, *Syntheses*, 810 (1979); (b) J. W. Worley, *J. Org. Chem.*, **44**, 1178 (1979); and references contained in both these citations.

(3) A. W. Baldwin and H. A. Piggott, U.S. Patent 2 131 362 to Imperial Chemical Industries, Ltd., 1938.

(4) J. P. Chupp and A. J. Speziale, *J. Org. Chem.*, **28**, 2592 (1963).

(5) J. P. Chupp, J. F. Olin, and H. K. Landwehr, *J. Org. Chem.*, **34**, 1192 (1969).

0022-3263/82/1947-3169$01.25/0