Available online at www.sciencedirect.com
SCIENCE DIRECT
Tetrahedron Letters 47 (2006) 4903–4905
Tetrahedron Letters

Unprecedented coexistence of a spirooxazine and its four transoid photomerocyanines

Jerome Berthet,[a,*] Stephanie Delbaere,[a] Luis M. Carvalho,[b] Gaston Vermeersch[a] and Paulo J. Coelho[b,†]

[a]*CNRS UMR 8009, Laboratoire de Physique et d'application RMN, Faculté de Pharmacie, Université de Lille 2, F-59006, France*
[b]*Centro de Química - Vila Real, Universidade de Trás-os-Montes e Alto Douro, 5001-911 Vila Real, Portugal*

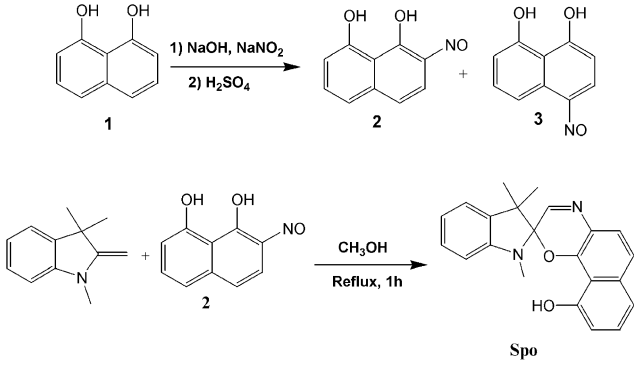
Received 3 April 2006; accepted 5 May 2006
Available online 30 May 2006

Abstract—The synthesis of the 5′-hydroxy-1,3,3-trimethylspiro[indoline-2,3′-[3*H*]naphtho[1,2-*b*][1,4]oxazine] is reported. Equilibrium in the dark between closed and open forms has been proved by NMR spectroscopy.

Among photochromic compounds, spirooxazines constitute one of the most studied families.[1,2] These compounds are of interest due to their ability to give intense photocolouration, fast thermal relaxation and good fatigue resistance. Absorption of UV light causes the cleavage of the spiro carbon–oxygen bond, leading after rearrangement to quasi-planar conjugated forms, the photomerocyanines, which absorb in the visible region. Among the eight possible isomers of the open form, TTC and CTC isomers have been underlined by NMR spectroscopy.[3,4] The electronic conjugation appears to play an important role in the stabilization of the photomerocyanine, giving rise to permanent open forms[5] or to thermal equilibrium between closed and open forms.[6] In the course of developing novel permanent photomerocyanines, we have investigated the effect of introducing an hydroxyl group in position 5′ of the 1,3,3-trimethylspiro[indoline-2,3′-[3*H*]naphtho[1,2-*b*]-[1,4]oxazine] (**Spo**), to induce stabilization by intramolecular hydrogen-bonding with the C=O of the open form.[7] The synthesis and the NMR observations are reported here.

Nitrosation of the readily available 1,8-dihydroxynaphthalene **1**,[8] gave a mixture of the isomeric 1,8-dihydroxy-2-nitrosonaphthalene **2** (74%) and 1,8-dihydroxy-4-nitrosonaphthalene **3** (14%) which were easily separated by column chromatography. Heating a methanolic yellow solution of 1,8-dihydroxy-2-nitrosonaphthalene **2** and 1,3,3-trimethyl-2-methyleneindoline under reflux for 1 h, yielded a deeply coloured blue solution. After solvent evaporation and column chromatography a blue compound **Spo** was isolated (Scheme 1).

One- and two-dimensional NMR spectra of **Spo** in $CDCl_3$ at 295 K revealed the presence of two structures, identified as the closed spirooxazine (~25%) and one open isomer (~75%) of the photomerocyanine (**PM**).[2] More particularly, the 2D-ROESY experiment made it possible to observe exchange phenomena between both compounds.[9] Indeed, each of the **Spo** signals give cross



Scheme 1. Synthesis of **Spo**.

* Corresponding author. Tel.: +33 320 964 013; fax: +33 320 959 009; e-mail addresses: jerome.berthet@univ-lille2.fr; pcoelho@utad.pt
† Tel.: +351 259 350 284; fax: +351 259 350480.

0040-4039/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.tetlet.2006.05.022

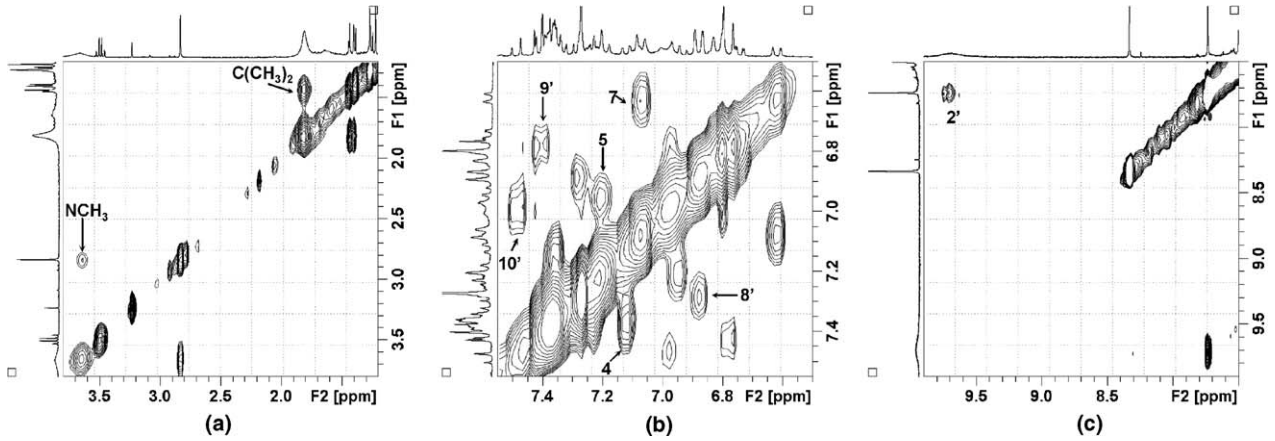


Figure 1. 2D-ROESY experiment at 295 K.

peaks with signals of **PM** (Fig. 1a–c), then characterizing thermal equilibrium between **Spo** and **PM**.

The NCH_3 signal at 3.66 ppm of the photomerocyanine (**PM**) shows a correlation with the signal at 2.83 ppm that can be attributed to the closed form (**Spo**). Similar correlations can be seen for the methyl protons $(CH_3)_2C$ (Fig. 1a) and H-10′, H-8′, H-7, H-9′, H-5 (Fig. 1b) and H-2′ (Fig. 1c).

In the ^1H NMR spectrum of the sample containing **Spo** and **PM** two OH signals can be observed: one sharp singlet at 8.33 ppm (**OH-Spo**) and a broad signal centered at 14.3 ppm that indicates the presence of a hydroxyl group involved in an intramolecular hydrogen bond (**PM**).

At 243 K, five different structures are distinguished: the closed spirooxazine and four sets of resonances which present cross-peaks in the ROESY map (Fig. 2). As the previous observed cross-peaks between **Spo** and **PM** have been replaced by correlations between the four new detected compounds, these are assigned to the four transoid open forms TTC, CTC, TTT and CTT. The elucidation of their exact structure is difficult due to the low intensity and overlapping of the signals. Nevertheless, by referring to previous reports on NMR, elucidation of photomerocyanines, characteristic chemical shifts can be used to identify the presence of these four **PM** isomers.[10] The ring opening of the spirooxazine is characterized by a downfield shift of protons $H_{2'}$ and N-CH_3. The range of the chemical shift is also indicative of the isomers structure. Consequently, signals at 9.73 and 3.65 ppm, and signals at 9.53 and 4.24 ppm are attributed to isomers TTC and CTC, respectively. The proton $H_{2'}$ is deshielded by the C=O and the N-methyl group in CTC appears at higher frequency than in TTC, due to deshielding by methine in TTC. In the same way, signals at 7.63 and 3.57 ppm, and signals at 7.47 and 4.32 ppm, are assigned to isomers TTT and CTT, respectively (Scheme 2).

As no equilibrium between the closed and the open forms has been reported with a non-substituted spirooxazine,[11] these results are a clear indication of the involvement of an hydroxyl group in the stabilization

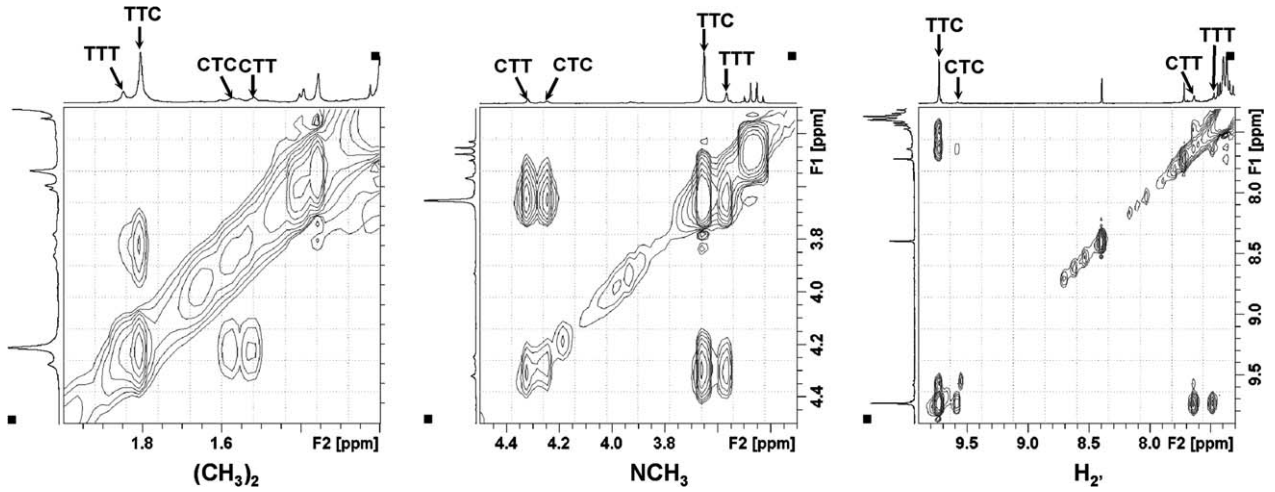
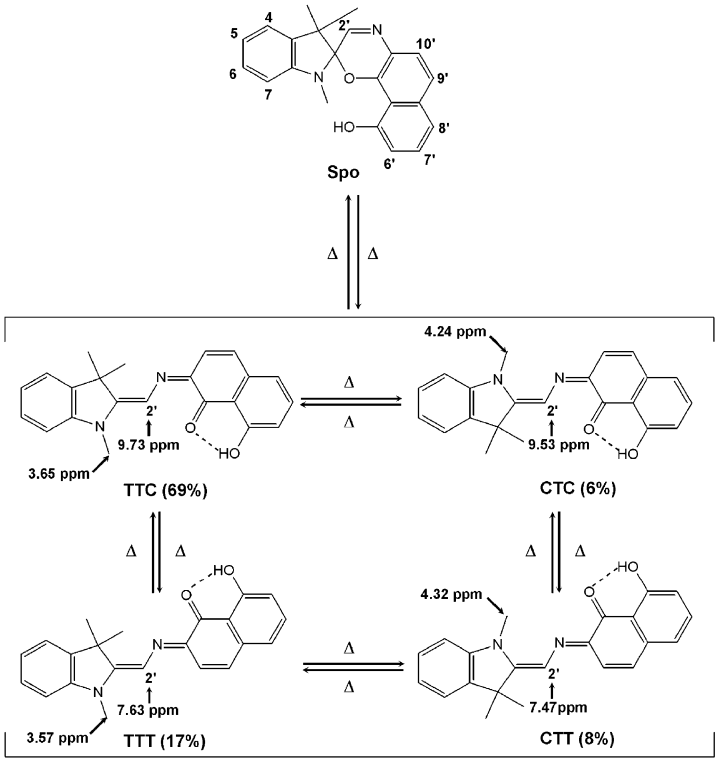


Figure 2. 2D-ROESY experiment at 243 K.



Scheme 2. Equilibrium in the dark between closed and open forms (**PM**).

of the open entities by intramolecular hydrogen bonding with the C=O group. At room temperature, the ring closure reaction is slower enough to observe the equilibrium between one opened isomer of photomerocyanine and the closed compound. Moreover, the four transoid isomers of photomerocyanines are in thermal equilibrium at low temperature (243 K). A similar equilibrium, at low temperature, but involving only two opened forms and a spirooxazine was reported.[12]

Acknowledgements

The 300 MHz NMR facilities were funded by the Région Nord-Pas de Calais (France), the Ministère de la Jeunesse, de l'Education Nationale et de la Recherche (MJENR) and the Fonds Européens de Développement Régional (FEDER). To FCT (Portugal's Foundation for Science and Technology) and FEDER for financial support to the research unit Centro de Química-Vila Real (POCTI-SFA-3-616).

Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.tetlet.2006.05.022. Supplementary data contains details of experiments and NMR spectra.

References and notes

1. Lokshin, V.; Samat, A.; Metelitsa, A. V. *Russ. Chem. Rev.* **2002**, *71*, 893–916.
2. Maeda, S. In *Organic Photochromic and Thermochromic Compound*; Crano, J. C., Guglielmetti, R. J., Eds.; Plenum Press: New York, 1999; Vol. 1, Chapter 2.
3. Delbaere, S.; Bochu, C.; Azaroual, N.; Buntinx, G.; Vermeersch, G. *J. Chem. Soc., Perkin Trans. 2* **1997**, 1499–1501.
4. Berthet, J.; Delbaere, S.; Lokshin, V.; Bochu, C.; Samat, A.; Guglielmetti, R.; Vermeersch, G. *Photochem. Photobiol. Sci.* **2002**, *1*, 333–339.
5. Laréginie, P.; Lokshin, V.; Samat, A.; Guglielmetti, R.; Pèpe, G. *J. Chem. Soc., Perkin Trans. 2* **1996**, 107–111.
6. Pozzo, J.-L.; Samat, A.; Guglielmetti, R.; De Keukeleire, D. *J. Chem. Soc., Perkin Trans. 2* **1993**, 1327–1332.
7. Carvalho, L. M.; Silva, A. M. S.; Martins, C. I.; Coelho, P. J.; Oliveira-Campos, A. M. F. *Tetrahedron Lett.* **2003**, *44*, 1903–1905; Martins, C. I.; Coelho, P. J.; Carvalho, L. M.; Oliveira-Campos, A. M. F. *Tetrahedron Lett.* **2002**, *43*, 2203–2205.
8. Bender, M. L.; Lawlor, J. M. *J. Am. Chem. Soc.* **1963**, *85*, 3010–3017.
9. Meier, B. H.; Ernst, R. R. *J. Am. Chem. Soc.* **1979**, *101*, 6441–6442.
10. Berthet, J.; Delbaere, S.; Lokshin, V.; Samat, A.; Vermeersch, G. *Photochem. Photobiol. Sci.* **2003**, *2*, 978–980.
11. Christie, R. M.; Chi, L.-J.; Spark, R. A.; Morgan, K. M.; Boyd, A. S. F.; Lycka, A. *J. Photochem. Photobiol. A: Chem.* **2005**, *169*, 37–45.
12. Hobley, J.; Malatesta, V. *Phys. Chem. Chem. Phys.* **2000**, *2*, 57–59.