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The synthesis, purification and spectroscopic characterization of several phenazines was undertaken with the goal of discovering useful or improved fluorescent probes.

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In keeping with our continuing interest in solvatochromism, we have initiated the synthesis and spectral characterization of some potentially solvatochromic fluorophores. Compounds which show sensitivity to their environment in their absorption and emission spectra are termed solvatochromic [2]. Solvatochromic effects can often be related to the ability of molecules to support intramolecular charge transfer in either their ground or excited electronic states. A well studied system is that of Nile Red 1 and its derivatives [3]. A key feature for these molecules is that resonance structures can be drawn which indicate that charge transfer can occur between an electron-donating group and an electron-accepting carbonyl oxygen (Figure 1). Variation of the electron-donating ability of the donor group could influence the solvent sensitivity effects, and could lead to increased or possibly complete loss of sensitivity due to the polarity of the environment.

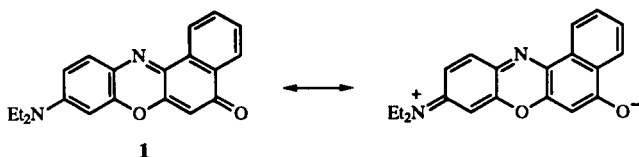


Figure 1.

Using Nile Red as a model, investigation of analogous 5,7-dihydrobenzo[*a*]phenazin-5-one derivatives 2-5 (Figure 2) was undertaken.

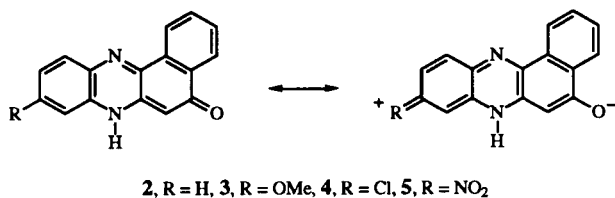
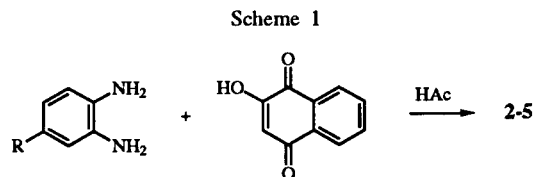


Figure 2.

These compounds, which can also support resonance structures demonstrating intramolecular charge transfer, appear to have undergone little previous chemical or physical characterization. In comparison to Nile Red, which has a 1,4-nitrogen-oxygen relationship, the presence of a 1,4-di-nitrogen heterocyclic structure in

these new molecules would be expected to affect the overall spectroscopic response. The 5,7-dihydrobenzo[*a*]phenazin-5-one derivatives have had only limited study, which is an added incentive for our work on their chemical behavior and physical properties. We present here in this note our preliminary results on the synthesis of various 5,7-dihydrobenzo[*a*]phenazin-5-one derivatives.

The general synthesis involved condensation of an aromatic 1,2-diamine with 2-hydroxynaphthoquinone (Scheme 1). In the presence of acetic acid several of the



products precipitated directly from solution. In other cases, neutralization and extraction followed by recrystallization resulted in product isolation. The method is attractive because a variety of compounds can be made from commercially available phenylenediamine derivatives. It is quite easy to make a variety of compounds with differing charge-transfer capabilities just by changing the electron-donating group R.

Crude yields for products 2-5 are very good, with purity sufficient for most uses. They are, however, difficult to get analytically pure. Initial attempts included column chromatography, recrystallization and vacuum sublimation. After a great deal of frustration, we found that analytically pure material could be achieved by first heating the compound at $\sim 100^\circ$ overnight, then recrystallization from DMSO or a mixed DMSO/acetonitrile solvent system, and then vacuum sublimation. Compounds 2-5 have extremely limited solubility, being appreciably soluble only in DMSO. These compounds are also high melting, with melting points commonly in excess of 300° .

We are currently investigating the fluorescence behavior of these compounds, those results, as well as the synthesis of other 5,7-dihydrobenzo[*a*]phenazin-5-one derivatives will be reported in due course.

EXPERIMENTAL

General.

Melting points were determined with a capillary melting point apparatus and are uncorrected. The ^1H nmr (300 MHz) and ^{13}C nmr (75 MHz) spectra were recorded on a Bruker ARX-300 spectrometer in DMSO-d_6 with TMS as the internal reference. High-resolution mass spectra were measured on a Kratos MS-9/50 Electron Impact Magnetic Sector Mass Spectra. The elemental analyses were performed by Galbraith Microanalytical Laboratories, Knoxville, TN.

General Procedure for Substituted 5,7-Dihydrobenzo[*a*]phenazin-5-ones, 2-5.

To a stirred solution of 2-hydroxynaphthoquinone (5 mmoles) in acetic acid (10 ml) was added a solution of a 2-aminoanilines (5 mmoles) in acetic acid (10 ml). The solution was refluxed overnight, diluted with water, neutralized with ammonium hydroxide and filtered to give products 2-5 in 77%, 62%, 94% and 91%, respectively. The solid products obtained were dried in an oven (110° , overnight) recrystallized, and vacuum sublimed to give the resulting products 2-5 analytically pure.

5,7-Dihydrobenzo[*a*]phenazin-5-one (2).

This compound was obtained as an orange solid in 77% yield before sublimation; ir (Nujol): ν 3060, 3020, 3000, 2950, 1700, 1650, 1600, 1520, 1440, 1320, 1240, 1150, 1010, 850 cm^{-1} ; ^1H nmr (DMSO-d_6 , 300 MHz): δ 9.27 (br s, 1H), 9.26 (dd, 1H), 8.33 (m, 2H), 8.16 (d, 1H), 7.91 (m, 4H), 7.20 (s, 1H); ^{13}C nmr (DMSO-d_6 , 75 MHz): δ 206.4, 156.8, 145.2, 142.4, 139.4, 139.1, 130.8, 130.1, 123.0, 129.1, 128.7, 128.4, 128.1, 124.7, 122.8, 103.3.

Anal. Calcd. for $\text{C}_{16}\text{H}_{10}\text{N}_2\text{O}$: C, 78.03; H, 4.09; N, 11.37. Found: C, 77.63; H, 4.18; N, 11.20.

9-Methoxy-5,7-Dihydrobenzo[*a*]phenazin-5-one (3).

This compound was obtained as a dark orange solid in 62% yield before sublimation; ir (Nujol): 3050, 2950, 2900, 1650, 1620, 1500, 1480, 1420, 1310, 1250, 1210, 1110, 840 cm^{-1} ; ^1H nmr (DMSO-d_6 , 300 MHz): δ 9.25 (m, 1H), 8.30 (m, 1H), 8.04 (d, 1H), 7.87 (m, 3H), 7.57 (m, 2H), 7.18 (s, 1H), 4.02 (s, 3H); ^{13}C nmr (DMSO-d_6 , 75 MHz): δ 206.4, 159.1, 155.4, 141.0, 138.7, 131.1, 130.3, 129.8, 129.1, 128.3, 128.2, 124.5, 124.1, 122.6, 122.2, 105.9, 103.5.

Anal. Calcd. for $\text{C}_{17}\text{H}_{12}\text{N}_2\text{O}_2$: C, 73.90; H, 4.37; N, 10.13.

Found: C, 73.73; H, 4.55; N, 9.96.

9-Chloro-5,7-Dihydrobenzo[*a*]phenazin-5-one (4).

This compound was obtained as a yellow solid in 94% yield before sublimation; ir (Nujol): ν 3060, 3000, 2960, 1700, 1670, 1620, 1560, 1470, 1390, 1340, 1250, 1210, 1080, 1020, 890, 850, 780, 720 cm^{-1} ; ^1H nmr (DMSO-d_6 , 300 MHz): δ 9.21 (br s, 1H), 8.31 (m, 2H), 8.14 (m, 1H), 7.90 (m, 4H), 7.15 (s, 1H); ^{13}C nmr (DMSO-d_6 , 75 MHz): δ 206.4, 157.3, 145.3, 139.8, 134.4, 132.4, 131.0, 130.6, 130.4, 130.2, 128.8, 127.5, 126.3, 124.7, 122.9, 103.1.

Anal. Calcd. for $\text{C}_{16}\text{H}_9\text{N}_2\text{OCl}$: C, 68.46; H, 3.23; N, 9.99. Found: C, 68.25; H, 3.21; N, 9.94.

9-Nitro-5,7-Dihydrobenzo[*a*]phenazin-5-one (5).

This compound was obtained as a red solid in 91% yield before sublimation; ir (Nujol): ν 3020, 2990, 2950, 1700, 1640, 1610, 1550, 1480, 1360, 1230, 1020, 880, 860, 840 cm^{-1} ; ^1H nmr (DMSO-d_6 , 300 MHz): δ 8.92 (d, 1H), 8.31 (m, 1H), 7.96 (m, 2H), 7.41 (m, 4H), 7.17 (s, 1H); ^{13}C nmr (DMSO-d_6 , 75 MHz): δ 206.4, 147.3, 143.2, 136.6, 133.8, 131.2, 131.0, 130.3, 129.2, 125.4, 123.1, 121.0, 115.5 (2), 111.3, 107.9; hrms: m/z Calcd. for $\text{C}_{16}\text{H}_9\text{N}_3\text{O}_3$: 291.2681. Found: 291.0649.

Anal. Calcd. for $\text{C}_{16}\text{H}_9\text{N}_3\text{O}_3$: C, 65.98; H, 3.11. Found: C, 65.43; H, 3.11.

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REFERENCES AND NOTES

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