

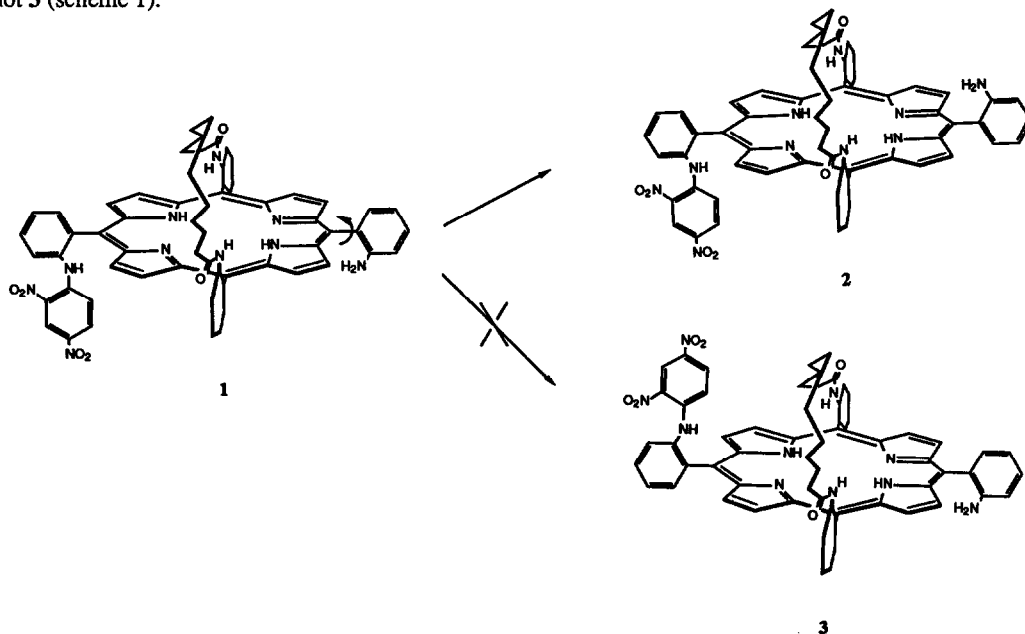
## APPLICATION OF NUCLEAR OVERHAUSER ENHANCEMENT TECHNIQUES TO THE STRUCTURAL CHARACTERISATION OF "STRAPPED" PORPHYRINS

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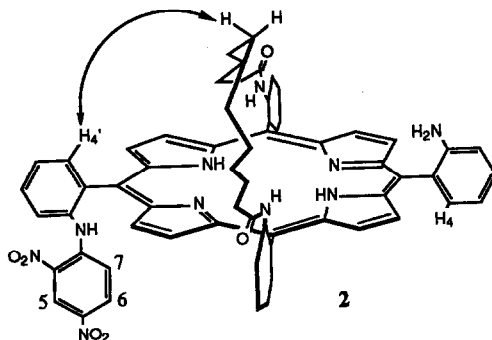
**Summary** Application of NOE techniques has enabled the structures of various atropisomeric "strapped" tetraarylporphyrins to be unambiguously defined.

As part of a project directed towards the synthesis of some new biological models<sup>1</sup>, we have prepared a series of derivatised polymethylene-"amide-strapped" porphyrins, e.g. **1**. Part of our synthetic plan involved the selective thermal atropisomerisation of a *meso*-substituent in the presence of another, bulkier *meso*-substituent. The expectation was that the much smaller substituent would rotate more easily,<sup>2</sup> forming **2** and not **3** (scheme 1).

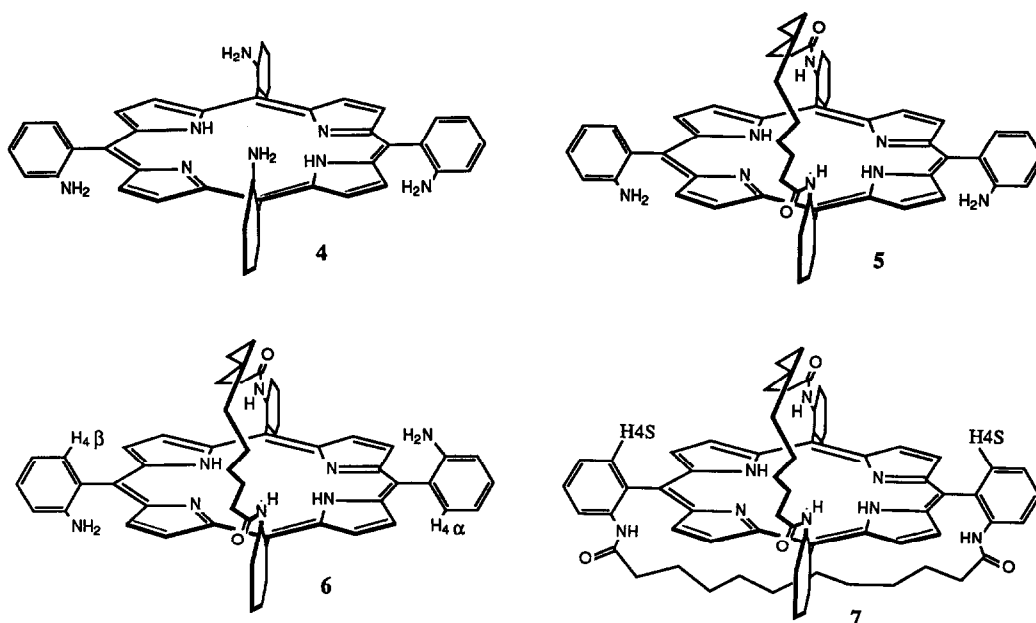


Indeed, heating a solution of **1** in toluene at reflux for 18h gave a single, new porphyrin, m.p. 218–220°C, in 51% yield after chromatography, together with recovered starting material.

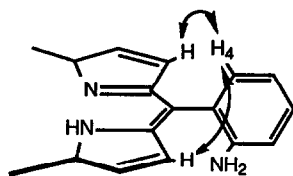
We surmised it might be possible to distinguish between structures 2 and 3 using a combination of 1D and 2D NOE techniques.<sup>4</sup> In particular, it seemed possible that some of the "strap" protons could interact, through space, with the ortho protons of the *meso*-aryl groups (see below). This in turn required the unambiguous assignment of all the *meso*-aryl protons, especially H<sub>4</sub> and H<sub>4'</sub>.



It was decided that a systematic study of several porphyrins, including 1 and 2, and those shown below, was required.



The first series of NOESY (2D NOE)<sup>5</sup> experiments, on porphyrin 4, showed an interaction between only one proton of each *meso*-aryl group and the adjacent  $\beta$ -pyrrolics. The proton, resonating as a doublet of doublets, clearly is H<sub>4</sub> due to its proximity in space to the  $\beta$ -pyrrolics (see diagram below). This observation allowed us to assign H<sub>4</sub> of any *meso*-aryl ring (i.e. H<sub>4</sub>, H<sub>4'</sub>, H<sub>4S</sub>, H<sub>4</sub> $\alpha$  and H<sub>4</sub> $\beta$ )<sup>6</sup> for all the porphyrins studied. Assignment of all the other *meso*-aryl resonances was then simply a matter of establishing connectivity using the appropriate H<sub>4</sub> as starting point.



Our results strongly support the literature assignments of the four protons on the unsubstituted *meso*-aminophenyl groups. However, the literature assignments<sup>7</sup> for the four protons on the *meso*-aromatic rings attached to a strap require revision. For example, when **4**<sup>2</sup> is "strapped" to give **5**<sup>7</sup>, one of the doublet of doublets of each "strapped" aryl group shifts dramatically to lower field. Previous arguments<sup>7</sup> hold that H4S is the shifted proton as it is "pulled", by the strap, closer to the porphyrin plane and hence into its deshielding zone. If this were the case, then there should be an NOE between this low-field resonance and the adjacent  $\beta$ -pyrrolics. However, we saw no such NOE for this low-field proton. Thus it cannot be H4S and must be H1S (see diagram below). There was, however, a substantial NOE to the other doublet of doublets of the "strapped" aryl group and from the above it follows that this is the resonance due to H4S.

Thus it is H1S and not H4S which shifts markedly to lower field. This observation held for all the strapped compounds we examined, i.e. **1**, **2**, **5**, **6**<sup>8</sup> and **7**<sup>7</sup>. This is consistent with previous studies<sup>9</sup> on acetanilide derivatives which showed just this sort of shift for protons ortho to the amide group where the amide carbonyl is fixed in close proximity to that proton. Just this situation exists in these strapped systems.



<sup>1</sup>H n.m.r. studies<sup>7,10</sup> indicate that the amide N–H proton sits over the porphyrin ring ( $\sim\delta$  6.8,  $\sim$ 2 ppm higher field than for acetanilide). As the amide is almost certainly *S-trans*, this places the carbonyl roughly coplanar with the aromatic ring and close to H1S. Selected assignments for these compounds are given in the Table.

NOESY experiments on porphyrins **1** and **2** also showed an interaction between both the dinitrophenyl–NH and H7 protons and the adjacent  $\beta$ -pyrrolics. Thus appropriate protons on groups attached to the *meso*-aromatic rings can also be useful in identifying pairs of  $\beta$ -pyrrolics.<sup>11</sup> As well as providing unambiguous information about *meso*-aryl resonances, the observed NOEs between various protons on these rings and the adjacent  $\beta$ -pyrrolics afford a simple method for assigning all the  $\beta$ -pyrrolic resonances of tetraporphyrins. This aspect of our study will be the subject of a future communication.<sup>11</sup>

Having completed the above analysis we returned to the initial problem, shown in Scheme 1. Using a series of 1D NOE difference spectroscopy experiments we found, by irradiating the methylene protons in the centre of the strap, NOEs to H4 and H4' for **1**. A similar experiment on the product from thermal atropisomerisation of **1** showed an NOE only to H4', confirming the isomerisation product as **2** and not **3**. Similarly, for compound **6**, no NOE was observed between the strapping methylene protons and H4 $\alpha$ .<sup>6</sup> We are

currently applying this method to the structural characterisation of a range of more complex tetraarylporphyrins.

### Acknowledgements

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Table Selected Chemical Shift Data for Porphyrins<sup>a,5</sup> 1,2,4,5,6 and 7

	H1	H2	H3	H4	H1S	H2S	H3S	H4S	H1'	H2'	H3'	H4'	DNP-NH
1	7.11	7.62	7.19	7.89	8.61	7.85	7.53	8.03	7.85	7.96	7.86	8.40	9.51
2	7.17	7.62	7.16	7.71	8.58	7.84	7.53	8.02	7.81	7.97	7.82	8.37	9.49
4	7.08	7.60	7.17	7.89									
5	7.11	7.62	7.20	7.90	8.63	7.84	7.50	7.98					
6 <sup>b</sup>	β 7.10	7.62	7.19	7.89	8.63	7.84	7.51	7.98					
	α 7.17	7.63	7.17	7.76									
7					8.62	7.86	7.54	7.99					

- a H1-H4 refer to the protons on the unsubstituted *meso*-aminophenyl group(s); H1S-H4S refer to the protons on the "strapped" *meso*-aminophenyl groups; H1'-H4' refer to the protons on the DNP-derivatised *meso*-aminophenyl group.
- b α refers to the ring bearing the amino group on the same face of the porphyrin as the strap, β refers to the ring bearing the amino group on the face opposite to the strapped face.

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- For definitions, see footnotes a and b of the Table.
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