Synthesis of the C_{30} Desethylaetioporphyrin from Petroleum

Paul J. Clewlow,[a] Anthony H. Jackson,*[a] and Ian Roberts[b]

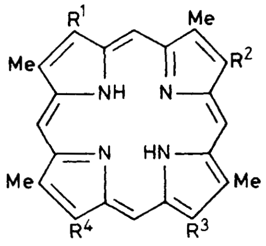
[a] *Department of Chemistry, University College, Cardiff, U.K.*
[b] *British Petroleum p.l.c., Sunbury-on-Thames, U.K.*

The four desethyl analogues of aetioporphyrin-III have been synthesised by the biladiene route; h.p.l.c. comparisons showed that the desethylaetioporphyrin obtained from petroleum is the C-ring isomer (**3c**).

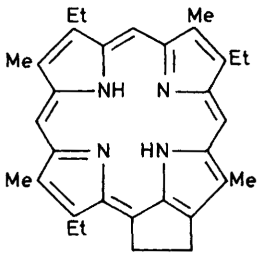
It is now fifty years since metalloporphyrins were first identified in ancient sedimentary organic matter.[1,2] Petroporphyrins may be found in petroleum, shale, bitumen, coal, and phosphate deposits but they are almost exclusively present as the nickel or vanadyl chelates. Mass spectrometric studies[3—5] have revealed the presence of two major series of porphyrins based on the 'aetio-' (**1**) and 'desoxophylloerythroaetio-' (**2**) structural-types, both presumably derived largely *via* degradation of chlorophylls over the course of geological time.[6] Homologues, with carbon numbers ranging from 28 to over 40, are observed for both series and there are several possible structural isomers at each carbon number. One of the more ubiquitous petroporphyrins has been identified by chromatographic, mass spectrometric, and nuclear magnetic resonance studies as a C_{30}-analogue of aetioporphyrin lacking one of the peripheral ethyl groups.[7,8] It was, therefore, of considerable interest to discover which of the four positional isomers (**3a**—**d**) corresponded to the natural C_{30}-petroporphyrin; we have accordingly synthesised all four porphyrins for comparisons with the natural material.

For a variety of reasons we synthesised the porphyrins (**3a**—**d**) *via* devinylation of the corresponding vinylporphyrins. Initially the MacDonald route[9] was investigated for the synthesis of the A-ring isomer[10] (**3a**). However, because of the low yields obtained in the ring closure stage we turned to the biladiene[11] and tripyrrene–biladiene routes.[12] We illustrate the latter method by the synthesis of the C-ring isomer. The unsymmetrical pyrromethane (**6a**) was first prepared by coupling the two pyrrolic precursors (**4**) and (**5**) in methanol containing toluene-*p*-sulphonic acid as catalyst. Hydrogenolysis of the benzyl ester over palladium charcoal to the carboxylic acid (**6b**) followed by acid catalysed condensation with the α-formylpyrrole (**7a**) then afforded the tripyrrene salt (**8**). The latter was dissolved in trifluoroacetic acid (to hydrolyse and decarboxylate the t-butyl ester) and treated with the α-formyl-β-chloroethylpyrrole (**7b**) to form the biladiene salt (**9**) in presence of hydrogen bromide–acetic acid. This was then oxidatively cyclised to the 2′-chloroethylporphyrin (**10a**) in good yield by brief treatment with copper(II) chloride in dimethylformamide at 145—150 °C. Dehydrohalogenation of the chloroethyl porphyrin to the vinyl porphyrin (**10b**), followed by devinylation in a resorcinol melt, then gave the C-ring desethylaetioporphyrin (**3c**). The other three isomers were also synthesised in a similar manner by variants of the biladiene route.[13]

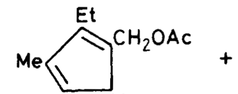
For comparisons with the naturally-occurring C_{30}-desethylaetioporphyrin it was necessary to devise an h.p.l.c. method for the separation of the four synthetic isomers. A variety of reversed phase systems (Hypersil, Spherisorb and Partisil ODS) were investigated, and eventually a good separation was achieved using two Perkin–Elmer ODS-HC-Sil-XI columns in series with acetonitrile as the mobile phase (Figure 1a). H.p.l.c. comparisons, including co-injection experiments, were then carried out with two C_{30}-



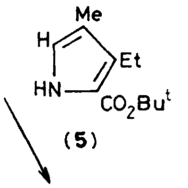
(1) $R^1 = R^2 = R^3 = R^4 = Et$
(3)a; $R^1 = H$, $R^2 = R^3 = R^4 = Et$
b; $R^2 = H$, $R^1 = R^3 = R^4 = Et$
c; $R^3 = H$, $R^1 = R^2 = R^4 = Et$
d; $R^4 = H$, $R^1 = R^2 = R^3 = Et$



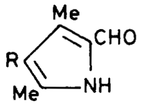
(2)



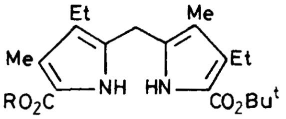
(4)



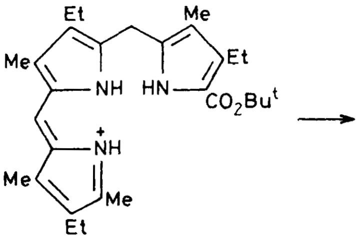
(5)



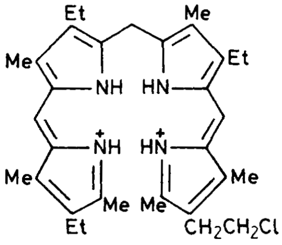
(7)
a; R = Et
b; R = CH_2CH_2Cl



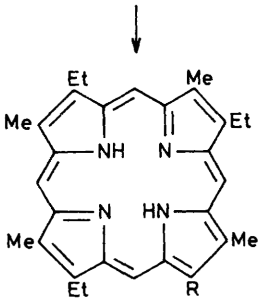
(6)
a; R = CH_2Ph
b; R = H



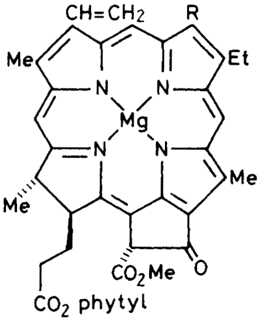
(8)



(9)



(10)
a; R = CH_2CH_2Cl
b; R = CH = CH_2



(11)
a; R = Me
b; R = CHO

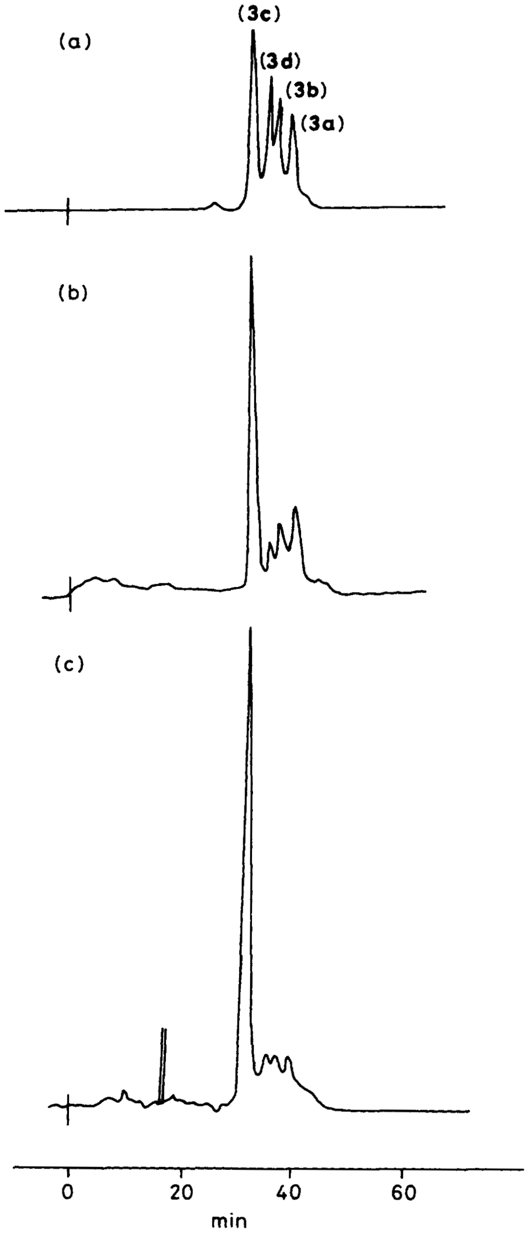


Figure 1. H.p.l.c. comparisons of (a) the four synthetic desethylaetioporphyrins (**3a**—**d**) with the corresponding petroporphyrin fractions from (b) Gilsonite and (c) Serpiano shale. (Conditions: 2 × 10 μ Perkin–Elmer ODS-HC-Sil-XI reversed phase silica columns, each 25 cm × 3 mm i.d.; mobile phase, acetonitrile with flow rate 0.3 ml/min and detector set at 400 nm.)

aetioporphyrin fractions isolated from Gilsonite and from Serpiano oil shale. The results (Figures 1b and 1c) clearly show that by far the major C_{30} aetioporphyrin present in both samples is the c-ring isomer of desethylaetioporphyrin-III (**3c**).

The predominance of the c-ring isomer is presumably due to the ease with which the isocyclic ring of chlorophyll *a* can be degraded[14] (hydrolytically or oxidatively) prior to the other maturation processes which take place over the course of geological time.[15] Similar conclusions have been reached by the Bristol group, based on careful nuclear Overhauser enhancement (n.O.e.) studies of an acetyl derivative of the C_{30}-aetioporphyrin from Serpiano shale, as described in the accompanying paper.[16] Interestingly h.p.l.c. analysis of a mixture of C_{28}-, C_{30}-, and C_{32}-porphyrins obtained from coal suggested the presence of the C-ring desethylaetioporphyrin, although the results were not as clear cut owing to the presence of another porphyrin (probably C_{32}-aetioporphyrin) which co-eluted close to the A-ring isomer.

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