Pergamon

Tetrahedron Letters 42 (2001) 2103–2106

TETRAHEDRON LETTERS

Reactivity of oxonaphtoporphyrins. Efficient β-functionalization of the porphyrin ring on reaction with nitrogen or carbon nucleophiles

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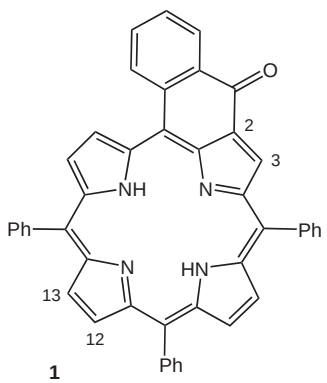
Received 18 December 2000; accepted 22 December 2000

Abstract—Oxonaphtoporphyrins show a 1,4 reactivity involving the conjugated pyrrole double bond, the addition being followed by oxidation or elimination leading to rearomatization. Addition of nitrogen or carbon nucleophiles gives amino and substituted aminoporphyrins, or alkyl and cyanoporphyrins, respectively.

The functionalization of the porphyrin β (pyrrolic) positions is actively investigated as an access to new chromophores, or to building blocks for oligomeric porphyrin preparation.[1] Porphyrins bearing a nitro group on a ββ-cross-conjugated double bond are particularly useful, the nitro group serving both as activating agent and as leaving group.[1–3] β-Acyl porphyrins have not yet been subjected to the same set of reactions. This may be due to a limited accessibility, or to an expected 1,2 and/or 1,4 reactivity leading to mixtures. However, elimination of the activating group cannot occur and a reactivity pattern different from that of nitroporphyrins is expected. While searching for new porphyrinic extended chromophores, we investigated the reactivity of ketone **1**.[4–7] In this letter, we wish to describe several unexpected reactions displayed by this compound and giving entries to new polyfunctional porphyrins.



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1. Reaction of 1 with tosylhydrazine

When treated with tosylhydrazine, ketone **1** never gave the expected product of condensation at the keto position. Under mild conditions (CH_2Cl_2, AcOH, 25°C) tosylhydrazine reacted slowly to afford product **2** resulting from a 1,4-addition followed by oxidation of the resulting dihydroporphyrin (Scheme 1).

Under the same conditions, except that the solution was heated at the reflux of CH_2Cl_2, tosylhydrazine gave enaminoketone **3** corresponding to a conjugate addition followed by acid-catalyzed elimination of tosylamide and double bond migration. We suspect that the low oxygen concentration, determined by the ebullition of the solvent, slowed down the oxidation step and favored the acid-catalyzed elimination (Scheme 2).

The same enaminoketone **3** was also obtained by reaction of hydroxylamine, or hydrazine in the presence of acetic acid, under elimination of water or ammonia, but the reaction is much slower. Since we wished to investigate the coordination chemistry of **3**,[8] the preparation was optimized and hydroxylamine *O*-sulfonic acid (HOSA) proved to be the choice reagent in CH_2Cl_2–AcOH–NaOAc under air (90% yield).

Chlorin **5** was obtained on reaction of **1** with hydrazine hydrate in CH_2Cl_2–MeOH. We think that **5** results from the reduction of the most reactive cross-conjugated 12,13 double bond by diimide, produced from hydrazine under our reaction conditions.

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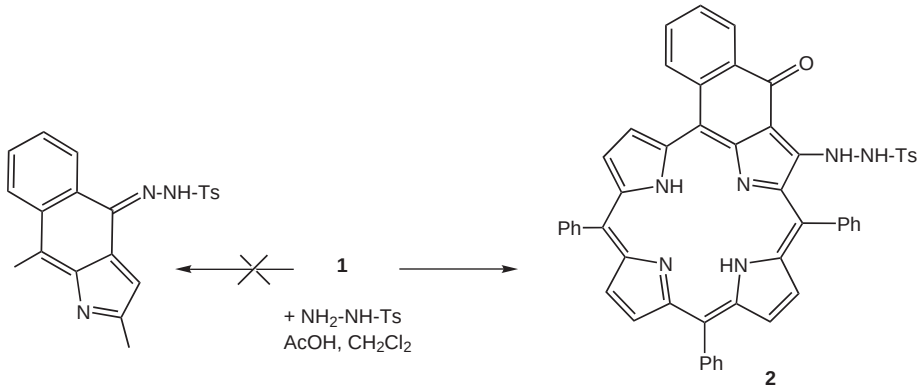
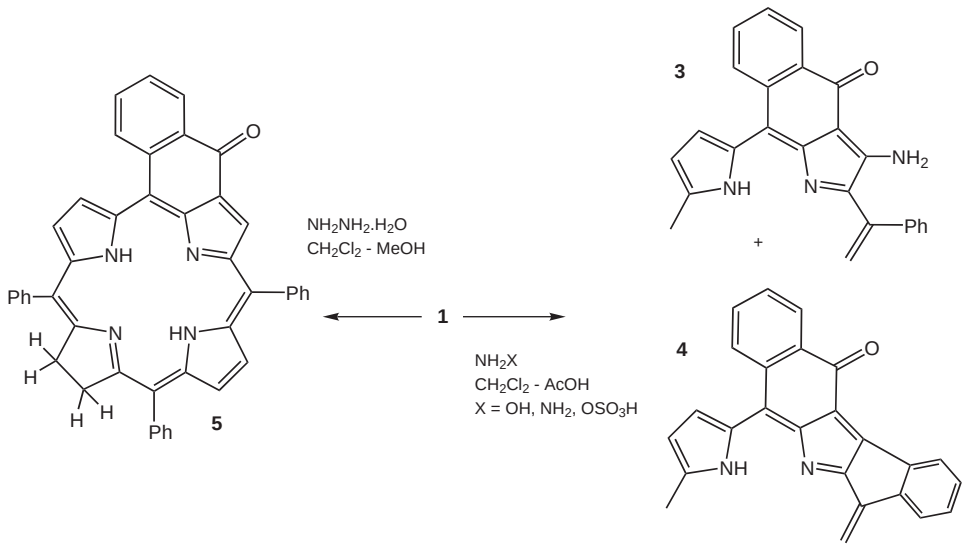
PII: S0040-4039(00)02345-5



Scheme 1.



Scheme 2.

Acid-catalyzed cyclization to give ketone **4** (Scheme 2) was observed as a side-reaction. Such a cyclization has been earlier described by Dolphin and co-workers[6] who noticed the peculiar UV–vis data of ketone **4**: very long wavelength Soret absorption, as well as relatively weak Q bands. We did not succeed in obtaining crystals of **4** or of its zinc complex suitable for an X-ray study. This last complex is highly insoluble, which suggests an Zn···O interaction to form polymeric entities. Treatment with pyridine allowed the isolation of the monomeric pyridine–zinc complex which gave suitable crystals.

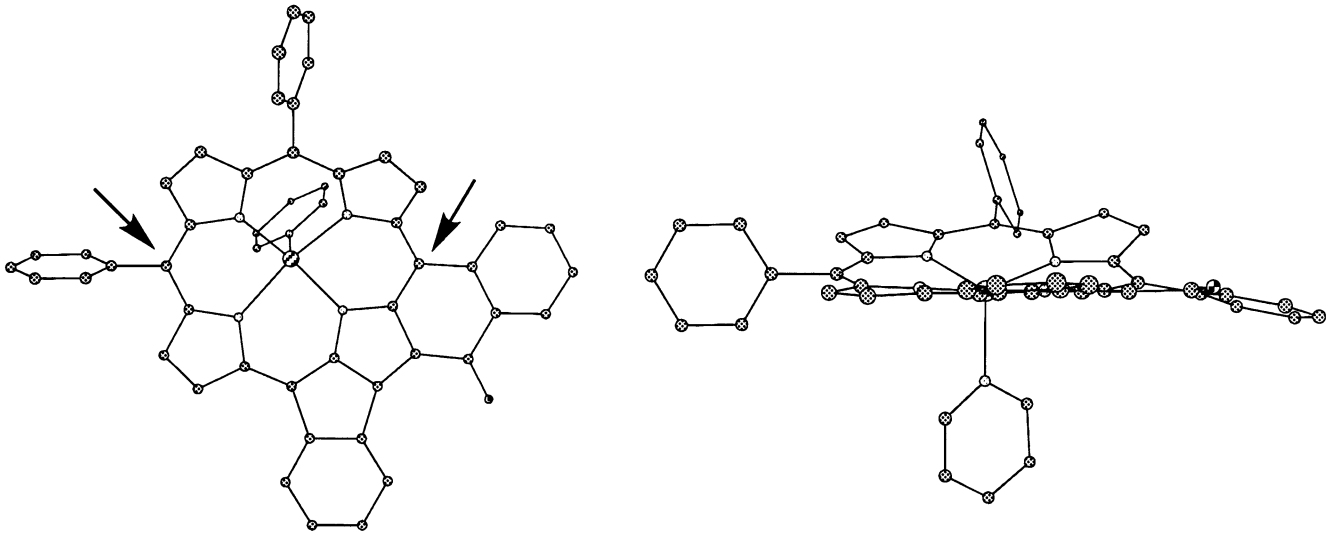
The pentacyclic unit terminated by the two cyclized phenyl groups is almost planar (less than 10° angle between the terminal phenyl rings), but the porphyrin shows a strong distorsion due to a ca. 30° roof-like folding (Scheme 3). This folding is similar to that of porphodimethenes[9] and may explain the abnormal UV–vis spectrum, which is common to both the base and the zinc complex.

2. Reaction of carbon nucleophiles with ketone 1 (Scheme 4)

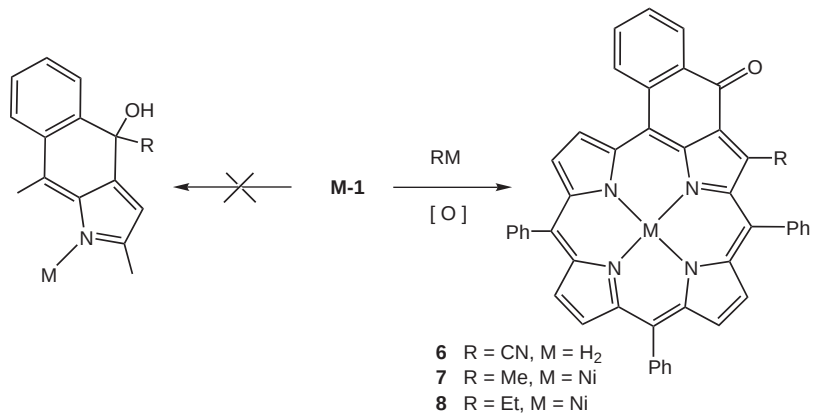
Addition of cyanide (NaCN in benzene–EtOH) to ketone **1** proceeded smoothly, as did the oxidation of the intermediate chlorin, to give cyanoporphyrin **6** in 60% yield.

The reaction with organometallics (RM = MeLi, EtMgI) with nickel-**1**, showed the same reactivity pattern to give β-alkylated porphyrins nickel-**7** and **8**, but yields are poor. In particular nickel-**8** decomposed on standing.

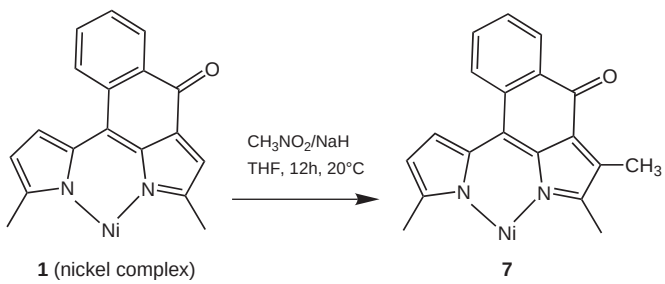
Reaction of nitromethane anion with β-nitroporphyrins has been used previously to prepare functionalized β-alkylporphyrins and formylporphyrins.[10] In our case the addition (Scheme 5) proceeded smoothly on the nickel complex of **1**, but the elimination involved the nitromethylene substituent to give β-methylporphyrin **7** in 98% yield.



Scheme 3. Pyridino–zinc complex of ketone **4** viewed perpendicularly to the macrocycle mean plane and in the plane of the pentacyclic fragment. The folding axis goes through the *meso* carbons pointed by arrows.†



Scheme 4.



Scheme 5.

In conclusion, we found that a porphyrin pyrrolic position next to an acyl group can be efficiently functionalized by a variety of reagents to form new C–N and C–C bonds. Several products are potential chelating ligands and their coordination chemistry is actively investigated.[8]

† Crystal data have been deposited at the CCDC, 12 Union Road, Cambridge CB2 1EZ, UK, under the deposition number CCDC 154818.

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