

**In Focus****Corroles: Acid-Catalysis Leading to *meso*-Substituted Corroles****Iglesias, B. A.***Rev. Virtual Quim.*, 2013, 5 (5), 1001-1006. Online publication: 14 August 2013<http://www.uff.br/rvq>**Corróis: Catálise Ácida Levando a Corróis *meso*-Substituídos**

**Resumo:** O uso da catálise ácida é uma importante ferramenta, sendo eficaz tanto na síntese de porfirinas, bem como para síntese de corróis *meso*-substituídos. O catalisador ácido é responsável pela protonação do grupo carbonila de aldeídos, que são atacados pelo pirrol através de uma reação de substituição eletrofílica aromática, levando à formação da cadeia tetrapirrólica. Outro fator determinante na formação do corrol é a natureza do ácido utilizado para a síntese destes compostos. Este manuscrito sumariza alguns procedimentos da síntese dos corróis *meso*-substituídos, utilizando diferentes metodologias, na presença de vários tipos de catalisadores ácidos ou não.

**Palavras-chave:** Corróis; metodologias sintéticas; macrociclos.

**Abstracts**

The use of acid catalysis is an important requirement, being effective both on the synthesis of porphyrins as well as for *meso*-substituted corroles. The acid catalyst is responsible for protonation of the carbonyl group of aldehydes, which are attacked in an aromatic electrophilic substitution by pyrrole, which leads to the formation of the tetrapyrrolic chain. Another determining factor in the corrole formation is about of the acid type used for these compounds synthesis. This In Focus manuscript reviews the procedures of the synthesis of *meso*-substituted corroles using different methodologies in the presence of different types of acid catalysts or without acid.

**Keywords:** Corroles; synthetic methodologies; macrocycles.

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## Corroles: Acid-Catalysis Leading to *meso*-Substituted Corroles

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Bernardo Iglesias obtained his PhD degree in August/2012 with a working programme carried out in University of São Paulo in the group of Professor Koiti Araki. His PhD thesis describes the studies carried out in the same group on the synthesis and characterization of new triazene-porphyrin derivatives.

Nowadays he is a postdoctoral researcher in Organic Chemistry at the Chemistry Department of the University of Aveiro. His scientific interests are based on the development of new corrole derivatives with potential applications in the charge-transfer systems.

### 1. Introduction

Corroles are tetrapyrrolic heterocycles which are being a promising work target for many researchers. Their contracted skeleton, with a direct C-C linkage between two neighboring pyrrole rings provide unique physical-chemical properties and some

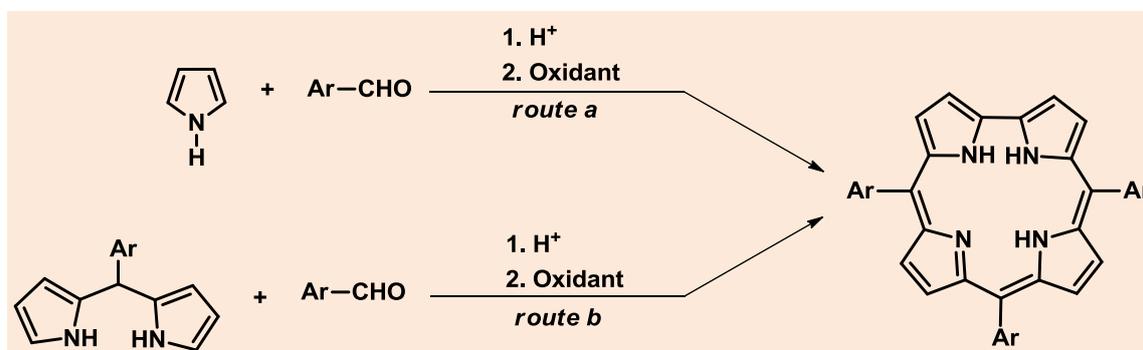
reactivity.<sup>1</sup> The synthetic approaches and the chemical functionalization of corroles have been studied in great detail. Such studies allow the access of corroles to several studies in different areas, namely as catalysts<sup>2</sup>, sensors<sup>3</sup>, medicine<sup>4</sup> and as functional materials.<sup>5</sup> The use of corroles and their derivatives can however be limited due their lack of stability. Several reports concerning stability studies of corroles refer that in presence of air and visible light, these macrocycles can undergo polymerization or ring opening transformations.<sup>6</sup>

Some factors are dependent on the solvent and the electronic nature of the substituents present on the corrole periphery. Two efficient methodologies to prepare these compounds consist in: (a) direct condensation of pyrrole and aldehydes or (b) reaction between dipyrromethanes and aldehydes, both procedures taking place in the presence of acid catalysts (Scheme 1).

The use of acid catalysis is a major requirement, being effective both on the synthesis of porphyrins as well as for *meso*-substituted corroles.<sup>7</sup> The acid catalyst is responsible for protonation of the carbonyl group of aldehydes, which are attacked in an aromatic electrophilic substitution by pyrrole, which leads to the formation of the tetrapyrrolic chain. Another determining factor of the corrole formation is about of the acid type used for these compounds synthesis.

This *In Focus* manuscript reviews the main procedures of the *meso*-substituted corrole synthesis, using different methodological

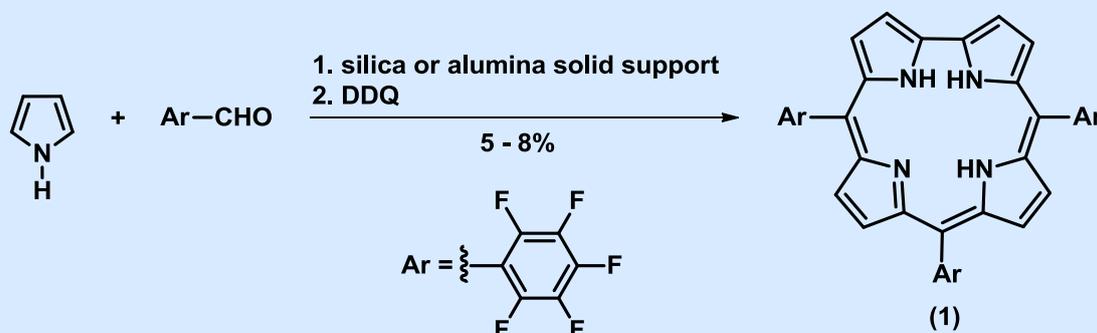
routes, in the presence of different types of acid catalysts (Lewis acid) or in his absence.



Scheme 1

## 2. Experimental Procedures

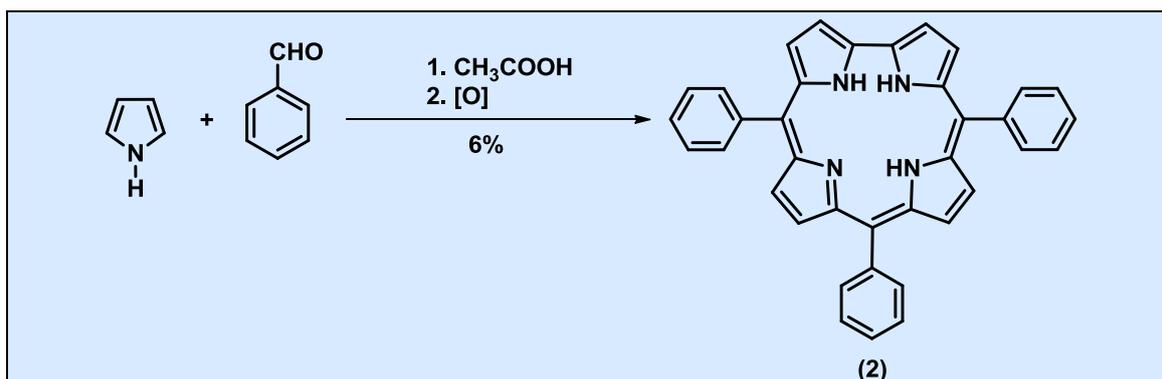
Gross and coworkers have reported the direct synthesis of *meso*-triarylcorroles by condensation of pyrrole and aromatic aldehyde, supported on silica or alumina (solid phase reaction). This condensation reaction between pyrrole and aldehydes in equimolar quantities occurs by heating up to 100°C for 4 hours, followed by DDQ oxidation.<sup>8</sup> No protonic acid was used in these studies. The *meso*-tris(pentafluorophenyl)corrole (**1**) (Scheme 2) was obtained in low yield from the reaction medium (5 to 8%).



Scheme 2

Such methodology also gave rise to the related porphyrins, in good yields (10-12%).<sup>8a,b</sup>

The route to direct synthesis of *meso*-triarylcorroles developed by Paolesse and coworkers is based on acid catalysis, followed the Adler-Longo conditions.<sup>6</sup> *meso*-Triarylcorroles can be obtained in approximately 6% yield, in a product mixture also containing the corresponding *meso*-tetraarylporphyrins. This approach requires the condensation of pyrrole and aldehydes in acetic acid at high temperatures, for example, at reflux. The oxidation step occurs under aerobic conditions. When using benzaldehyde *meso*-triphenylcorrole (**2**) free-base is obtained (Scheme 3).<sup>6</sup>

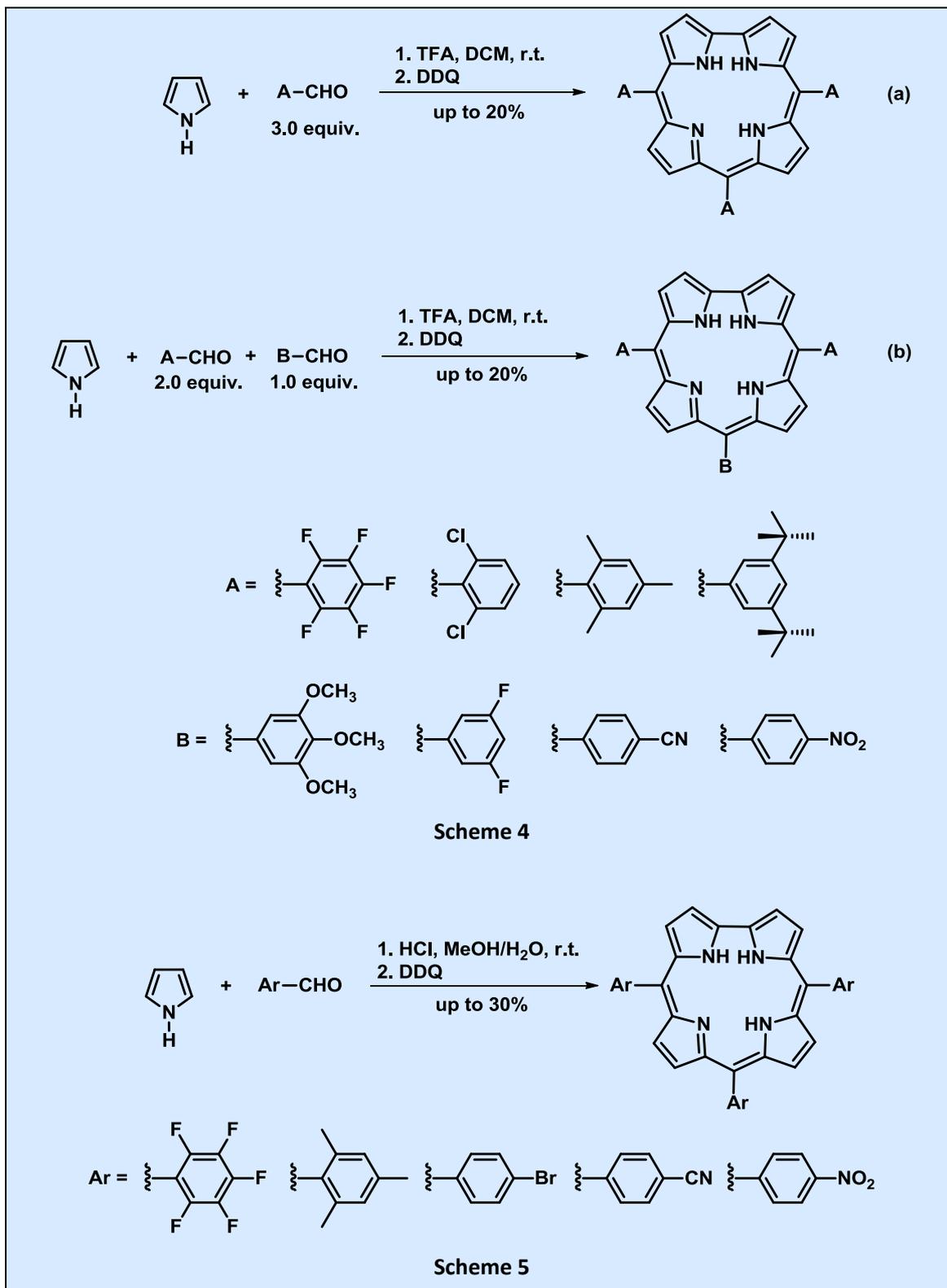


Scheme 3

This methodology has been applied for the synthesis of several *meso*-arylcorroles, using several aldehydes and, the global yields can reach up to 30% depending on the aldehydes to be used.<sup>6</sup>

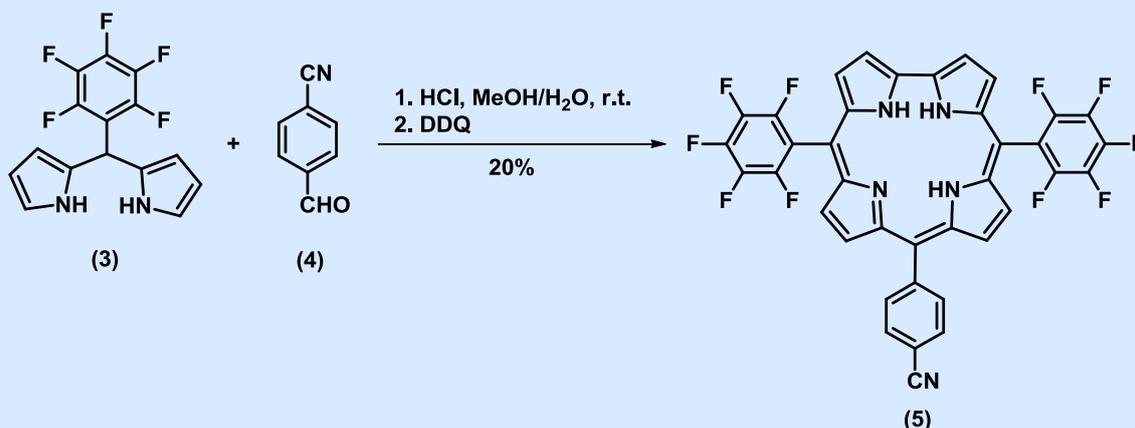
Two other important synthetic methodologies have been reported by Gryko's group; improvements were introduced in this experimental conditions for *meso*-substituted A<sub>3</sub>- (Scheme 4a) and *trans*-A<sub>2</sub>B-corrole formation (Scheme 4b) (where A and B are groups coming from different aldehydes).<sup>9</sup> After careful review of various physico-chemical parameters (reactivity of aldehyde, catalyst, solvent, concentration, time, etc.), the same authors have developed different sets of conditions, which are basically dependent on the reactivity of the aromatic aldehyde and possible steric factors to give *meso*-A<sub>3</sub>-corroles. It was observed that small amounts of TFA may promote the undesirable formation of various polymers and it was clear that the amount of pyrrole to be used depends directly on the aldehyde reactivity. This process involves the direct condensation of pyrrole and aldehydes in the presence of acid catalyst (TFA) in dichloromethane (DCM) as a solvent, at room temperature, following DDQ oxidation (Scheme 4).<sup>9</sup>

The Gryko's group also reported the condensation of pyrrole and aldehyde in a water/methanol mixture, in the presence of HCl as acid catalyst.<sup>10</sup> Under these conditions, *meso*-triarylcorrole was obtained in yields up to 30%.<sup>11</sup> These reactions are conducted in a similar procedure to the one using TFA acid catalysis, followed by DDQ oxidation at room temperature (Scheme 5).



Reactions between dipyrromethanes with aldehydes leading to *trans*-A<sub>2</sub>B-corroles have been extensively studied in Gryko's group.<sup>9,10</sup> Previous studies have shown that reasonable yields obtained for *meso*-corroles may be due to sterically hindered dipyrromethanes and those bearing electron-withdrawing groups. However, from unhindered dipyrromethanes, corroles can be obtained only in very low yields (up to 6-7%). All attempts to increase the yield

by increasing the acid concentration has led to significant scrambling. To our delight, aryl-dipyrromethanes react with electron-withdrawing benzaldehydes under the optimized conditions to afford the respective corrole in 38% yield, with no detectable scrambling. *Meso*-10-(4-cyanophenyl)-5,15-di-pentafluorophenylcorrole (**5**) ( $C_6F_5CNCor$ ) was efficiently prepared by condensation of pentafluorophenyl-dipyrromethane (**3**) and 4-cyanobenzaldehyde (**4**) in the presence of HCl as catalyst, in water/methanol mixture solution, at room temperature, following DDQ oxidation (**Scheme 6**).<sup>10</sup>



Corrole compounds containing electron-donating or electron-withdrawing substituents at the *meso*-phenyl groups, and others with sterical substituents at the *ortho*-phenyl positions, were also synthesized in good yields (15-25% of isolated products).

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