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The reaction of triptycene haloquinones with alkoxides. An unusual route to pentiptycene quinones

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Abstract—Triptycene haloquinones **3** react with sodium alkoxides in refluxing alcohol to afford, besides the expected substitution products, pentiptycene quinone **4**. This approach to **4** is compared with a Diels–Alder strategy to the same compound.

Triptycene quinones form an interesting class of compounds. The rigid structure of triptycene combined with the redox potential of the quinone ring confer some unique properties to triptycene quinone derivatives. Triptycene quinones exhibit interesting intramolecular charge transfer characteristics,[1] they are precursors to liquid crystalline triptycene derivatives,[2] and they form three-dimensional supramolecules.[3] Triptycene quinone and derivatives also find application as acceptors, with porphyrin derivatives[4] and tetrathiafulvalene[5] serving as donors, for the synthesis of electron-transfer compounds. Also, in a preclinical study[6] it was shown that some triptycene quinones decrease the viability of leukemic cells in vitro.

Pentiptycene quinones, **4**, bearing two triptycene units, are particularly promising reagents for the preparation of polymeric chemosensors,[7] materials with monolayer assembly structures,[8] fluorescent chemosensors for metal ions,[9] electron-donor porphyrin quinone diads and triads[10] and building blocks for the construction of novel chain and channel networks.[11]

Although there is increasing interest in the use of these compounds for the construction of molecules with intriguing properties, less is known about their chemistry. Recently we reported the preparation of triptycene hydroxyquinone and its transformation through phenyliodonium chemistry to the corresponding cyclopentenedione analogue, a potential dienophile.[12]

Also recently, an unusual reaction of triptycene diquinones with amines was reported to afford derivatives with potent anticancer and antimalarial activities.[13]

In the context of our previous study[12] we examined the reaction of triptycene chloroquinone **3**, with MeONa/MeOH. Quinone **3** (X = Cl) is prepared in one step from a Diels–Alder reaction of anthracene **1** with two equivalents of chlorobenzoquinone **2** in 96% yield. Its reaction with the alkoxide would hopefully have provided an alternative route to triptycene hydroxyquinones, a reaction known for other halogenated quinones.[14] In refluxing MeOH the reaction afforded the expected dimethoxy- and chloromethoxy-triptycene quinones **5** and **6**, anthracene, and, quite unexpectedly, pentiptycene quinone, **4**. This compound was identical to that prepared by an independent route, namely a double Diels–Alder reaction of anthracene with benzoquinone and subsequent oxidation of the resulting dihydroxy derivative.[7] This unusual reaction pathway seems to be of general character since anthracene **1** and pentiptycene quinone **4** were isolated, in varying yields (5–10% for anthracene and 28–32% for **4**), when using different haloquinones and alkoxides (Scheme 1). The same compounds were obtained, although in lower yields (10–15% for **4**), even when KOH/MeOH was used as reagent. Yields of alkoxyquinones **5** and **6** vary between 13 and 20%.

The formation of anthracene indicates that a retro-Diels–Alder reaction takes place. This reaction is a typical one as it has been observed with a variety of triptycene quinones under basic conditions.[15] In order to explain the formation of **4** the reaction was repeated in the presence of substituted (1,5-dichloro-, 9,10-

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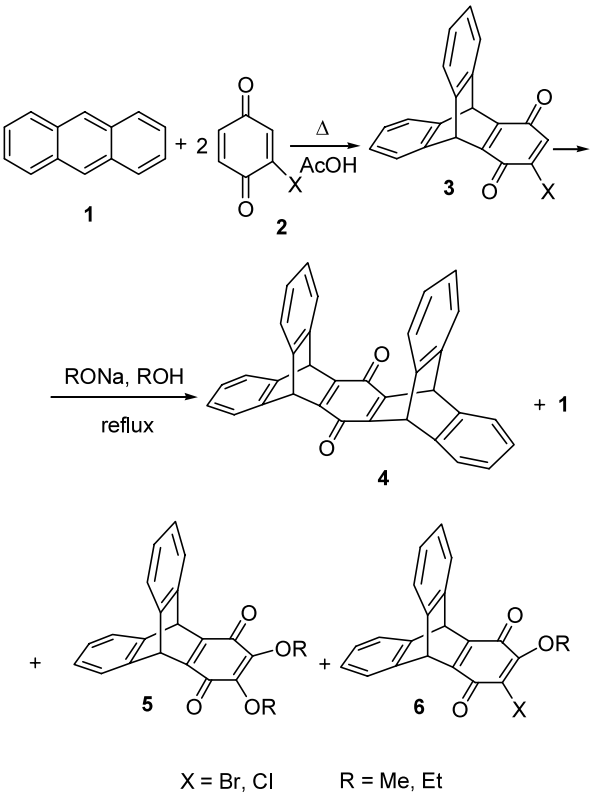


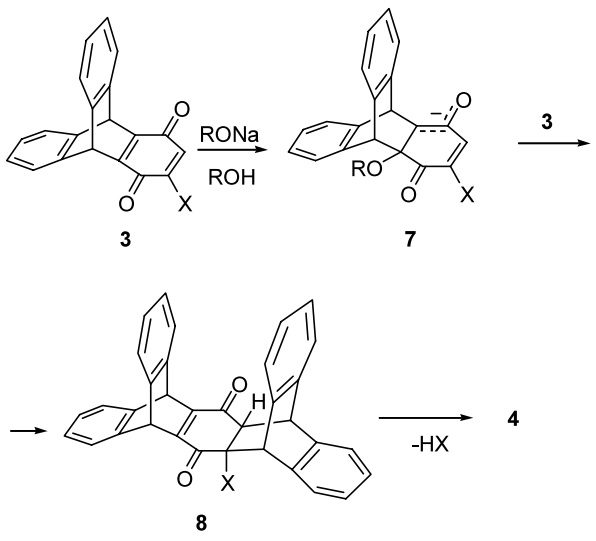
Scheme 1. Reaction of triptycene haloquinones with alkoxides.

dimethyl- and 1,4-dimethoxy-) anthracenes (1–3 mmol). In all cases the reaction products were the same as those in Scheme 1 and no cross pentiptycene quinones were isolated. This finding indicates that the formation of **4** takes place through some internal process. Otherwise one would normally expect cross derivatives, at least with dimethyl and dimethoxyanthracenes, which were reported to be more reactive than anthracene in Diels–Alder reactions with maleic anhydride and benzyne.[16] The same results were also obtained when the reaction was conducted in the presence of other dienes such as 2,3-dimethylbutadiene, isoprene and furan.

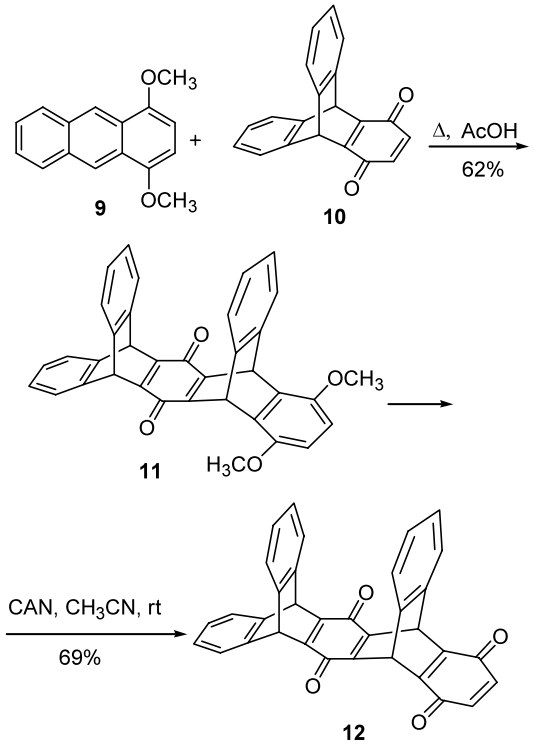
On the basis of the above results it is possible that nucleophilic attack of an alkoxide anion gives rise to enolate **7** through an initially formed charge transfer complex.[17] The latter either affords anthracene in a retro-Diels–Alder reaction or reacts with **3** to give Diels–Alder adduct **8**. Finally **8** is dehydrohalogenated to pentiptycene quinone **4** (Scheme 2).

As mentioned, when the reaction of triptycene haloquinones **3** with alkoxides takes place in the presence of 1,4-dimethoxyanthracene no cross derivative was isolated. In order to verify that such a derivative can exist we prepared it by an independent method (Scheme 3).

Diels–Alder reaction of 1,4-dimethoxyanthracene **9** with triptycene quinone **10**[12] in refluxing acetic acid afforded directly the desired 1,4-dimethoxypentiptycene quinone **11** in 62% yield. Quinone **11** was oxidatively



Scheme 2. Suggested reaction pathway for the formation of pentiptycene quinone **4**.



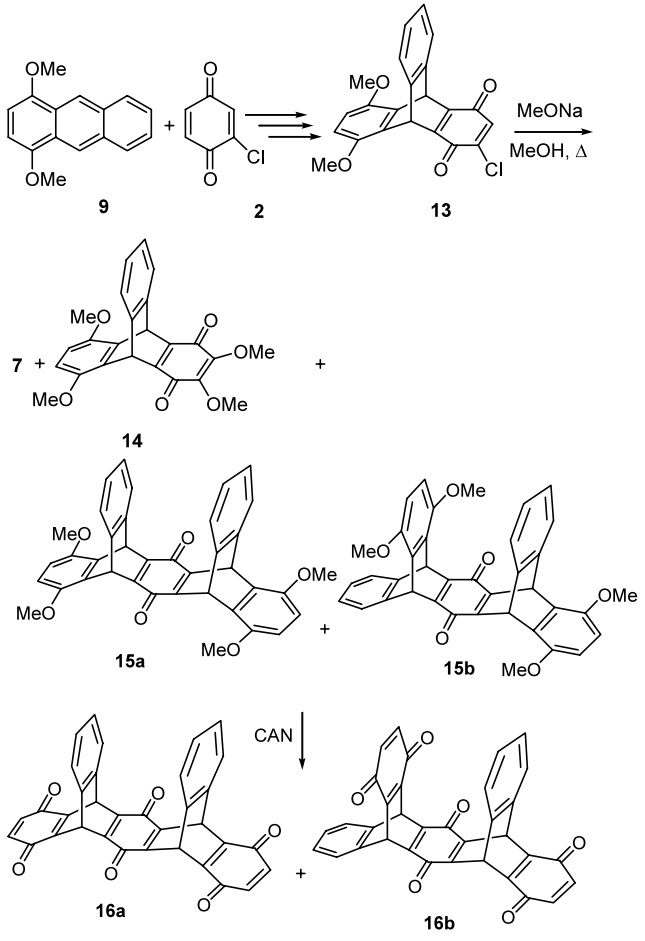
Scheme 3. Diels–Alder synthesis of 1,4-dimethoxy-pentiptycene quinone and pentiptycene diquinone.

demethylated to triptycene diquinone **12** by $Ce(NH_4)_2(NO_3)_6$ (CAN), in 69% yield.

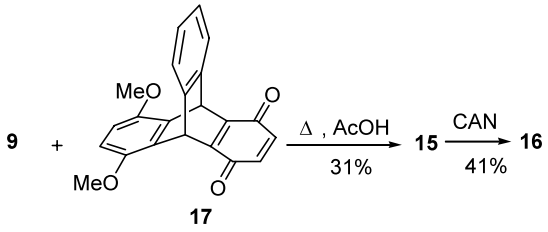
The formation of pentiptycene quinones from triptycene haloquinones seems to be a general phenomenon. Dimethoxytriptycene chloroquinone **13**, prepared from dimethoxyanthracene **9** and chlorobenzoquinone **2** through the Diels–Alder enolisation–oxidation sequence, upon reaction in MeOH/MeONa afforded one of the tetramethoxypentiptycene quinone regioisomers, **15a** or **15b**, in 10% yield. The other

products of the reaction were dimethoxyanthracene **9** (7%) and tetramethoxytriptycene quinone **14** in 10% yield (Scheme 4). Again **15a** (or **15b**) was demethylated to the corresponding pentiptycene triquinone, **16a** or **16b** in 30% yield.

In order to confirm the structures of **15**, a different approach to these compounds was attempted. A Diels–Alder cycloaddition reaction of dimethoxyanthracene **9** with dimethoxytriptycene quinone **17**[18] in refluxing acetic acid afforded on this occasion a mixture of the two possible regioisomers **15a** and **15b** in 31% yield, which was also demethylated to the mixture of **16a** and **16b** (Scheme 5).



Scheme 4. The triptycene haloquinone-alkoxide route to tetramethoxypentiptycene quinones and pentiptycene triquinones.

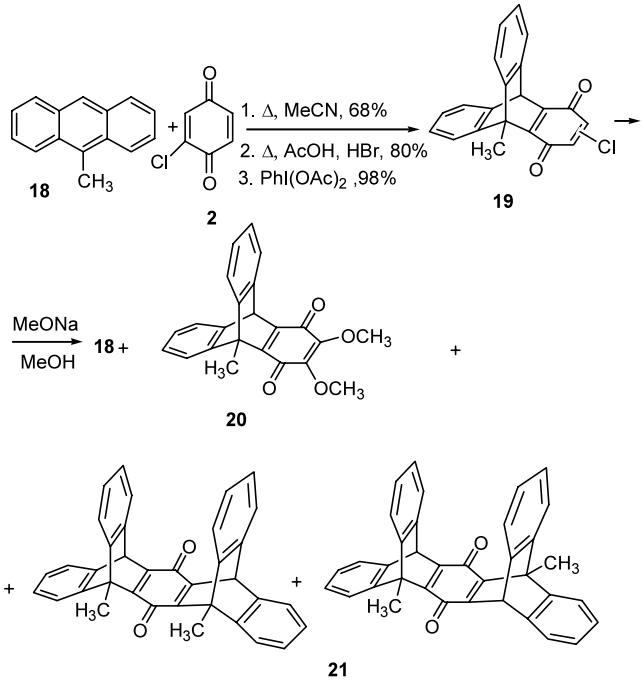


Scheme 5. The Diels–Alder route to tetramethoxy-pentiptycene quinones.

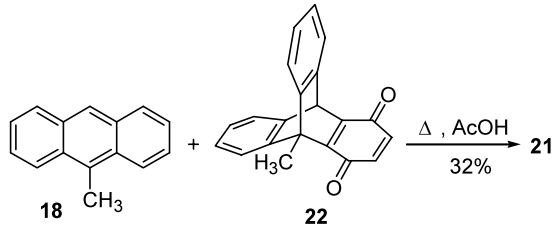
Triptycene chloroquinones with substituents on the bridge exhibited the same reactivity. The cycloaddition reaction of 9-methylanthracene **18** with chlorobenzoquinone **2** afforded in three steps (addition-enolization-oxidation) a mixture of the isomeric chloroquinone adducts **19**. The treatment of **19** with MeONa/MeOH gave, besides the usual retro Diels–Alder product methylanthracene **18**, an equimolecular mixture of the two dimethylpentiptycene quinone isomers **21** in 12% yield (Scheme 6). Dimethoxytriptycene quinone, **20**, was also isolated in 7% yield from the reaction.

Again, pentiptycene quinones **21** were prepared by a cycloaddition methodology. Methyltriptycene quinone **22**[19] reacted with methylanthracene **18** in refluxing acetic acid to afford the same mixture of pentiptycene quinones **21** in 32% yield. This time a complicated mixture of *endo-exo* dihydroadducts was also isolated in 4% yield (Scheme 7).

In summary, the reaction of triptycene haloquinones with alkoxides provides a short route to pentiptycene quinones, through an unusual reaction pathway. This



Scheme 6. Preparation of pentiptycene quinones with methyl substituents on the bridge.



Scheme 7. The Diels–Alder route to **21**.

route and the Diels–Alder strategy, with comparable yields, are the two main approaches to these interesting building blocks, which find many applications in Chemistry.

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18. Prepared from Diels–Alder reaction of **3** with 1,4-benzoquinone, enolization of the resulting mixture of the *endo-exo* dihydroadducts with HBr acid to the corresponding hydroquinone derivative and finally oxidation of the latter with $PhI(OAc)_2$.
19. Prepared from Diels–Alder reaction of **18** with 1,4-benzoquinone, exactly as for **17** (Ref. 18).