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PHOTOCHEMICAL CYCLOADDITION REACTIONS INVOLVING CARBOSTYRILS

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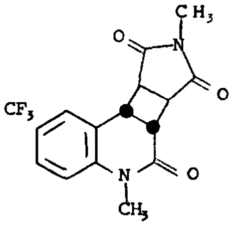
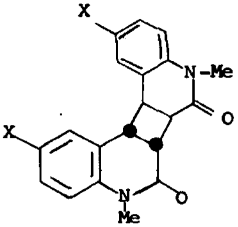
The appearance of a recent publication by Evanega and Fabiny (1) on the photochemical reactions of unsubstituted carbostyril prompts us to publish our own extensive work* on photoadditions of N-methylcarbostyrils. The condensation with a variety of functionally substituted olefins is reported in addition to two simple olefins, including ethylene. Previous examples of photocycloadditions involving ethylene have been few (2).

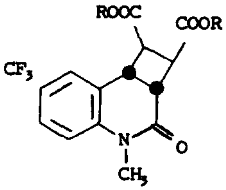
A solution of N-methyl-6-trifluoromethylcarbostyril (I, 0.022 moles) and N--methylmaleimide (0.051 moles) in 200 ml ethylenechloride containing 2 g of benzophenone was irradiated with a 200 watt, medium pressure, Hanovia lamp for 16 hours. A 14% yield of the adduct II (m.p. 202-205°), a 40% yield of IIIb (m.p. 252-53°, the photodimer of I), and the photodimer



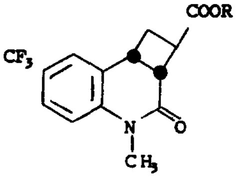
II



IIIa, X=H
IIIb, X=CF₃



IV, R=H
V, R=Et



VI, R=Et
VII, R=H

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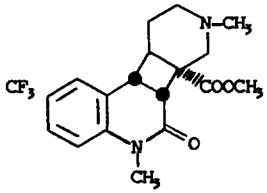
*First presented in July 1965 at the Gordon Research Conferences session on Organic Reactions and Processes, New Hampton, New Hampshire.

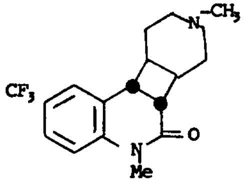
of N-methylmaleimide (m.p. 305°) were obtained. The structure IIIb was assigned on the basis of similarities to compound IIIa, whose structure was unequivocally proven by Buchardt (3).

The following condensations were carried out in a manner similar to that described above (olefin, solvent, sensitizer, structure of product, m.p. or b.p., % yield):

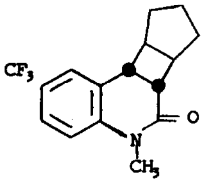
(a) Doubly activated olefins: maleic anhydride, benzene, benzophenone, IV ·1/2 H_2O, m.p. 234-36°, 10%; diethyl maleate, dioxan, acetone, V, m.p. 119-20°, 35%. (b) Singly activated olefins: ethyl acrylate, ethylene chloride, acetone, VI, m.p. 117-18°, 70%; acrylic acid, dioxan, acetone, VII, m.p. 170-171.5°, 50%; arecoline (N-methyl-3-carbomethoxy-1,2,5,6-tetrahydropyridine), dioxan, acetone, VIII, m.p. 156-58°, 66%. (c) Unactivated olefins: N-methyl-1,2,5,6-tetrahydropyridine, dioxan, acetone, IXa and b, b.p. 190° (0.01 mm), 50%; cyclopentene, dioxan, acetone, X, m.p. 117-19°, 53%; ethylene, benzene, acetone, XI, m.p. 41-42°, b.p. 94° (0.05 mm), 12%. The latter reaction was carried out by bubbling ethylene gas through the irradiated solution for 48 hours. Unexpectedly, attempts to photodimerize or photocondense N-methylsulfostyril (4) failed. Alkaline hydrolysis of VI gave a low yield of VII and a large amount of I. At its melting point, VII reverted to I and acrylic acid.



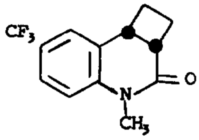
VIII



IX a & b



X

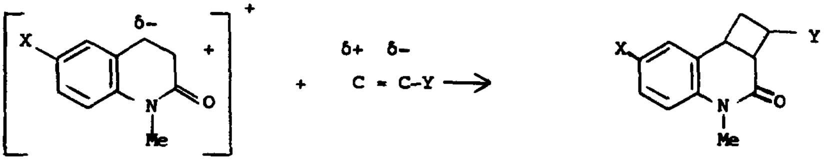


XI

In all of the reactions except the one utilizing N-methyl-1,2,5,6-tetrahydropyridine, only a single product (by TLC or VPC) was isolated. The exception appeared to give two isomers (XI a & b), as indicated by its failure to crystallize, by its giving a broad melting, hygroscopic hydrochloride (m.p. 69-100°), and the fact that it gave two (piperidino-)N-methyl absorptions in the NMR.

In most cases, attempts to directly determine the stereochemistry or the exact position of substitution of the unsymmetrical reaction products by study of the NMR spectra, have not been fruitful. This difficulty has been encountered by the other investigators (1).

The structures illustrated have been assigned the head-to-head <u>trans</u> configurations on the basis of the following arguments. Carbostyril, N-methylcarbostyril, and coumarin all condense in photocatalyzed sensitized reactions, in a head-to-head <u>trans</u> fashion (3,5). These and the suggested orientations of products in this report are consistent with the concept (6) of an oriented n, π^* excited state of an α,β-unsaturated olefin (in these cases, carbostyril) with the ground state of another olefin (in these cases, a carbostyril, coumarin, α,β-unsaturated ester, or simple olefin). A similar suggestion was made (7) to explain the nature of the coumarin cycloaddition product with ketene diethyl acetal; this accounts for the observed orientation in the condensation of carbostyril with methyl vinyl ether (1). The formation of the two isomers IX a and b is also consistent with this concept, since there would be no electronically preferred direction for the tetrahydropyridine to approach the excited carbostyril.



The assigned structures are consistent with the presence of an NMR absorption peak at δ=3.6, assigned by Buchardt (3) to the cis-3,4-hydrogens in the cyclobutane ring of the <u>trans</u> photodimers. The assigned structures are consistent with the failure to observe abnormal $-O-CH_2-$ester absorption in the NMR, as would have been expected for a head-to-tail adduct where the ester would be shielded by the aromatic ring. They are also consistent with predictions based on steric considerations, since space-filling models show the head-to-head configuration to be significantly less hindered than a head-to-tail form.

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