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THE PHOTOREACTION OF MORUSIN TRIMETHYL ETHER

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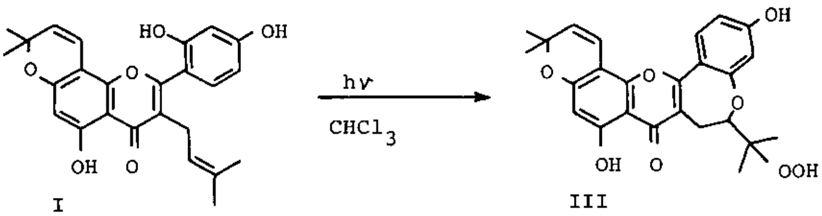
The photoreaction of morusin trimethyl ether (Ia) afforded hydroperoxide (II), the structure of which was confirmed on the basis of spectral and chemical data. On the other hand, the photoreaction of morusin-2',4'-dimethyl ether (Ib) did not occur. The possible mechanism of the photoreaction of Ia is discussed being based on the several experimental results obtained here.

In the previous papers[1], the authors reported the structure determination of a series of isoprene-substituted flavonoids obtained from the root bark of Morus alba L., and described the photooxidative cyclization of morusin (I) and the other 3-prenylflavones.[1b,2] When a solution of I in chloroform was irradiated with a high-pressure mercury lamp, morusin hydroperoxide (III) was obtained in ca 80 % yield.[2a] This reaction was dependent on the solvent and proceeded in chloroform or benzene solution whereas the starting material was recovered unchanged in methanol, ethanol, or tert-butyl alcohol solution.[2a] For the photoreaction, the mechanism which proceeds via a charge transfer complex was suggested.[2b] When a solution of morusin dimethyl ether (Ib) or morusin diacetate (Ic) was irradiated in chloroform, photoreaction did not occur and starting material was recovered unchanged.[2a] On the other hand, Matsuura and his co-workers reported[3] that 5-hydroxyflavone derivatives resist photoreaction and the stability to photoreaction



is due to hydrogen bonding of the 5-hydroxyl to the 4-carbonyl group, and that such an interaction causes an intramolecular hydrogen abstraction in the excited state to yield tautomer. Considering this assumption, in the case of Ib and Ic, it is imagined that the stability to photoreaction is due to the hydrogen bonding. On the other hand, if the solution of morusin trimethyl ether (Ia)[4] which has no hydrogen bonding of the 5-hydroxyl to the 4-carbonyl group, is irradiated, photoreaction would be expected to occur. In this connection, we attempted the photoreaction of morusin trimethyl ether (Ia).

A solution of Ia (50 mg) in benzene (8 ml) was externally irradiated in a glass vessel with a 100 W high-pressure mercury lamp for 16 hr. The reaction products were purified by preparative TLC (ether:chloroform=1:4) to give II and starting material in 6 % and 72 % yield, respectively. The structural elucidation of II was accomplished on the basis of the following results.

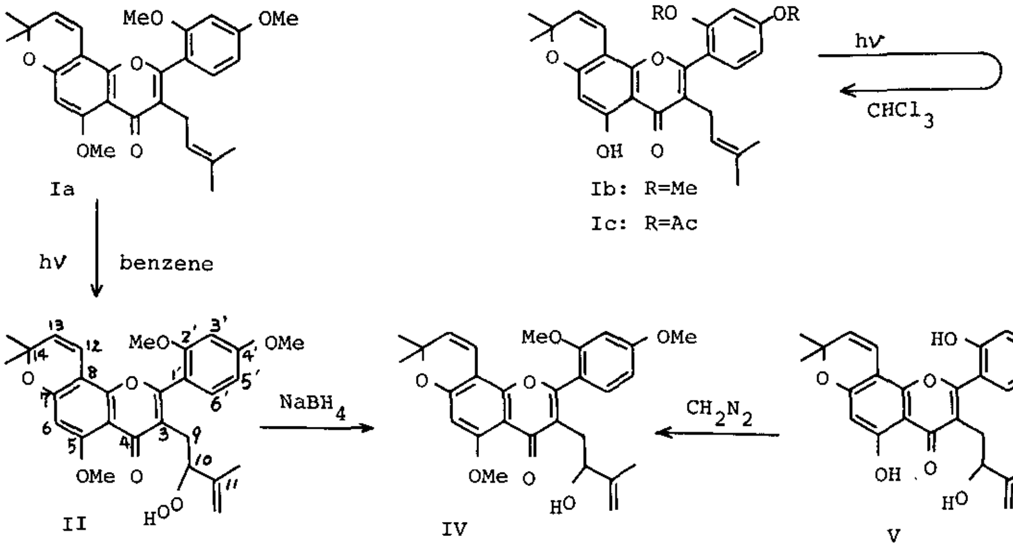


Chart 1

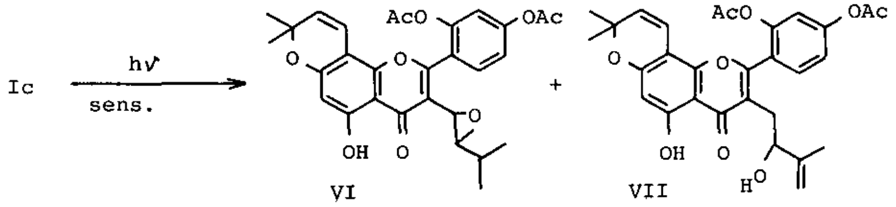
Compound (II), $C_{28}H_{30}O_8$(M^+ 494), mp 133-134°, colorless prisms from ether, negative on ferric chloride reaction, ir [ν_{max}^{Nujol} 3240, 1650, 1625, 1605, 1575 cm^{-1}], uv [λ_{max}^{MeOH} nm(log ε): 262(3.95), 295(sh 3.75)], nmr(δ in $CDCl_3$)[1.47(6H,s,C_{14}-CH_3x2), 1.55(3H,br s,C_{11}-CH_3), 2.63(1H,dd,J=4 and 15Hz,C_9-H), 3.00(1H,dd,J=8 and 15Hz,C_9-H), 3.78, 3.86, 3.95(each 3H,OMe), 4.18(1H,dd,J=4 and 8Hz,C_{10}-H), 4.77(2H,br s,C_{11}=CH_2), 5.45(1H,d,J=10Hz,C_{13}-H), 6.29(1H,s,C_6-H), 6.56(1H,d,J=10Hz,C_{12}-H), 6.57(1H,dd, J=2 and 8Hz,$C_{5'}$-H), 6.58(1H,d,J=2Hz,$C_{3'}$-H), 7.23(1H,d,J=8Hz,$C_{6'}$-H), 10.94(1H,s,OOH)], FD-ms m/e: 494(M^+), 478(M^+-O), 477(M^+-OH), 476(M^+-H_2O), 463(M^+-OCH_3), 462(M^+-2xO), 436(M^+-C_3H_5-OH). When II (10 mg) was treated with sodium borohydride in methanol for 30 min, compound (IV, 3 mg) was obtained. The product (IV) was identified with authentic specimens obtained by methylation of V,[5] by nmr, ms, and ir spectroscopy. From these results, compound (II) is represented by the formula II.

The following two possible mechanisms can be proposed for the primary step of the photoreaction of Ia.[6] 1. a reaction mechanism involving "singlet oxygen", 2. a photochemical autoxidation involving a radical chain mechanism.
Above two possible mechanisms were examined on the basis of experimental results.

1. A reaction mechanism involving "singlet oxygen".

Considering the ultraviolet and visible absorption spectrum of Ia,[1a] it is probable that Ia acts as a triplet sensitizer and produces singlet oxygen (Chart 2).[6]

$$\text{Ia} \xrightarrow{h\nu} {}^1\text{Ia}^* \longrightarrow {}^3\text{Ia}^* + {}^3O_2 \longrightarrow \text{Ia} + {}^1O_2$$



$$\text{Ia} + \text{Ic} \xrightarrow{h\nu} \text{II} + \text{VI(none)} + \text{VII(none)}$$

Chart 2

So we tried the photoreaction of Ia in the presence of morusin diacetate (Ic).[1a] A solution of Ia (20 mg) and Ic (20 mg) in benzene (3 ml) was externally irradiated in a glass vessel with a 100 W high-pressure mercury lamp for 16 hr. The reaction products were purified by preparative TLC to give II, Ia, and Ic in 5 %, 92 %, and 88 % yield, respectively. In this reaction, VI[2b] and VII[2b] could not be obtained. If Ia could generate singlet oxygen, VI and VII should be formed as reported in the previous paper.[2b] These data indicate that Ia does not generate singlet oxygen as well as Ic does not,[2b] and the reaction mechanism involving singlet oxygen can be excluded.

2. A photochemical autoxidation involving a radical chain mechanism.

To investigate this assumption, we tried the reaction in the presence of a radical quencher, 2,4,6-tri-*tert*-butylphenol, as follows. A solution of Ia (50 mg), 2,4,6-tri-*tert*-butylphenol (50 mg) in benzene (8 ml) was irradiated for

16 hr as described above. The products were purified by preparative TLC to give II and Ia in 4 % and 77 % yield, respectively. Blank runs without 2,4,6-tri-*tert*-butylphenol gave II and Ia in 6 % and 72 % yield, respectively. Although these results are not so clear cut to support the radical chain reaction mechanism, but considering the similar photochemical autoxidation of flavonoid derivatives reported by Matsuura *et al*.[3a] in our case, it is suggested that the formation of II from Ia may be achieved by sequences as described in Chart 3.

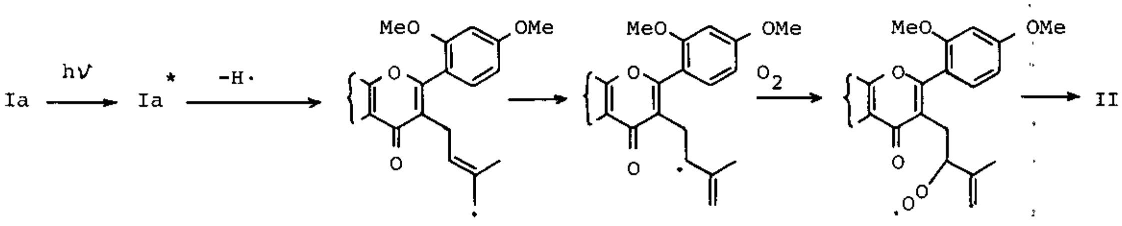


Chart 3

From above results, it is clear that the flavonoids having no hydrogen bonding of the 5-hydroxyl to the 4-carbonyl group are susceptible to photoreaction, while those having hydrogen bonding are not. This result is consistent with the Matsuura's reports.[3] In the case of morusin (I), however, having the intramolecular hydrogen bonding between the 5-hydroxyl and the 4-carbonyl group, the photooxidative cyclization occured in high yield.[2a] In this respect, the photooxidative cyclization of I seems to be a novel reaction in the photochemistry of flavonoids.

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obtained as colorless prisms, mp 152-154°.

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