ACID-CATALYZED PHOTOREARRANGEMENT OF 1,3-DIMETHYL-CYCLOOCTAPYRIMIDINE-2,4-DIONE INTO 10,12-DIAZATRICYCLO-[6.4.0.0^{1,5}]DODECA-3,7-DIENE-9,11-DIONES[1]

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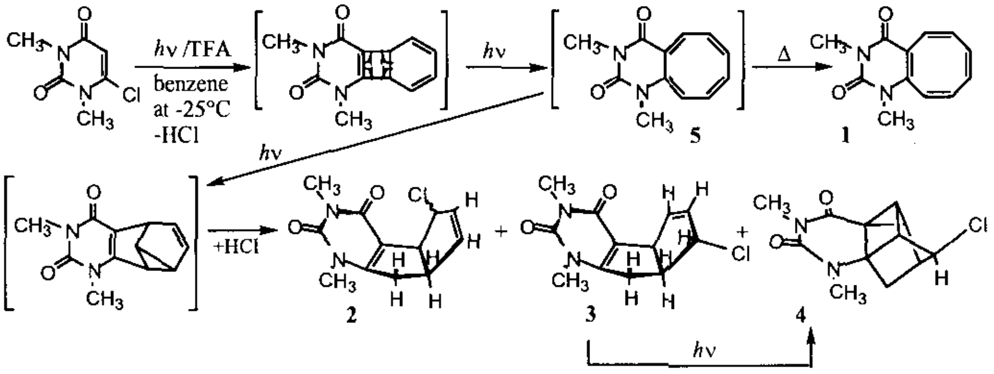
Abstract— UV irradiation of 1,3-dimethylcyclooctapyrimidine-2,4-dione in the presence of a large excess of trifluoroacetic acid (>10 equiv. molar) at low temperature afforded 6-substituted 10,12-diaza-10,12-dimethyltricyclo[6.4.0.0^{1,5}]-dodeca-3,7-diene-9,11-dione, which is regarded as a product through intramolecular photo-Diels-Alder reaction.

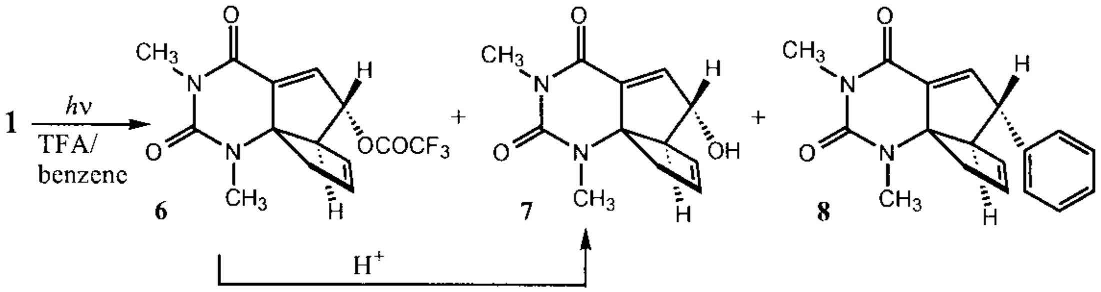
In the course of our studies on the acid-catalyzed photoreaction of pyrimidine bases with substituted benzenes, we have reported that photolysis of 6-chloro-1,3-dimethyluracil (6-ClDMU) in benzene in the presence of trifluoroacetic acid (TFA) gave 1,3-dimethylcyclooctapyrimidine-2,4-diones (**1**),[2] while the corresponding reaction conducted in frozen benzene resulted in the formation of a new system of tricyclic compounds consisting of a pentaleno[1,2-*e*]pyrimidine skeleton (**2**, **3**, and **4**).[3] The preferential formation of these products at low temperature (-25°C) is interpreted by the mechanism involving a [4πs + 2πa] type photo-Diels-Alder reaction of the tautomeric isomer (**5**) of **1**, generated as the precursor for **1** (Scheme 1).[1] Although no evidence was obtained to substantiate the generation of the key intermediate (**5**) in the reaction, this photoreaction could be regarded as a photoreaction of a cyclooctatetraene, wherein some unique transformation reactions have been reported.[4] These reports encouraged us to investigate the potentiality of the photoreaction of **2**, which was insusceptible under the previously employed reaction conditions using 2 equiv. molar TFA.



Scheme 1

In the present paper, we describe our findings that UV-irradiation of **1** in frozen benzene in the presence of a large excess of TFA (10-20 equiv. molar) gave rise to the formation of intramolecular photo-Diels-Alder products, 6-substituted 10,12-diaza-10,12-dimethyltricyclo[6.4.0.0^{1,5}]dodeca-3,7-diene-9,11-diones in fair yields.

Neither direct photolysis of **1** under the reaction conditions employed for our continuing works; *i.e.*, a 500W high pressure mercury lamp with a Pyrex filter in the presence (2-4 mmol) or absence of TFA at room temperature or at low temperature (-25°C) in benzene, nor acetone-sensitized photolysis under various conditions caused any rearrangement. By contrast, UV-irradiation of **1** in the presence of 10 equiv. molar TFA at low temperature (-25°C) gave rise to the formation of novel tricyclic compounds consisting of a pentalene skeleton; 10,12-diaza-10,12-dimethyl-9,11-dioxotricyclo[6.4.0.0^{1,5}]dodeca-3,7-dien-6-yl 2,2,2-trifluoroacetate (**6**), 10,12-diaza-6-hydroxy-10,12-dimethyltricyclo[6.4.0.0^{1,5}]dodeca-3,7-diene-9,11-dione (**7**), and 10,12-diaza-10,12-dimethyl-6-phenyltricyclo[6.4.0.0^{1,5}]dodeca-3,7-diene-9,11-dione (**8**) in 55%, 5%, and 23% yields, respectively)[5] (Scheme 2).



Scheme 2

The structural assignment of **6**[6] was deduced from the spectral analogy with **7**,[7] whose structure was determined by X-Ray crystallographic analysis[8] (Figure 1). The structure of **6** was supported by the fact that **6** was converted into **7** quantitatively upon standing overnight at room temperature under an acidic condition. The structure of **8**[9] was deduced by the comparison of its spectra with those of **6** and **7**.

The formation of these tricyclic compounds (**6**-**8**) could be explained formally by the mechanism involving an intramolecular photo-Diels-Alder reaction[10] of the cyclooctatetraene moiety into the semibullvalen intermediate (**9a**; R = H) or (**10a**; R = H) through the 1,5 + 4,6 bonding.[11]

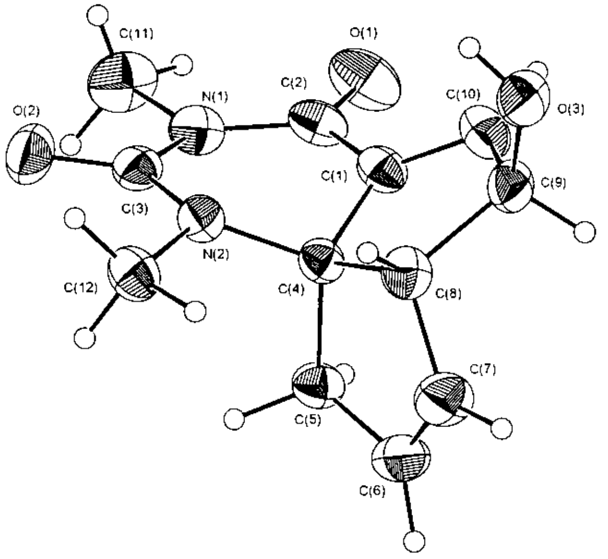
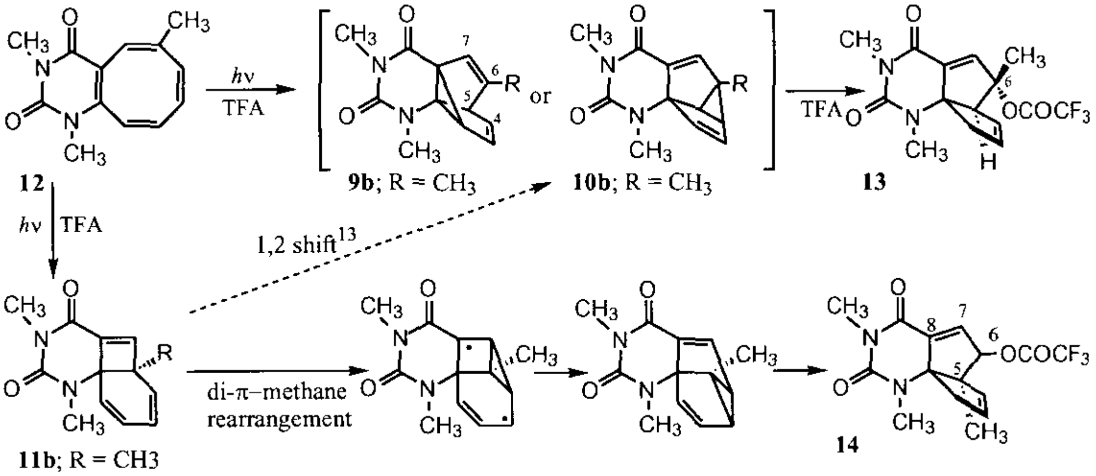


Figure 1. Stereoscopic view of **7**.

An alternative pathway involving di-π-methane rearrangement through the cyclobutaquinazoline intermediate (**11a**; R = H)[12] can be eliminated by the fact that the analogous reaction with the 6-methyl derivative of **1** [1,3,6-trimethylcyclooctapyrimidine-2,4-diones (**12**)] afforded the 6-methyl derivative (**13**) of **6**,[13] and no formation of the 5-methyl derivative (**14**), which could be derived (see Scheme 3) through a di-π-methane rearrangement,[12] was detected.



Scheme 3

Thus, the present photoreaction produced a different type of pentalenopyrimidines, whose formation is predictable from the mechanism proposed for the photoreaction of 6-ClDMU in frozen benzene[1] (Scheme 1). These findings may give a support to our assumption that the tautomeric isomer (**5**) of **1** participates in the formation of pentaleno[1,2-*e*]pyrimidines (**2**, **3**, and **4**).

The present photorearrangement can be explained superficially in terms of an antarafacial intramolecular photo-Diels-Alder reaction of the cyclooctatetraene moiety. However, from a mechanistic point of view it is uncertain if the reaction which requires the presence of a large excess of TFA could be discussed analogously with those conducted under neutral conditions. Although the precise role of the added acid on the present photoreaction is equivocal, sequential addition of TFA (0 to 10 equiv. molar) to a solution of **1** in cyclohexane decreased the absorbance at λ_{max}249 nm (ε=10400) to ε=9960 and increase the λ_{max}307 nm (ε=1640) to ε=1820 with the isosbestic points at 242 and 248 nm. Furthermore, addition of potassium carbonate returned the spectrum to its original display, suggesting that **1** may form the charge transfer complex with TFA or the proton adduct under the reaction condition. The addition of piperylene surpressed the rearrangement significantly, suggesting that the present photoreaction may proceed *via* the excited triplet states.

Further investigations on the scope and the mechanism of the present acid-catalyzed intramolecular photoreaction are currently under investigation.

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3. K. Ohkura, Y. Noguchi, and K. Seki, *Heterocycles*, 1997, **46**, 141.
4. L. T. Scott and M. Jones, JR, *Chem. Rev.*, 1972, **72**, 181.
5. Yields are given on the bases of **1** consumed (31%) .
6. 10,12-Diaza-10,12-dimethyl-9,11-dioxotricyclo[6.4.0.0^{1,5}]dodeca-3,7-dien-6-yl 2,2,2-trifluoroacetate (**6**): Colorless oil. ^{1}H-NMR (C_6D_6) δ : 1.65 (1H, dddd, J = 18.1, 2.4, 1.5, ~0 Hz, H-2a), 1.90 (1H, dq, J = 18.1, 2.4 Hz, H-2b), 2.32 (3H, s, N^{12}-CH_3), 2.98 (1H, m, H-5), 3.19 (3H, s, N^{10}-CH_3), 4.82 (1H, dd, J = 2.9, 2.0 Hz, H-6), 5.01 (1H, dddd, J = 5.9, 2.4, 2.4, 1.5 Hz, H-3), 5.33 (1H, dq, J = 5.9, 2.4 Hz, H-4), 6.01 (1H, d, J = 2.0 Hz, H-7). MS *m/z* (%) 330 (M^+, 68), 217 (100). HRMS: Calcd for $C_{14}H_{13}N_2O_4F_3$: 330.0827. Found: 330.0817.
7. 10,12-Diaza-6-hydroxy-10,12-dimethyltricyclo[6.4.0.0^{1,5}]dodeca-3,7-diene-9,11-dione(**7**): Colorless crystals, mp 130-130.5°C (recrystallized from ethyl acetate). ^{1}H-NMR ($CDCl_3$)δ : 2.00 (1H, d, J = 7.8 Hz, C^6-OH), 2.47 (1H, dddd, J = 18.1, 2.4, 1.5, ~0 Hz, H-2a), 2.68 (1H, dq, J = 18.1, 2.4 Hz, H-2b), 2.90 (3H, s, N^{12}-CH_3), 3.26 (3H, s, N^{10}-CH_3), 3.50 (1H, ddddd, J = 2.9, 2.4, 2.4, 2.0, ~0 Hz, H-5), 4.63 (1H, ddd, J = 7.8, 2.9, 1.5 Hz, H-6), 5.75 (1H, dddd, J = 5.9, 2.4, 2.0, 1.5 Hz, H-3), 5.93 (1H, dq, J = 5.9, 2.4 Hz, H-4), 6.64 (1H, d, J = 1.5 Hz, H-7). MS *m/z* (%) 234 (M^+, 49), 233 (14), 216 (11), 205 (100). HRMS: Calcd for $C_{12}H_{14}N_2O_3$: 234.1004. Found: 234.1007.
8. X-Ray crystallography of **7** was obtained by using a Mac Science MXC18K diffractometer with CuKα radiation: molecular formula, $C_{12}H_{14}N_2O_3$; molecular weight, 224.25; space group C_2/c (Z = 8), a = 14.171 (3), b = 13.364 (3), c = 13.132 (3) Å, β = 111.46 (2)°, V = 2314.4 (9) Å^3, Dx = 1.287 g/cm^3. R = 0.045.
9. 10,12-Diaza-10,12-dimethyl-6-phenyltricyclo[6.4.0.0^{1,5}]dodeca-3,7-diene-9,11-dione (**8**): Colorless oil. ^{1}H-NMR ($CDCl_3$)δ : 2.52 (1H, dddd, J = 18.1, 2.4, 2.0, ~0 Hz, H-2a), 2.83 (1H, dq, J = 18.1, 2.4 Hz, H-2b), 2.88 (3H, s, N^{12}-CH_3), 3.28 (3H, s, N^{10}-CH_3), 3.59 (1H, ddddd, J = 4.9, 2.4, 2.4, 1.5, ~0 Hz, H-5), 3.80 (1H, dd, J = 4.9, 2.0 Hz, H-6), 5.80 (1H, dddd, J = 6.4, 2.4, 2.0, 1.5 Hz, H-3), 5.92 (1H, dq, J = 6.4, 2.4 Hz, H-4), 6.64 (1H, d, J = 2.0 Hz, H-7), 7.12-7.14 (2H, d, J = 6.8 Hz, H-2', H-6'), 7.27-7.30 (1H, d, J = 7.3 Hz, H-4'), 7.33-7.37 (2H, dd, J = 6.8, 7.3 Hz, H-3', H-5'). MS *m/z* (%) 294 (M^+, 100), 236 (12). HRMS: Calcd for $C_{18}H_{18}N_2O_2$: 294.1368. Found: 294.1380.
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13. 10,12-Diaza-6,10,12-trimethyl-9,11-dioxotricyclo[6.4.0.0^{1,5}]dodeca-3,7-dien-6-yl 2,2,2-trifluoroacetate (**13**): Colorless oil. ^{1}H-NMR ($CDCl_3$) δ : 1.54 (3H, s, C^6-CH_3), 2.48 (1H, dddd, J = 18.2, 2.0, 2.0, ~0 Hz, H-2a), 2.69 (1H, dq, J = 18.2, 2.4 Hz, H-2b), 2.89 (3H, s, N^{12}-CH_3), 3.25 (3H, s, N^{10}-CH_3), 3.79 (1H, br.s, H-5), 5.90 (1H, m, H-3), 5.98 (1H, m, H-4), 6.75 (1H, s, H-7). MS *m/z* (%) 344 (M^+, 9), 231 (100), 205 (45). HRMS: Calcd for $C_{15}H_{15}N_2O_4F_3$: 344.0984. Found: 344.0992.

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