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Photoaddition of 4(3*H*)-Quinazolinone Derivatives to Olefins: Effects of the 2-Substituent[1)]

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The photochemical behavior of 3-(3-butenyl)-4(3*H*)-quinazolinone (**2a**) and its 2-chloro (**2b**) and 2-trifluoromethyl derivatives (**2c**) was examined in methanol at a variety of wavelengths (254, 300, and 350 nm). The intramolecular 2+2 photoadducts (**10** and **14**) were obtained only when **2c** and its higher methylene homologue (**13**) were irradiated. Though the 2-unsubstituted quinazolone (**2a**) was photostable, its 2-chloro derivative (**2b**) afforded the cyclized product (**4**) *via* homolytic fission of the C–Cl bond. An enhancement of the photocycloaddition reactivity of the C=N bond in the quinazolone ring by introduction of a trifluoromethyl group was also demonstrated by the formation of the intermolecular adducts from 2-trifluoromethyl-4(3*H*)-quinazolinone (**1c**) by irradiation in the presence of olefins. The reactions due to C–N bond fission of the azetidine ring in these adducts are also described. Finally, by utilizing photo-induced C–Cl bond fission as found in **2b**, rutecarpine (**26**) was synthesized by irradiation of 2-chloro-3-[2-(indol-3-yl)ethyl]-4-(3*H*)-quinazolinone (**25**).

Keywords——photochemical reaction; 3-(ω-alkenyl)-4(3*H*)-quinazolinone; 2+2 photocycloaddition; wavelength dependency; azetidine; rutecarpine; vasicinone; 3-trifluoromethyl-4(3*H*)-quinazolinone; photoarylation

The C=C bond of the enone function involved in heteroaromatic rings is known to add to olefins under irradiation *via* the triplet excited state of the heteroaromatics.[2,3)] Such photoaddition also proceeds in the case of the aza-analogues. Thus, the C=N bond in 6-azauracils[4)] and 2(1*H*)-quinoxalinones[5)] participates in 2+2 photoaddition reactions. Though 1(2*H*)-isoquinolones add photochemically to olefins in the same manner,[6)] photoaddition of 4-quinazolones to olefins has never been reported. In this connection, we have examined such photoaddition reactions of 4-quinazolones in detail and found that though 4(3*H*)-quinazolinone itself does not photoadd to olefins, its 2-trifluoromethyl derivatives give the corresponding photoadducts, irrespective of the kinds of olefins. At the same time, a novel photocyclization of 2-chloro-3-(ω-alkenyl)-4(3*H*)-quinazolinones *via* photo-induced homolytic fission of the C–Cl bond has been found, and the reaction was successfully applied to the synthesis of rutecarpine from 2-chloro-3-[2-(indol-3-yl)ethyl]-4(3*H*)-quinazolinone. In this paper, we describe these results in detail.

Intramolecular 2+2 Photocycloaddition of 3-(ω-Alkenyl)-2-trifluoromethyl-4(3*H*)-quinazolinones

At the outset of this work, we chose 3-(3-butenyl)-4(3*H*)-quinazolinone (**2a**) and its 2-substituted derivatives (**2b**—**2c**) as the starting materials. Since the corresponding isoquinolones gave the intramolecular 2+2 photoadducts with much higher efficiency than the corresponding intermolecular ones,[1,7)] examination of the photochemical behavior of these compounds (**2**) might not only directly establish the ability of 4-quinazolones to photoadd to olefins, but also reveal the effects of 2-substituents in the quinazolone ring upon such

photoaddition reactions.

Two 4-quinazolones (**2a** and **2b**) were synthesized readily by the reaction of **1a** and its 2-chloro derivative (**1b**)[8] with 4-bromo-1-butene under basic conditions, though the reaction was accompanied by minor formation of the *O*-alkylated derivatives (**3a** and **3b**). These 4-quinazolones were irradiated in methanol at a variety of wavelengths (254, 300, or 350 nm) using a Rayonet photo-reactor. The parent compound (**2a**) was found to be stable under all irradiation conditions and was recovered almost quantitatively. However, **2b**, though it was stable to irradiation at either 300 or 350 nm, gave the cyclized product (**4**) on irradiation at 254 nm. This compound was identical with 3-methylenedeoxyvasicinone recently synthesized.[9] Though compound **4** was unstable, it gave the stable dihydro compound (**5**) upon catalytic hydrogenation over palladium–charcoal. In order to clarify the mechanism of this cyclization reaction, **2b** was irradiated in methanol in the presence of triethylamine, and the same dihydro derivative (**5**) was obtained in high yield. The increase in the yield of **5** on irradiation in the presence of a suitable hydrogen-donor (triethylamine) as well as the requirement for a short irradiation wavelength (254 nm) indicates that the reaction proceeds by an initial photo-induced homolytic C–Cl bond fission to give **6** *via* the S_1 state of **2b**, followed by conversion to **7**, which finally affords either **4** or **5**. The similar photo-induced arylation reactions (both intra- and intermolecular) of 3-chloroisoquinolines[10] also supported this view.

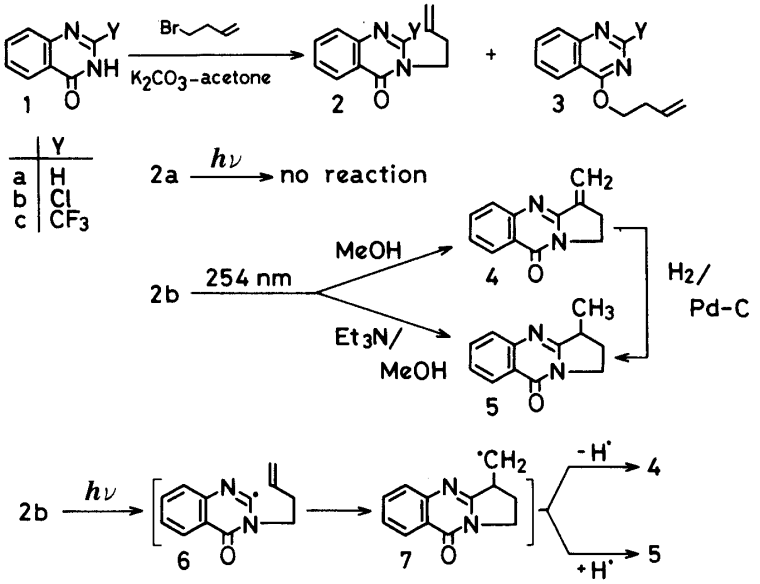

Chart 1

The fact that 2-methyl-4-alkoxycarbonyloxazoles are photostable whereas their 5-trifluoromethyl derivatives dimerize efficiently upon irradiation[11] prompted us to examine the photochemical behavior of 3-(3-butenyl)-2-trifluoromethyl-4(3*H*)-quinazolinone (**2c**) in order to effect the desired intramolecular photocycloaddition reaction.[12] The butenylation of 2-trifluoromethyl-4(3*H*)-quinazolinone (**1c**)[13] as in the case of **1a** and **1b** was unsuccessful, giving only the *O*-alkylated derivative (**3c**). However, the desired compound (**2c**) was synthesized from 2-trifluoromethyl-4*H*-3,1-benzoxazin-4-one (**8**)[14] by the reaction with 3-butenylamine followed by cyclization (**9**→**2c**).[15] The same reaction also proceeded smoothly using ammonia to give **1c**, which was later used in the corresponding intermolecular photoaddition reactions (*vide infra*).

In contrast to the photoreactions of **2a** and **2b**, **2c** afforded the corresponding 2+2 adduct (**10**) in 95% yield as the sole product even on irradiation at 350 nm. The parallel

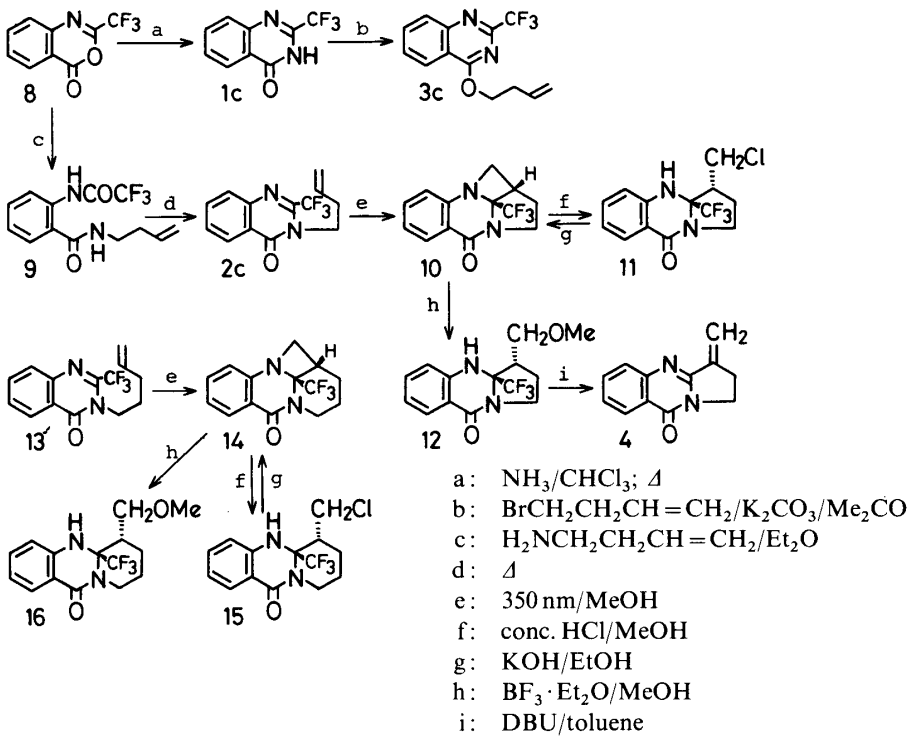

Chart 2

structure of the adduct was deduced from the nuclear magnetic resonance (NMR) spectrum and determined unequivocally from the reactions described below. Thus, refluxing of **10** in methanol containing hydrochloric acid gave the tricyclic compound, *trans*-3-chloromethyl-9-oxo-3a-trifluoromethyl-1,2,3,3a,4,9-hexahydropyrrolo[2,1-*b*]quinazoline (**11**), which recyclized to **10** on heating in ethanol containing potassium hydroxide. The facile cyclization clearly indicates a *trans* relationship between the chloro-methyl and trifluoromethyl groups in **11**. Similar C–N bond fission of **10** also occurred smoothly to give the tricyclic compound (**12**), when the former was refluxed in methanol containing borontrifluoride etherate. The 3a,4-dihydrovasicinone structure of these tricyclic compounds (**11** and **12**) was further demonstrated by the conversion of **12** to 3-methylenedeoxyvasicinone (**4**) by refluxing of the former in toluene in the presence of 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU). The parallel adduct (**14**) was obtained again in a regioselective manner when 3-(4-pentenyl)-2-trifluoromethyl-4(3*H*)-quinazolinone (**13**: prepared from **8** by the same method as used for **2c**) was irradiated in methanol at 350 nm. The adduct (**14**) also gave the tricyclic compounds (**15** and **16**) under the same acidic conditions, showing that the azetidine ring in **10** and **14** is strained significantly.[16]

It should also be noted that these adducts (**10** and **14**) are stable to irradiation at 300 nm and they can be prepared by irradiation at $\geq$300 nm (high-pressure mercury lamp with a Pyrex filter) without any difficulty.

Intermolecular 2+2 Photocycloaddition of 4(3*H*)-Quinazolinones to Olefins

Knowing that the C=N bond in **2c** and **13** exhibits remarkable activity to photoaddition, we then investigated the intermolecular reaction. As expected, irradiation of **1c** in methanol under bubbling of ethylene gave the 2+2 adduct (**17**) as the sole product. The facts that the reaction proceeded slowly and the yield of the adduct was poor are probably due to the low solubility of ethylene in methanol.[17] Actually, when other olefins were used, all the reactions proceeded with satisfactory yields. When isobutene was used as the counterpart in

the cycloaddition reaction, the ene type product (**18**) was obtained in 65% yield, showing that the biradical (**19**) is involved as an intermediate. Irradiation of **1c** with ethyl vinyl ether and *n*-butyl vinyl ether in methanol gave the corresponding acetals (**20a** and **20b**) as mixtures of diastereoisomers. Probably, the adduct (**21**) initially formed was converted to the final products by solvolysis with methanol. When **1c** was irradiated in ethanol containing ethyl vinyl ether, the corresponding diethylacetal derivative (**20c**) was obtained as the sole product. Furthermore, the addition reaction also proceeded when 1,1-dichloroethylene (an electron-poor olefin) was used as the olefin. In this case, the 2-methoxycarbonylmethyl derivative (**22**) was obtained, showing again that the initially formed adduct (**23**) was converted to the final product (**22**) under the irradiation conditions.

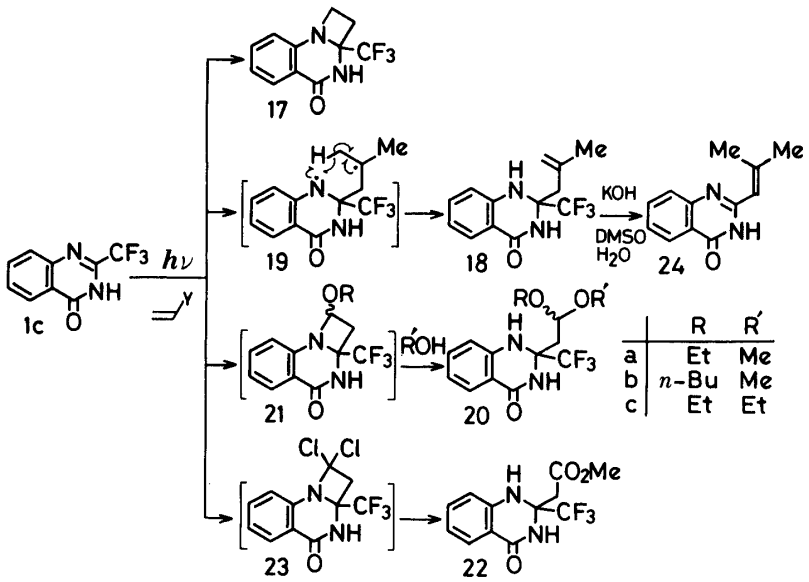

Chart 3

Clearly, all of these intermolecular reactions proceeded in a regiospecific manner to give 1-substituted azeto[1,2-*a*]quinazolines (**21** and **23**), just as in the photoaddition of isoquinolones to olefins,[6] and this indicates that the addition reactions proceed in a stepwise manner *via* the most stable biradicals (*e.g.* **19**) as intermediates.

It should be noted that, just as in the conversion of **12** to **4**, compound **18** afforded the aromatized quinazolone (**24**) on treatment with potassium hydroxide in dimethyl sulfoxide (DMSO). These results show that the trifluoromethyl group can act as a leaving group only when a gain of aromaticity in the product is attained in the elimination step.[18]

Synthesis of Rutecarpine by Photochemical Means

The ready cyclization of 3-(3-butenyl)-2-chloro-4(3*H*)-quinazolinone (**2b**) as well as the photoarylation of 3-chloro-1-isoquinolones[10] prompted us to examine the photoreaction of 2-chloro-3-[2-(indol-3-yl)ethyl]-4(3*H*)-quinazolinone (**25**). Irradiation of **25** in acetonitrile afforded three products (**26**—**28**), in proportions that depended strongly upon the wavelength employed (254, 300, and 350 nm), and the results are summarized in Table I.

Previously, we reported a novel synthetic method for rutecarpine (**26**) and vasicolinone by acid cyclization of **25**.[19] The mechanism was proposed to involve the spiro compound (**30**) as an intermediate. In the photoreaction, though the mechanism for the formation of **28** is uncertain at present, it is clear that the same spiro compound (**30**) also participates in these photocyclization reactions to give either **26** (by direct ring enlargement) or **27** (by addition of water to the imine function in **30** followed by retro-aldol type C–C bond fission). In contrast to the fact that cyclization of **2b** did not proceed on irradiation at 300 nm, the corresponding

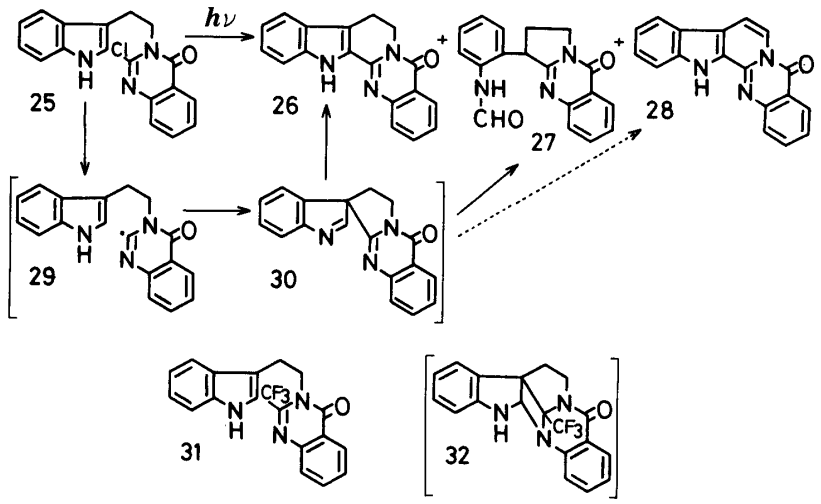

Chart 4

TABLE I. Photocyclization of 2-Chloro-3-[2-(indol-3-yl)ethyl]-4(3*H*)-quinazolinone (**25**) in Acetonitrile

Run	Irradiation Wavelength (nm)	Product (%)		
		26	**27**	**28**
1	350	No cyclization product		
2	300	42	37	8
3	254	18	32	23

cyclization of **25** proceeded even at 300 nm. This result indicates that the initial homolytic fission of the C–Cl bond is assisted by the so-called aryl participation.[10,20] Such participation is especially attractive in this case, because indole is a π-excessive heteroaromatic while the quinazolone is a π-deficient one.

It should be noted that the corresponding 2-trifluoromethyl derivative (**31**) did not afford the cyclized product (*e.g.* **32**) under any irradiation conditions. This shows that a double bond involved in an aromatic ring can not participate in the photochemical 2+2 cycloaddition reaction.

Conclusions

It was found that photochemical reactions of 4-quinazolones depend markedly upon the kind of substituent at the 2-position. Thus, while 2-unsubstituted quinazolones are unable to participate in either intra- or intermolecular photoaddition reaction, the 2-chloro derivative gave intramolecular cyclization products through a photo-induced homolytic C–Cl bond fission. Introduction of a trifluoromethyl group at the 2-position to the 4-quinazolone ring remarkably enhances the reactivity of the C=N bond in 2+2 photocycloaddition reactions. This indicates strongly that the system (–C(CF_3)=N–) may be an attractive function in a heteroaromatic ring system as a component in the 2+2 photoaddition reaction. The clarification of the mechanism as well as an application of the present reactions to other heteroaromatic compounds are under investigation.

Experimental

All melting points were determined on a micro-hot stage (Yanagimoto) and are uncorrected. Infrared (IR) spectra were recorded on a JASCO A-102 spectrometer and ^{1}H-NMR spectra on a JEOL JNM-PMX 60 or JNM-FX-100 spectrometer (with tetramethylsilane as an internal standard). Mass spectra (MS) were taken with a JEOL JNM-01SG spectrometer. Column chromatography was performed on silica gel (Wakogel C-200) and thin-layer chromatography (TLC) on Merck Kieselgel 60F_{254}.

Irradiation Conditions——a) Irradiation at $\geq$300 nm: The photolyses were carried out in a Pyrex immersion apparatus equipped with a Riko UVL-400HA high-pressure mercury lamp.

b) Irradiation at 253, 300, or 350 nm: Irradiation for photochemical reactions having a wavelength dependency was performed in a quartz vessel using Rayonet photochemical reactor lamps (RPR-2537 Å, RPR-3000 Å, or RPR-3500 Å) under an argon atmosphere.

3-(3-Butenyl)-4(3*H*)-quinazolinone (2a)——Finely powdered K_2CO_3 (829 mg, 6 mmol) was added to a solution of 4(3*H*)-quinazolinone (**1a**, 585 mg, 4 mmol) and 4-bromo-1-butene (1.62 g, 12 mmol) in acetone (50 ml), and the whole was refluxed for 10 h with stirring. The reaction mixture was filtered, and the filtrate was evaporated *in vacuo*. The residue was taken up in ether and the organic layer was dried over Na_2SO_4. The residue obtained after evaporation of the solvent was chromatographed on silica gel. Elution with hexane–ethyl acetate (4 : 1) gave 30 mg (4%) of 4-(3-butenyloxy)quinazoline (**3a**) as an oil. High-resolution MS *m/z*: M^+ Calcd for $C_{12}H_{12}N_2O$: 200.0949. Found: 200.950. IR ($CHCl_3$): 1620 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.41 (2H, m), 4.59 (2H, t, J=7 Hz), 4.96—5.36 (2H, m), 5.60—6.20 (1H, m), 7.30—8.20 (4H, m), 8.64 (1H, s). Further elution with hexane–ethyl acetate (2 : 1) gave 740 mg (92%) of **2a** as colorless needles (pentane), mp 58—58.5 °C. *Anal.* Calcd for $C_{12}H_{12}N_2O$: C, 71.98; H, 6.04; N, 13.99. Found: C, 71.93; H, 6.24; N, 14.01. IR ($CHCl_3$): 1675, 1610 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.56 (2H, br q, J=7 Hz), 4.06 (2H, t, J=7 Hz), 4.92—5.20 (2H, m), 5.80 (1H, ddt, J=17.5, 9, 6.5 Hz), 7.35—7.85 (3H, m), 7.97 (1H, s), 8.29 (1H, d, J=7.5 Hz).

3-(3-Butenyl)-2-chloro-4(3*H*)-quinazolinone (2b)——Finely powdered K_2CO_3 (829 mg, 6 mmol) was added to a solution of 2-chloro-4(3*H*)-quinazolinone (**1b**, 722 mg, 4 mmol) and 4-bromo-1-butene (1.62 g, 12 mmol) in acetone (100 ml), and the whole was refluxed for 10 h with stirring. The precipitates were filtered off and the filtrate was evaporated *in vacuo*. Ether was added to the residue, and the ether-insoluble material was recrystallized from CH_3CN to give 162 mg (22%) of the starting material (**1b**) as colorless needles. The ethereal layer was dried over Na_2SO_4 and evaporated. The residue was chromatographed on silica gel. Elution with hexane–ethyl acetate (20 : 1) gave 98 mg (10%) of 2-chloro-4-(3-butenyloxy)quinazoline (**3b**) as colorless prisms (pentane), mp 49.5—50 °C. *Anal.* Calcd for $C_{12}H_{11}ClN_2O$: C, 61.42; H, 4.72; Cl, 15.11; N, 11.94. Found: C, 61.68; H, 4.61; Cl, 15.50; N, 11.94. IR ($CHCl_3$): 1615 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.66 (2H, br q, J=7 Hz), 4.64 (2H, t, J=7 Hz), 5.04—5.14 (2H, m), 5.92 (1H, ddt, J=16.5, 10, 6.5 Hz), 7.40—7.90 (3H, m), 8.10 (1H, br d, J=8 Hz). Further elution with hexane–ethyl acetate (20 : 1) gave 482 mg (51%) of **2b** as an oil. *Anal.* Calcd for $C_{12}H_{11}ClN_2O$: C, 61.42; H, 4.72; Cl, 15.11; N, 11.94. Found: C, 61.22; H, 4.52; Cl, 15.46; N, 11.82. IR ($CHCl_3$): 1690, 1610 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.56 (2H, br q, J=7.5 Hz), 4.35 (2H, br t, J=7.5 Hz), 4.95—5.23 (2H, m), 5.86 (1H, ddt, J=16.5, 9.5, 7 Hz), 7.37—7.85 (3H, m), 8.21 (1H, df, J=7.5 Hz).

3-Methylene-9-oxo-1,2,3,9-tetrahydropyrrolo[2,1-*b*]quinazoline (4)——A solution of **2b** (387 mg, 1.65 mmol) in MeOH (190 ml) was irradiated at 254 nm under an argon atmosphere for 1.5 h. The solvent was evaporated off and the residue was dissolved in $CHCl_3$. The $CHCl_3$ solution was washed with 5% aq. $NaHCO_3$ and dried over Na_2SO_4. The residue obtained after evaporation of the solvent was chromatographed on silica gel. Elution with hexane–ethyl acetate (3 : 2) gave 209 mg (64%) of **4** as a solid, mp 138—142 °C (lit.[9] mp 140—144 °C). IR ($CHCl_3$): 3380, 1665, 1605 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.90—3.15 (2H, m), 4.21 (2H, br t, J=7.5 Hz), 5.62 (1H, t, J=3 Hz), 6.55 (1H, t, J=3 Hz), 7.35—7.85 (3H, m), 8.27 (1H, df, J=8 Hz).

3-Methyl-9-oxo-1,2,3,9-tetrahydropyrrolo[2,1-*b*]quinazoline (5)——1) A solution of **2b** (70 mg, 0.3 mmol) and Et_3N (2 ml) in MeOH (200 ml) was irradiated at 254 nm under an argon atmosphere for 30 min. The solvent was evaporated off *in vacuo* and the residue was subjected to silica gel column chromatography. Elution with hexane–ethyl acetate (3 : 1) gave 26 mg (43%) of **5** as colorless prisms (hexane–ether), mp 134.5—136 °C. High-resolution MS *m/z*: M^+ Calcd for $C_{12}H_{12}N_2O$: 200.0949. Found: 200.0953. IR (KBr): 1665, 1620 cm^{-1}. ^{1}H-NMR($CDCl_3$) δ: 1.50 (3H, d, J=7 Hz), 1.63—2.83 (2H, m), 2.97—3.70 (1H, m), 3.70—4.57 (2H, m), 7.13—7.73 (3H, m), 8.07—8.33 (1H, m).

2) A solution of **4** (117 mg, 0.59 mmol) in MeOH (20 ml) was hydrogenated in an atmosphere of hydrogen in the presence of 10% Pd–C (150 mg) for 12 h. The catalyst was filtered off and the filtrate was evaporated *in vacuo*. The crystalline residue was recrystallized from hexane–ether to give 73 mg (62%) of **5** as colorless prisms.

4-(3-Butenyloxy)-2-trifluoromethylquinazoline (3c)——Finely powdered K_2CO_3 (138 mg, 1 mmol) was added to a solution of **1c** (107 mg, 0.5 mmol) and 4-bromo-1-butene (270 mg, 2 mmol) in acetone (15 ml), and the whole was refluxed for 12 h. The precipitates were filtered off, and the filtrate was evaporated *in vacuo*. The residue was chromatographed on silica gel. Elution with hexane–ethyl acetate (20 : 1) gave 62 mg (46%) of **3c** as colorless prisms (pentane), mp 49.5—50.5 °C. *Anal.* Calcd for $C_{13}H_{11}F_3N_2O$: C, 58.21; H, 4.13; N, 10.44. Found: C, 58.25; H, 4.30; N,

10.31. IR ($CHCl_3$): 1618 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.70 (2H, br q, J=7 Hz), 4.75 (2H, t, J=7 Hz), 5.02—5.49 (2H, m), 5.67—6.37 (1H, m), 7.55—8.84 (4H, m).

***N*-(3-Butenyl)-2-(trifluoroacetamido)benzamide (9)**——A solution of 2-trifluoromethyl-3,1-benzoxazin-4-one (**8**, 1.075 g, 5 mmol) and 3-butenylamine (426 mg, 6 mmol) in anhydrous ether (30 ml) was stirred for 1 h at room temperature. The crystalline residue obtained after evaporation of the solvent was recrystallized from hexane to give 1.15 g (80%) of **9** as colorless needles, mp 101.5—103 °C. *Anal.* Calcd for $C_{13}H_{13}F_3N_2O_2$: C, 54.55; H, 4.58; N, 9.79. Found: C, 54.66; H, 4.37; N, 9.52. IR ($CHCl_3$): 3460, 1725, 1645 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.39 (2H, q, J=6.5 Hz), 3.52 (2H, q, J=6.5 Hz), 4.98—5.27 (2H, m), 5.81 (1H, dd t, J=16.5, 9.5, 6.5 Hz), 6.40 (1H, br s), 7.05—7.60 (3H, m), 8.40—8.60 (1H, m), 12.62 (1H, br s).

3-(3-Butenyl)-2-trifluoromethyl-4(3*H*)-quinazolinone (2c)——Compound **9** (400 mg, 1.4 mmol) was heated at 200 °C for 1 h. The reaction mixture was dissolved in $CHCl_3$, and the solution was chromatographed on silica gel. Elution with hexane–ethyl acetate (10 : 1) gave 318 mg (85%) of **2c** as colorless needles (pentane), mp 51.5—53 °C. *Anal.* Calcd for $C_{13}H_{11}F_3N_2O$: C, 58.21; H, 4.13; N, 10.44. Found: C, 58.15; H, 3.93; N, 10.34. IR ($CHCl_3$): 1675, 1610 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.33—2.67 (2H, m), 4.19 (2H, br t, J=8 Hz), 5.00—5.26 (2H, m), 5.84 (1H, dd t, J=17, 10, 7 Hz), 7.45—7.90 (3H, m), 8.28 (1H, br d, J=8.0 Hz).

9-Oxo-3a-trifluoromethyl-1,2,3,3a,4,9-hexahydro-3,4-(methano)pyrrolo[2,1-*b*]quinazoline (10)——A solution of **2c** (800 mg, 2.98 mmol) in MeOH (180 ml) was irradiated at 350 nm in an argon atmosphere for 1 h. The solvent was evaporated off *in vacuo* to give a crystalline substance, which was recrystallized from hexane to give 758 mg (95%) of **10** as colorless needles, mp 112.5—114 °C. *Anal.* Calcd for $C_{13}H_{11}F_3N_2O$: C, 58.21; H, 4.13; N, 10.44. Found: C, 57.93; H, 4.08; N, 10.16. IR ($CHCl_3$): 1655 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 1.70—2.45 (2H, m), 3.30—3.68 (3H, m), 4.25—4.72 (2H, m), 6.95 (1H, dd, J=7.5, 1.5 Hz), 7.06—7.52 (2H, m), 8.01 (1H, dd, J=7.5, 2 Hz).

3-Chloromethyl-9-oxo-3a-trifluoromethyl-1,2,3,3a,4,9-hexahydropyrrolo[2,1-*b*]quinazoline (11)——A solution of **10** (125 mg, 0.47 mmol) in conc. HCl (0.5 ml) and MeOH (3 ml) was refluxed for 30 min. The solvent was evaporated off *in vacuo*, and the residue was neutralized with 10% aq. $NaHCO_3$ then extracted with ether. The ethereal layer was washed with water and dried over Na_2SO_4. The residue obtained after evaporation of the solvent was chromatographed on silica gel. Elution with hexane–ethyl acetate (4 : 1) gave 118 mg (83%) of **11** as colorless prisms (hexane–$CHCl_3$), mp 193.5—195 °C. *Anal.* Calcd for $C_{13}H_{12}ClF_3N_2O$: C, 51.25; H, 3.97; N, 9.19. Found: C, 51.19; H, 3.88; N, 8.91. IR ($CHCl_3$): 3400, 1655, 1612 cm^{-1}. ^{1}H-NMR ($CHCl_3$) δ: 1.63—2.04 (1H, m), 2.14—2.55 (1H, m), 2.68—3.20 (1H, m), 3.38—3.70 (2H, m), 3.91 (1H, dd, J=11.5, 8 Hz), 4.08—4.39 (1H, m), 5.23 (1H, br s), 6.64—6.98 (2H, m), 7.20—7.42 (1H, m), 7.86 (1H, dd, J=8, 1.5 Hz).

Cyclization of 11 to 10 by Alkali——A solution of 85% KOH (100 mg, 1.5 mmol) in EtOH (1 ml) was added to a solution of **11** (31 mg, 0.10 mmol) in EtOH (1 ml), and the whole was refluxed for 30 min. The solvent was evaporated off *in vacuo*, and water was added to the residue. The resulting mixture was extracted with ether. The ethereal layer was washed with water and dried over Na_2SO_4. The crystalline residue obtained after evaporation of the solvent was recrystallized from hexane to give 23 mg (84%) of **10**.

3-Methoxymethyl-9-oxo-3a-trifluoromethyl-1,2,3,3a,4,9-hexahydropyrrolo[2,1-*b*]quinazoline (12)——$BF_3 \cdot OEt_2$ (0.5 ml) was added to a solution of **10** (268 mg, 1 mmol) in abs. MeOH (5 ml) with ice-cooling and stirring. The mixture was heated under reflux for 3 h. The residue obtained after evaporation of the solvent was neutralized with 10% aq. $NaHCO_3$, and extracted with ether. The ethereal layer was washed with water and dried over Na_2SO_4. The solvent was evaporated off and the residue was chromatographed on silica gel. Elution with hexane–ethyl acetate (2 : 1) gave 276 mg (92%) of **12** as colorless prisms (hexane–ether), mp 121—122 °C. *Anal.* Calcd for $C_{14}H_{15}F_3N_2O_2$: C, 56.00; H, 5.03; N, 9.33. Found: C, 56.09; H, 5.06; N, 9.30. IR ($CHCl_3$): 3400, 1645, 1612 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 1.25—1.75 (1H, m), 1.97—2.38 (1H, m), 2.75—3.16 (1H, m), 3.39 (3H, s), 3.25—3.87 (3H, m), 4.08—4.40 (1H, m), 5.53 (1H, br s), 6.57—6.92 (2H, m), 7.15—7.38 (1H, m), 7.85 (1H, dd, J=8, 1.5 Hz).

Conversion of 12 to 4——A solution of **12** (23 mg, 0.077 mmol) and 0.2 ml of DBU in toluene (1 ml) was heated under reflux for 4.5 h. The residue obtained after evaporation of the solvent was separated by preparative silica gel TLC (hexane–ethyl acetate, 2 : 1) to give 6 mg (40%) of **4**.

***N*-(4-Pentenyl)-2-(trifluoroacetamido)benzamide**——A solution of **8** (215 mg, 1 mmol) and 4-pentenylamine (85 mg, 1 mmol) was stirred for 1 h at room temperature. The residue obtained after evaporation of the solvent was chromatographed on silica gel. Elution with hexane–ethyl acetate (5 : 1) gave 211 mg (70%) of the product as colorless leaves (pentane), mp 68—69 °C. *Anal.* Calcd for $C_{14}H_{15}F_3N_2O_2$: C, 56.00; H, 5.03; N, 9.33. Found: C, 56.12; H, 5.04; N, 9.19. IR ($CHCl_3$): 3460, 1725, 1645 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 1.56—1.96 (2H, m), 2.05—2.33 (2H, m), 3.47 (2H, br q, J=6 Hz), 4.90—5.20 (2H, m), 5.84 (1H, ddt, J=17.5, 10, 6.5 Hz), 6.48 (1H, br s), 7.07—7.30 (1H, m), 7.38—7.63 (2H, m), 8.54 (1H, br d, J=8 Hz).

3-(4-Pentenyl)-2-trifluoromethyl-4(3*H*)-quinazolinone (13)——1) The amide obtained as above (423 mg, 1.41 mmol) was heated at 240 °C for 30 min. The reaction mixture was dissolved in $CHCl_3$ and chromatographed on silica gel. Elution with hexane–ethyl acetate (40 : 1) gave 294 mg (74%) of **13** as colorless needles (pentane), mp 39.5—41 °C. *Anal.* Calcd for $C_{14}H_{13}F_3N_2O$: C, 59.57; H, 4.64; N, 9.92. Found: C, 59.70; H, 4.53; N, 9.81. IR ($CHCl_3$): 1688 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 1.65—2.03 (2H, m), 2.07—2.35 (2H, m), 4.12 (2H, br t, J=8 Hz), 4.94—5.20 (2H, m), 5.83 (1H, ddt, J=17.5, 10, 6.5 Hz), 7.28—7.90 (3H, m), 8.32 (1H, br d, J=8 Hz).

2) A solution of **8** (4 g, 18.6 mmol) and 4-pentenylamine (1.51 g, 17.7 mmol) was stirred for 1 h at room temperature. The residue obtained after evaporation of the solvent was heated at 240 °C for 1 h. The reaction mixture was chromatographed on silica gel. Elution with hexane–ethyl acetate (30 : 1) gave 4.48 g (89%) of **13**.

11-Oxo-5a-trifluoromethyl-5,5a,6,7,8,9-hexahydro-11*H*-5,6-(methano)pyrido[2,1-*b*]quinazoline (14)——A solution of **13** (265 mg, 0.94 mmol) in MeOH (106 ml) was irradiated at 350 nm in an argon atmosphere for 2.5 h. The residue obtained after evaporation of the solvent was chromatographed on silica gel. Elution with hexane–ethyl acetate (5 : 1) gave 234 mg (88%) of **14** as colorless needles (pentane), mp 91—92 °C. *Anal.* Calcd for $C_{14}H_{13}F_3N_2O$: C, 59.57; H, 4.64; N, 9.92. Found: C, 59.62; H, 4.47; N, 9.85. IR ($CHCl_3$): 1645 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 1.50—2.03 (4H, m), 2.80—3.10 (1H, m), 3.16—3.45 (1H, m), 3.68 (1H, dd, J=7.5, 6.5 Hz), 4.10 (1H, dd, J=7.5, 6.5 Hz), 4.35—4.67 (1H, m), 6.85 (1H, br d, J=7.5 Hz), 6.98—7.48 (2H, m), 8.01 (1H, br d, J=7.5 Hz).

6-Chloromethyl-11-oxo-5a-trifluoromethyl-5,5a,6,7,8,9-hexahydro-11*H*-pyrido[2,1-*b*]quinazoline (15)——A solution of **14** (152 mg, 0.54 mmol) in MeOH (10 ml) and conc. HCl (2 ml) was heated under reflux for 4.5 h. The residue obtained after evaporation of the solvent was neutralized with 10% aq. $NaHCO_3$ and extracted with ether. The ethereal layer was washed with water and dried over Na_2SO_4. The solvent was evaporated off to give a crystalline substance, which was recrystallized from hexane–$CHCl_3$ to give 166 mg (97%) of **15** as colorless needles, mp 185—186.5 °C. *Anal.* Calcd for $C_{14}H_{14}ClF_3N_2O$: C, 52.76; H, 4.43; Cl, 11.12; N, 8.79. Found: C, 52.69; H, 4.43; Cl, 11.38; N, 8.73. IR ($CHCl_3$): 3410, 1655, 1618 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 1.45—2.28 (4H, m), 2.38—2.56 (1H, m), 2.80—3.20 (1H, m), 3.63 (1H, dd, J=11.5, 8 Hz), 4.19 (1H, dd, J=11.5, 5.3 Hz), 4.77 (1H, br d, J=16 Hz), 4.85 (1H, br s), 6.53—6.92 (2H, m), 7.16—7.40 (1H, m), 7.85 (1H, br s, J=8 Hz).

Cyclization of 15 to 14 by Alkali——A solution of **15** (27 mg, 0.085 mmol) and 85% KOH (106 mg, 1.6 mmol) in EtOH (2 ml) was heated under reflux for 15 min. The solvent was evaporated off *in vacuo* and water was added to the residue. The resulting mixture was extracted with ether. The ethereal layer was washed with water and dried over Na_2SO_4. The crystalline residue obtained after evaporation of the solvent was recrystallized from pentane to give 19 mg (79%) of **15**.

6-Methoxymethyl-11-oxo-5a-trifluoromethyl-5,5a,6,7,8,9-hexahydro-11*H*-pyrido[2,1-*b*]quinazoline (16)——$BF_3 \cdot OEt_2$ (2 ml) was added to a solution of **14** (300 mg, 1.06 mmol) in abs. MeOH (10 ml) with ice-cooling and stirring. The mixture was refluxed for 48 h. The residue obtained after evaporation of the solvent was neutralized with 10% aq. $NaHCO_3$ and extracted with CH_2Cl_2. The CH_2Cl_2 layer was washed with water and dried over Na_2SO_4. The solvent was evaporated off to give a crystalline substance, which was recrystallized from hexane to give 310 mg (93%) of **16** as colorless needles, mp 152—154 °C. High-resolution MS m/z: M^+ Calcd for $C_{15}H_{17}F_3N_2O_2$: 314.1241. Found: 314.1241. IR ($CHCl_3$): 3380, 1648, 1615 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 1.50—2.10 (4H, m), 2.25—2.53 (1H, m), 2.75—3.15 (1H, m), 3.22—3.50 (1H, m), 3.34 (3H, s), 3.99 (1H, dd, J=9, 8 Hz), 4.50—4.83 (1H, m), 5.68 (1H, br s), 6.48—6.90 (2H, m), 7.10—7.37 (1H, m), 7.87 (1H, dd, J=8, 1.8 Hz).

4-Oxo-2a-trifluoromethyl-2,2a,3,4-tetrahydro-1*H*-azeto[1,2-*a*]quinazoline (17)——A solution of **1c** (214 mg, 1 mmol) in MeOH (200 ml) was irradiated at ≥300 nm under bubbling of ethylene for 9 h. After evaporation of the solvent, the residue was chromatographed on silica gel. Elution with hexane–ethyl acetate (3 : 1) gave 160 mg (75%) of the starting material (**1c**). Further elution with hexane–ethyl acetate (3 : 1) gave 33 mg (14%) of **17** as colorless needles, mp 186—188.5 °C (hexane). *Anal.* Calcd for $C_{11}H_9F_3N_2O$: C, 54.55; H, 3.75; N, 11.57. Found: C, 54.53; H, 3.53; N, 11.63. IR ($CHCl_3$): 3400, 1678, 1610 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.43—2.75 (1H, m), 2.96 (1H, ddd, J=12.2, 8, 6.5 Hz), 3.95 (1H, ddd, J=9.5, 7, 6.5 Hz), 4.23 (1H, ddd, J=8, 7, 5 Hz), 6.73 (1H, dd, J=7.8, 1.2 Hz), 6.90—7.15 (2H, m), 7.30—7.50 (1H, m), 7.96 (1H, dd, J=7.8, 1.8 Hz).

2-(2-Methyl-2-propenyl)-4-oxo-2-trifluoromethyl-1,2,3,4-tetrahydroquinazoline (18)——A solution of **1c** (214 mg, 1 mmol) in MeOH (200 ml) was irradiated at ≥300 nm under bubbling of isobutene for 5 h. The residue obtained after evaporation of the solvent was chromatographed on silica gel. Elution with hexane–ethyl acetate (5 : 1) gave 46 mg (21%) of the starting material (**1c**). Further elution with the same solvent afforded 134 mg (51%) of **18** as colorless prisms, mp 136—139 °C (hexane). High-resolution MS m/z: M^+ Calcd for $C_{13}H_{13}F_3N_2O$: 270.0979. Found: 270.0966. IR ($CHCl_3$): 3410, 1680, 1615 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 1.87 (3H, s), 2.67 (2H, br s), 4.51 (1H, br s), 4.90—5.13 (2H, m), 6.57—7.02 (2H, m), 7.17—7.50 (1H, m), 7.61 (1H, br s), 7.89 (1H, br d, J=7.5 Hz).

General Procedure for Photochemical Reaction of 1c with Vinyl Ethers——A solution of **1c** (214 mg, 1 mmol) and ethyl (or *n*-butyl) vinyl ether (10—15 ml) in MeOH or EtOH (200 ml) was irradiated at ≥300 nm for 2—10 h under an argon atmosphere at room temperature. The solvent was evaporated off and the residue was chromatographed on silica gel with hexane–ethyl acetate (4 : 1 or 3 : 1) to give the acetal (**20**).

2-(2-Ethoxy-2-methoxyethyl)-4-oxo-1,2,3,4-tetrahydroquinazoline (**20a**). Irradiation time: 4 h. Yield, 225 mg (71%). Colorless powder, mp 109—118 °C. High-resolution MS m/z: M^+ Calcd for $C_{14}H_{17}F_3N_2O_3$: 318.1190. Found: 318.1209. IR ($CHCl_3$): 3410, 1675, 1615 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 1.19, 1.24 (3H, each t, J=7 Hz), 2.22 (2H, d, J=5.2 Hz), 3.35, 3.37 (3H, each s), 3.40—3.90 (2H, m), 4.83 (1H, t, J=5.2 Hz), 4.98—5.17 (1H, m), 6.53—6.92 (2H, m), 7.10—7.40 (2H, m), 7.82 (1H, br d, J=8 Hz).

2-(2-Butoxy-2-methoxyethyl)-4-oxo-2-trifluoromethyl-1,2,3,4-tetrahydroquinazoline (**20b**). Irradiation time: 2 h. Yield: 334 mg (96%), less polar **20b**: colorless prisms, mp 102—103.5 °C (pentane). *Anal.* Calcd for $C_{16}H_{21}F_3N_2O_3$: C, 55.49; H, 6.11; N, 8.09. Found: C, 55.36; H, 6.05; N, 8.06. IR ($CHCl_3$): 3410, 1675, 1615 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ:

0.80—1.02 (3H, m), 1.15—1.77 (4H, m), 2.23 (2H, d, $J=5.2$ Hz), 3.35 (3H, s), 3.40—3.70 (2H, m), 4.82 (1H, t, $J=5.2$ Hz), 5.11 (1H, br s), 6.55—6.91 (2H, m), 7.05—7.40 (2H, m), 7.83 (1H, dd, $J=8$, 1.5 Hz), more polar **20b**: colorless prisms, mp 118—119 °C (hexane). *Anal.* Calcd for $C_{16}H_{21}F_3N_2O_3$: C, 55.49; H, 6.11; N, 8.09. Found: C, 55.60; H, 6.19; N, 7.94. IR ($CHCl_3$): 3410, 1675, 1615 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 0.75—0.97 (3H, m), 1.10—1.70 (4H, m), 2.22 (2H, d, $J=5.4$ Hz), 3.37 (3H, s), 3.25—3.78 (2H, m), 4.82 (1H, t, $J=5.2$ Hz), 5.03 (1H, br s), 6.55—6.93 (2H, m), 7.18—7.42 (2H, m), 7.83 (1H, dd, $J=8$, 1.5 Hz). MS *m/z*: 346 (M^+).

2-(2,2-Diethoxyethyl)-4-oxo-2-trifluoromethyl-1,2,3,4-tetrahydroquinazoline (**20c**). Yield, 151 mg (45%). Colorless needles, mp 113—114 °C (hexane). *Anal.* Calcd for $C_{15}H_{19}F_3N_2O_3$: C, 54.21; H, 5.76; N, 8.43. Found: C, 54.32; H, 5.96; N, 8.38. IR ($CHCl_3$): 3400, 1675, 1615 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 1.19 (3H, t, $J=7$ Hz), 1.24 (3H, t, $J=7$ Hz), 2.25 (2H, d, $J=5.2$ Hz), 3.33—3.90 (4H, m), 4.89 (1H, t, $J=5.2$ Hz), 5.18 (1H, br s), 6.55—6.95 (2H, m), 7.15—7.41 (1H, m), 7.49 (1H, br s), 7.84 (1H, dd, $J=8$, 3 Hz).

2-Methoxycarbonylmethyl-2-trifluoromethyl-4-oxo-1,2,3,4-tetrahydroquinazoline (22)——A solution of **1c** (214 mg, 1 mmol) and 1,1-dichloroethylene (20 ml) in MeOH (200 ml) was irradiated at ≥300 nm in an argon atmosphere for 2.5 h. The precipitates were filtered off and the filtrate was evaporated *in vacuo*. The residue was chromatographed on silica gel. Elution with hexane–ethyl acetate (3 : 1) gave 190 mg (89%) of the starting material (**1c**). Further elution with the same solvent afforded 21 mg (7%) of **22** as colorless needles, mp 186—187 °C (hexane–$CHCl_3$). High-resolution MS *m/z*: M^+ Calcd for $C_{12}H_{11}F_3N_2O_3$: 288.0721. Found: 288.0711. IR ($CHCl_3$): 3400, 3280, 1730, 1675 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 3.02 (2H, s), 3.74 (3H, s), 5.71 (1H, br s), 6.60—7.05 (2H, m), 7.15—7.53 (1H, m), 7.67—8.02 (2H, m).

2-(2-Methyl-1-propenyl)-4(3*H*)-quinazolinone (24)——KOH (100 mg) was added to a solution of **18** (18 mg, 0.067 mmol) in DMSO (1 ml) and H_2O (0.5 ml), and the mixture was refluxed for 2 h. The solvent was evaporated off *in vacuo* and the residue was taken up in MeOH–CH_2Cl_2 (1 : 50). The organic layer was dried over Na_2SO_4 and evaporated *in vacuo*. The residue was separated by preparative TLC (hexane–ethyl acetate, 2 : 1) to give 11 mg (82%) of **24** as colorless needles, mp 192.5—194 °C (hexane–ether). High-resolution MS *m/z*: M^+ Calcd for $C_{12}H_{12}N_2O$: 200.0949. Found: 200.0932. IR ($CHCl_3$): 3390, 1675, 1645 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.05 (3H, s), 2.33 (3H, s), 6.11 (1H, br s), 7.22—7.80 (4H, m), 8.17—8.39 (1H, m).

Photocyclization of 2-Chloro-3-[2-(indol-3-yl)ethyl]-4(3*H*)-quinazolinone (25) in Acetonitrile——1) A solution of **25**[19] (162 mg, 0.5 mmol) in CH_3CN (200 ml) was irradiated at 254 nm in an argon atmosphere for 10 min. The solvent was evaporated off *in vacuo* and the residue was taken up in 5% MeOH–CH_2Cl_2. The organic layer was washed with 5% aq. K_2CO_3 and then brine, and dried over Na_2SO_4. The residue obtained after evaporation of the solvent was chromatographed on silica gel. Elution with hexane–ethyl acetate (4 : 1) gave 26 mg (18%) of rutecarpine (**26**) as colorless needles (ethyl acetate), mp 258.5—259 °C (lit.[21] mp 258 °C). *Anal.* Calcd for $C_{18}H_{13}N_3O$: C, 75.25; H, 4.56; N, 14.62. Found: C, 75.44; H, 4.60; N, 14.41. IR (KBr): 3340, 1655, 1600 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 3.23 (2H, t, $J=6.6$ Hz), 4.58 (2H, t, $J=6.6$ Hz), 7.10—7.85 (8H, m), 8.23 (1H, br d, $J=7.5$ Hz).

Further elution with the same solvent gave 33 mg (23%) of 7,8-dehydrorutecarpine (**28**) as yellow needles (CH_2Cl_2), mp 279.5—280.5 °C (lit.[14b,22] mp 280—281 °C). High-resolution MS *m/z*: M^+ Calcd for $C_{18}H_{11}N_3O$: 285.0900. Found: 285.0900. IR (KBr): 3300, 1668 cm^{-1}. ^{1}H-NMR (DMSO-d_6) δ: 7.05—8.00 (6H, m), 7.83 (1H, d, $J=7.8$ Hz), 8.17 (1H, br d, $J=7.3$ Hz), 8.20 (1H, br d, $J=7.3$ Hz), 8.64 (1H, d, $J=7.8$ Hz), 12.69 (1H, br s).

Subsequent elution with hexane–ethyl acetate (1 : 2) gave 49 mg (32%) of 3-(2-formamidophenyl)-9-oxo-1,2,3,9-tetrahydropyrrolo[2,1-*b*]quinazoline (**27**) as colorless prisms, mp 218—219.5 °C (hexane–CH_2Cl_2). High-resolution MS *m/z*: M^+ Calcd for $C_{18}H_{15}N_3O_2$: 305.1164. Found: 305.1164. IR (KBr): 3160, 1660, 1618 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.71 (2H, q, $J=7$ Hz), 4.32 (2H, t, $J=7$ Hz), 4.77 (1H, br t, $J=7$ Hz), 7.00—7.90 (7H, m), 8.13 (1H, br d, $J=7$ Hz), 8.35 and 8.50 (1H, each br s, 1 : 3), 10.10 (1H, br s).

2) A solution of **25** (162 mg, 0.5 mmol) in CH_3CN (200 ml) was irradiated at 300 nm in an argon atmosphere for 20 min. Work-up as above gave 61 mg (42%) of **26**, 12 mg (8%) of **28**, and 56 mg (37%) of **27**.

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References and Notes

1) Part XXX of "Cycloadditions in Syntheses." Part XXIX, see, C. Kaneko, K. Uchiyama, M. Sato, and N. Katagiri, *Chem. Pharm. Bull.*, **34**, 3658 (1986).
2) C. Kaneko and T. Naito, *Heterocycles*, **19**, 2183 (1982); T. Naito and C. Kaneko, *Yuki Gosei Kagaku Kyokai Shi*, **42**, 51 (1984).
3) S. W. Baldwin, "Photochemistry," A. Padwa, Ed., Marcel Dekker, New York, 1981, Vol. 5, p. 123.
4) J. S. Swenton and J. A. Hyatt, *J. Am. Chem. Soc.*, **96**, 4879 (1974).
5) T. Nishio, *J. Org. Chem.*, **49**, 827 (1984).
6) *a*) G. R. Evanega and D. L. Fabiny, *Tetrahedron Lett.*, **1971**, 1749; *b*) T. Naito and C. Kaneko, *ibid.*, **22**, 2671 (1981).

7) C. Kaneko, N. Katagiri, K. Uchiyama, and T. Yamada, *Chem. Pharm. Bull.*, **33**, 4160 (1985).
8) H. Miki, *Chem. Pharm. Bull.*, **30**, 3121 (1982).
9) A. D. Dunn and K. L. Kinnear, *J. Heterocycl. Chem.*, **22**, 311 (1985).
10) C. Kaneko, T. Naito, and C. Miwa, *Chem. Pharm. Bull.*, **30**, 752 (1982).
11) H. Dworschak and F. Weygand, *Chem. Ber.*, **101**, 302 (1968).
12) Mukai *et al.* recently reported that 2-isoxazolines with an electron-withdrawing substituent at the 3-position gave 2+2 photocycloadducts across the C=N bond with alkenes, while those with an electron-donating substituent did not give the corresponding adducts. Y. Kawamura, T. Kumagai, and T. Mukai, *Chemistry Lett.*, **1985**, 1937 and references cited therein.
13) *a*) V. Gorbatenko, V. N. Fetynkhin, N. V. Mel'nichenko, and L. I. Samarai, *Zh. Org. Khim.*, **13**, 2320 (1977) [*Chem. Abstr.*, **88**, 74171*v*]; *b*) J. Greiner, R. Pastor, and A. Cambon, *J. Fluorine Chem.*, **18**, 185 (1981) [*Chem. Abstr.*, **95**, 169118*s*].
14) *a*) L. A. Errede, H. T. Oien, and D. R. Yarian, *J. Org. Chem.*, **42**, 12 (1977); *b*) J. Bergman and S. Bergman, *ibid.*, **50**, 1246 (1985).
15) Synthesis of 2-substituted derivatives of **1a** from **8** was reported originally by Zentmyer and Wagner; D. T. Zentmyer and E. C. Wagner, *J. Org. Chem.*, **14**, 967 (1949).
16) The presence of a trifluoromethyl group at the 2-position of an azetidine ring may also facilitate such ring opening. See, P. F. Bevilacqua, D. D. Keith, and J. L. Roberts, *J. Org. Chem.*, **49**, 1430 (1984); G. Guanti, L. Banfi, and E. Narisano, *Synthesis*, **1985**, 609.
17) T. Naito and C. Kaneko, *Chem. Pharm. Bull.*, **33**, 5328 (1985).
18) Eliminations of CF_3^- induced by base to give aromatic systems were reported previously: *a*) J. Bergman and S. Bergman, *Heterocycles*, **16**, 347 (1981); *b*) Y. Kobayashi, I. Kumadaki, S. Taguchi, and Y. Hanzawa, *Chem. Pharm. Bull.*, **20**, 1047 (1972).
19) C. Kaneko, T. Chiba, K. Kasai, and C. Miwa, *Heterocycles*, **23**, 1385 (1985).
20) An example of photo-induced homolytic C–Cl bond fission assisted by aryl participation was first reported by Grimshaw and de Silva: J. Grimshaw and A. P. de Silva, *J. Chem. Soc., Chem. Commun.*, **1980**, 302.
21) T. Kametani, C. V. Loc, T. Higa, M. Koizumi, M. Ihara, and K. Fukumoto, *J. Am. Chem. Soc.*, **99**, 2306 (1977).
22) H. Möhrle, C. Kamper, and R. Schmid, *Arch. Pharm.*, **313**, 990 (1980).