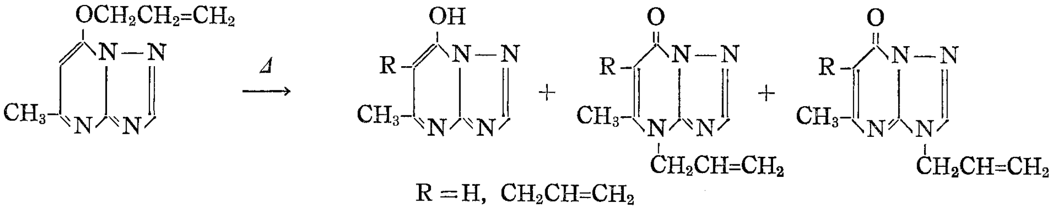
[Chem. Pharm. Bull. 12 (7) 789 ~ 796]

UDC 547.831.7.07

112. **Yasuo Makisumi**: The Claisen Rearrangement in Aromatic Heterocyclic Compounds. I. The *ortho*-Claisen Rearrangement of Allyl, Methallyl, and Crotyl Ethers of 2-Methyl-4-quinolinol.

(*Shionogi Research Laboratory, Shionogi & Co., Ltd.*[*1])

It was discovered by the author[1] that the *ortho*-Claisen rearrangement and the alkyl rearrangement[*2] occur competitively on heating 5-methyl-7-allyloxy-*s*-triazolo[1,5-*a*]-pyrimidine. Moreover, it was shown that the alkyl rearrangement proceeds by a mechanism involving ion-pair collapse and intermolecular alkylation.



In 1932, Mandel-Jones and Trikojus[2] reported the application of the Claisen rearrangement to allyl 2-methyl-4-quinolyl ether to give 2-methyl-3-allyl-4-quinolinol. While the thermal rearrangements of an alkyl group to the ring nitrogen atom in 4-quinolyl ethers have been reported,[3] the above reaction is unique in that rearrangement of an allyl group to an adjacent carbon takes place when the possibility for rearrangement to a ring nitrogen atom also exists.

The *ortho*-Claisen rearrangement is generally believed to be an intramolecular reaction proceeding through a six-membered cyclic transition state.[4] It has been demonstrated that the *ortho*-Claisen rearrangement of allyl phenyl ethers proceeds with inversion of the migrating group.[5]

Nevertheless, Salzer and co-workers[6] have reported that the thermal rearrangement of crotyl 2-methyl-7-methoxy-4-quinolyl ether affords 2-methyl-3-crotyl-7-methoxy-4-quinolinol.[*3]

The object of the present investigation is (a) to examine whether the alkyl rearrangement product 1-allyl-4(1*H*)-quinolone is produced as the minor product in addition to the *ortho*-rearrangement product obtained by Mandel-Jones and Trikojus[2] and (b) to determine whether the *ortho*-rearrangement proceeds with or without inversion of the

---

[*1] Fukushima-ku, Osaka (牧角徳夫).

[*2] This rearrangement indicates the migration of the allyl group to the ring nitrogen atoms at the 3- and 4-positions. It has been demonstrated by the authors that the same rearrangement occurs in the corresponding methyl or ethyl ether (This Bulletin, **11**, 67 (1963)).

[*3] Any evidence for the structure of this product has not been shown in the Salzer's report.[6]

1) Y. Makisumi: This Bulletin, **11**, 851 (1963).
2) B. Mandel-Jones, W.M. Trikojus: J. Am. Chem. Soc., **54**, 2570 (1932); J. Proc. Roy. Soc. New South Wales, **66**, 300 (1932).
3) M. Conrad, L. Limpach: Ber., **20**, 948 (1887); M. Conrad, Fr. Eckhardt: *Ibid.*, **22**, 73 (1889); H. Meyer: Monatsh., **27**, 259, 265 (1906).
4) D.S. Tarbell: Org. Reactions, **II**, 22 (1944); E.S. Gould: "Mechanism and Structure in Organic Chemistry," 644 (1959). Henry Holt & Co., Inc., New York.
5) For example, see *a*) L. Claisen, E. Tietze: Ber., **58**, 275 (1925); *b*) C.J. Hurd, M.A. Pollack: J. Org. Chem., **3**, 550 (1938); *c*) J.P. Ryan, P.R. O'Connor: J. Am. Chem. Soc., **74**, 5866 (1952).
6) W. Salzer, H. Timmler, H. Andersag: Chem. Ber., **81**, 12 (1948).

migrating allyl group. The allyl, methallyl, and crotyl ethers of 2-methyl-4-quinolinol were chosen for study, since rearrangement in the last case would lead to different products depending upon whether or not inversion takes place.

The allyl ether (Ia) was prepared and rearranged according to the Mandel-Jones method.[2] By treatment of the reaction mixture with benzene, the benzene-soluble product (A) of m.p. 68.5~69.5° was newly obtained in 9.5% yield along with the *ortho*-rearrangement product, 2-methyl-3-allyl-4-quinolinol[2] (IIa) (88% yield) as benzene-insoluble crystals. The compound (A) was a basic substance corresponding to an isomer of the starting material (Ia) and showed a similar curve to that of Ia in the ultraviolet spectrum. The infrared spectrum of A exhibited absorption bands due to the ether linkage at 1259, 1087, and 1037 cm^{-1} instead of those of the vinyl group and the carbonyl group which would be expected in 1-allyl-2-methyl-4(1*H*)-quinolone. From these spectra, the structure of A was assumed to be 2,4-dimethyl-2,3-dihydrofuro[3,2-*c*]quinoline (IIIa) which was supposedly formed by the intramolecular cyclization of IIa. This assignment was also supported from the nuclear magnetic resonance (NMR) spectrum as illustrated in Fig. 3.

The methallyl and crotyl ethers (Ib and Ic) of 2-methyl-4-quinolinol were prepared by the action of methallyl chloride and crotyl bromide on 2-methyl-4-quinolinol in the presence of alkali.[*4] These ethers (Ib and Ic) showed similar curves to the curve[7] of the known 4-methoxyquinaldine in the ultraviolet spectrum (see Fig. 1) and absorption bands at 900 and 964 cm^{-1}, respectively, due to the CH out-of-plane deformation vibration of $\rangle C=CH_2$ group and $-CH=CH-$ group in the infrared spectrum.[8] These spectral evidences show that Ib and Ic are the methallyl and crotyl ethers of 2-methyl-4-quinolinol, respectively.

Rearrangement of the methallyl ether (Ib) under the same conditions as for Ia produced 2-methyl-3-methallyl-4-quinolinol (IIb) and its isomeric compound (B), m.p. 96.5~97°, in yields of 67 and 31.5%, respectively. Similar rearrangement of the crotyl ether (Ic) afforded 2-methyl-3-(1-methylallyl)-4-quinolinol (IIc) and its isomeric compound (C) of m.p. 74.5~75.5° in a respective yield of 89.7 and 8.7%. The structure of the major products (IIb and IIc) in both rearrangements was confirmed by ultraviolet and infrared spectrum. Namely, IIb and IIc showed absorption curves corresponding to those of the 4(1*H*)-quinolones in the ultraviolet spectrum[*5] (see Fig. 2) and the absorption bands of the NH group and C=O group in the infrared spectrum.[*5] Moreover, the CH out-of-plane deformation vibration of the $\rangle C=CH_2$ group was shown at 894 cm^{-1} in the spectrum of IIb and that of the $-CH=CH_2$ group instead of the $-CH=CH-$ group appeared at 995 and 910 cm^{-1} in the spectrum of IIc. From the ultraviolet and infrared spectra, the structures of the minor products (B and C) in both rearrangements were respectively assumed to be 2,2,4-trimethyl- and 2,3,4-trimethyl-2,3-dihydrofuro[3,2-*c*]quinolines (IIIb and IIIc), which were probably formed by the intramolecular cyclization of IIb and IIc.

[*4] Since the 4-quinolinol derivatives show the keto-enol tautomerism, the alkylation of these compounds may afford either or both the ether and the N-alkyl compound. But, the allylation of 2-methyl-4-quinolinol under several conditions (see experimental part) always produced the ethers. The structure of these ethers was confirmed by the infrared spectrum (lack of C=O) and the ultraviolet spectrum.

[*5] Although the 4-quinolinols can exist in either the lactim or lactam form, it is generally known by ultraviolet and infrared spectral studies[7,9] that these compounds show the latter form in a neutral medium and solid state; see A. R. Katritzky: "Physical Methods in Heterocyclic Chemistry," **II**, 263 (1963), Academic Press, New York and London.

7) G. W. Ewing, E. A. Steck: J. Am. Chem. Soc., **68**, 2181 (1946).

8) L. J. Bellamy: "The Infrared Spectra of Complex Molecules," 34 (1958). John Willey & Sons, Inc., New York.

9) J. R. Price, J. B. Willis: Austral. J. Chem., **12**, 589 (1959).

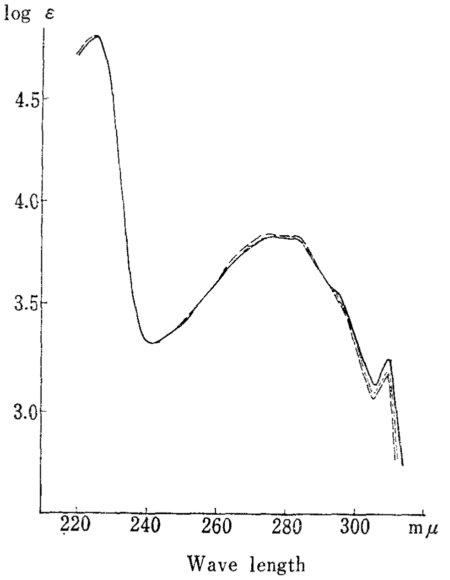


Fig. 1. Ultraviolet Absorption Spectra in Ethanol

——— Ia, ----- Ib, — — — Ic

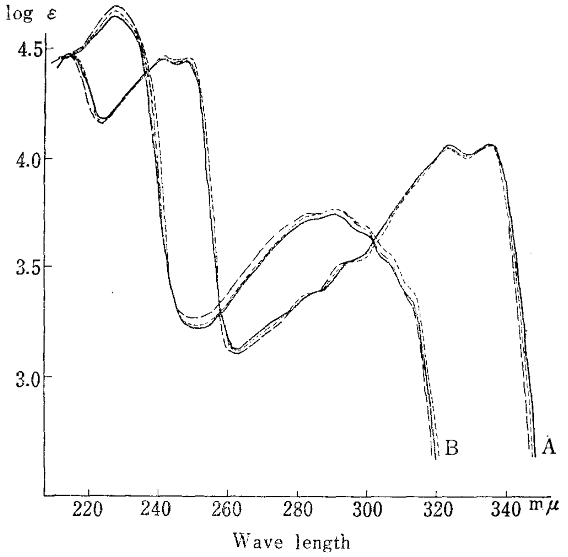


Fig. 2. Ultraviolet Absorption Spectra in Ethanol

(A: 4-Quinolinols, B: 2,3-Dihydrofuro[3,2-*c*]quinolines)

A { ——— IIa, ----- IIb, — — — IIc

B { ——— IIIa, ----- IIIb, — — — IIIc

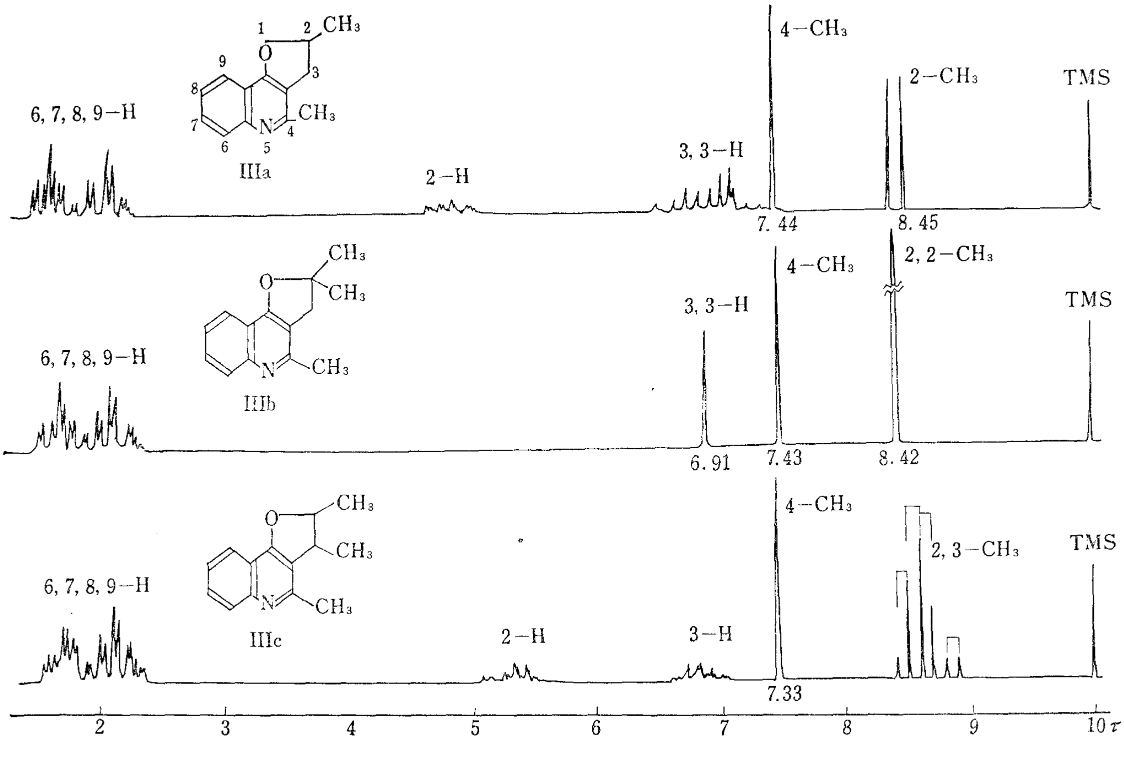


Fig. 3. Nuclear Magnetic Resonance Spectra of 2,3-Dihydrofuro[3,2-*c*]quinolines, at 60 Mc. p. s., in 10% Solution in Deuterochloroform

The NMR spectra of B and C[*6] substantiated their assigned structures as illustrated in Fig. 3.

[*6] Although the NMR spectrum of C shows the methyl signals corresponding to a mixture of *cis*- and *trans*-2,3,4-trimethyl-2,3-dihydrofuro[3,2-*c*]quinolines, separation of the *cis* and *trans* isomers has not succeeded yet.

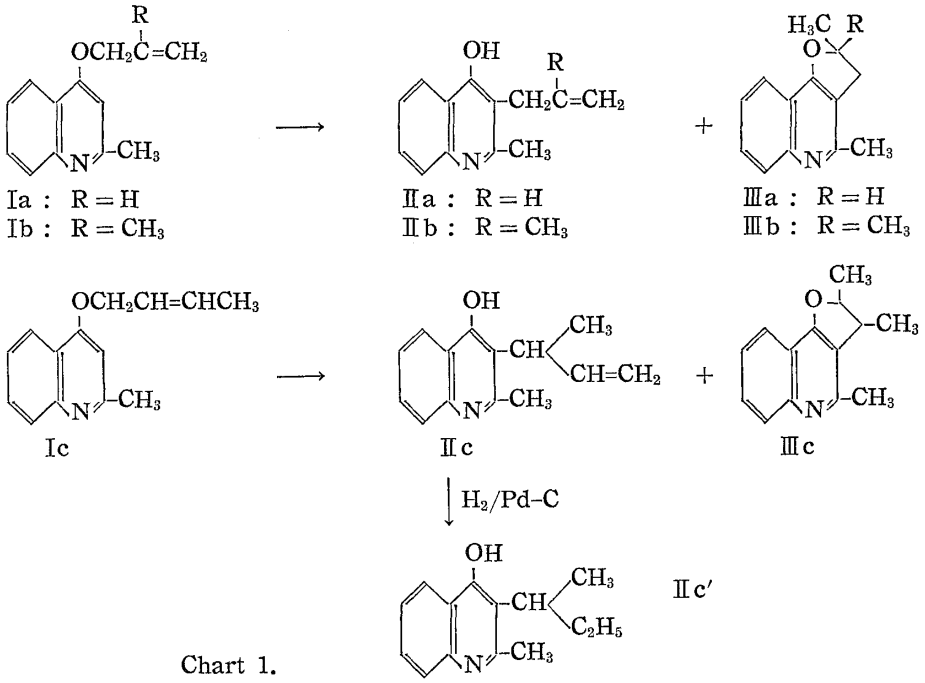


Chart 1.

In order to establish the structure of the above rearrangement products, unequivocal synthetic methods were carried out.

Conrad and Limpach[10] have reported that the 2-methyl-4-quinolinols are prepared by ring-closure of the anil compounds obtained by condensation of ethyl acetoacetate with arylamine. This is the most convenient method for the preparation of 2-methyl-4-quinolinol and its derivatives.

IIb was prepared by the ring-closure of ethyl 2-methallyl-3-anilinocrotonate (IVb) which was obtained by the condensation of ethyl 2-acetyl-4-methyl-4-pentenoate with aniline in the presence of a small amount of conc. hydrochloric acid at room temperature. A comparison of the infrared spectrum of this synthetic material with that of the major product (IIb) obtained by thermal rearrangement of Ib proved their identity. Similarly, 2-methyl-3-*sec*-butyl-4-quinolinol (IIc') was prepared by ring-closure of ethyl

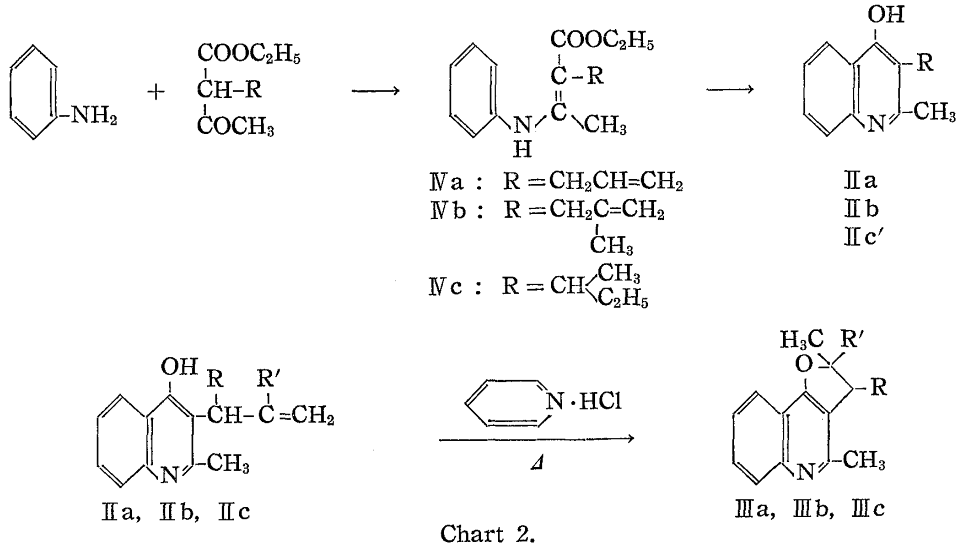


Chart 2.

---

10) M. Conrad, L. Limpach: Ber., **20**, 944, 988 (1887); L. Limpach: *Ibid.*, **64**, 969 (1931).

2-*sec*-butyl-3-anilinocrotonate (IVc) obtained by the condensation of ethyl 2-acetyl-3-methylpentanoate with aniline. This synthetic compound was also identical with the material obtained by catalytic reduction of the thermal rearrangement product (IIc). It can therefore be concluded that inversion of the migrating allyl group does take place during the *ortho*—rearrangement of allyl 2-methyl-4-quinolyl ethers.

Claisen and Eisleb[11] have reported that heating of 2-allylphenol in the presence of pyridine hydrochloride produces 2-methylcumaran by its intramolecular cyclization.

Application of this method to the *ortho*-rearrangement products (IIa, IIb, and IIc) afforded the 2,3-dihydrofuro[3,2-*c*]quinoline derivatives (IIIa, IIIb, and IIIc) in good yields and these ring-closure products were, respectively, identical with the minor products (A, B, and C) in the thermal rearrangement of the ethers (Ia, Ib, and Ic) by mixed melting point determination and infrared spectral comparison.

These thermal rearrangements of the 2-methyl-4-quinolyl ethers were investigated under several conditions and the results are listed in Table I.

Table I. Thermal Rearrangement of Allyl 2-Methyl-4-quinolyl Ethers (Ia, Ib, and Ic)

Ether	Reaction conditions$^{a)}$ (°C)	*ortho*-Rearrangement product (%)		Ring-closure product (%)		Recovered ether (%)
Ia	180	94.0	IIa	1.4	IIIa	4.0
	200	88.0		9.5		Nil
	230	80.5		18.5		〃
Ib	180	88.5	IIb	8.0	IIIb	1.5
	200	67.0		31.5		Nil
	230	40.5		59.0		〃
Ic	180	89.7	IIc	1.7	IIIc	8.3
	200	89.7		8.7		Nil
	230	76.0		21.7		〃

a) All the reactions were continued for 30 min.

The following facts were evident from the results of the above experiments. Thermal rearrangement of the allyl 2-methyl-4-quinolyl ethers produces the *ortho*-rearrangement product in a good yield by a mechanism involving the six-membered cyclic transition state with inversion of the migrating allyl group and this product is partially transformed to the 2,3-dihydrofuro[3,2-*c*]quinoline derivative by its consecutive intramolecular cyclization during the rearrangement reaction. This intramolecular cyclization reaction occurs more easily in the methallyl compound than in the allyl compound. Detectable amounts of the 1-allyl-2-methyl-4(1*H*)-quinolones resulting from alkyl rearrangement are not formed during these rearrangements.

Although it was observed that the intramolecular *ortho*-Claisen rearrangement and the intermolecular alkyl rearrangement occur competitively in the *s*-triazolo[1,5-*a*]pyrimidine system,[1] this paper showed that only the *ortho*-Claisen rearrangement and not the alkyl rearrangement occurs in the quinoline system. These different results of the thermal rearrangement in both ring systems are considered as follows:

It is evident that the *ortho*-Claisen rearrangement proceeds by a mechanism involving the intramolecular six-membered cyclic transition state, whereas the alkyl rearrangement proceeds by involving the ion-pair collapse and intermolecular alkylation, and that the rearrangement involving the intramolecular cyclic transition state proceeds by very small activation energy compared with the intermolecular ionic rearrangement.

---

[11] L. Claisen, O. Eisleb: Ann., **401**, 21 (1913).

Therefore, the former reaction generally proceeds more easily than the latter. Ionic collapse of the alkyl group in 7-alkoxy-*s*-triazolo[1,5-*a*]pyrimidines occurs very easily as shown in our previous work.*[2] On the other hand, alkyl rearrangement in the quinoline system would required relatively large activation energy as can be seen from the fact that alkyl rearrangement of the 4-alkoxyquinaldines requires heating above 300°. Thus, the different results in the thermal rearrangement of both ring systems may be readily understood on the basis of these relationships.

Experimental*[7]

4-Allyloxyquinaldine (Ia)——a) Ag salt (26.6 g.) of 2-methyl-4-quinolinol was reacted with allyl bromide (13 g.) in abs. EtOH (150 ml.) by the method of Mandel-Jones and Trikojus[2)] to give 10.3 g. of a crude oil. Distillation*[8] gave a colorless oil (Ia), b.p$_{0.18}$ 119~120° (b.p$_{1.2}$ 152~153°[2)] and b.p$_{0.5}$ 153°[6)]). UV: see Fig. 1. It gave a picrate of yellow pillars, m.p. 190~191° (from benzene). *Anal.* Calcd. for $C_{13}H_{13}ON \cdot C_6H_3O_7N_3$: C, 53.27; H, 3.77; N, 13.08. Found: C, 53.31; H, 3.85; N, 13.01.

b) A freshly prepared solution of EtONa, 0.23 g. (0.01 mole) of Na in 20 ml. of abs. EtOH, was mixed with 1.59 g. (0.01 mole) of 2-methyl-4-quinolinol. To the boiling solution was added 1.33 g. (0.011 mole) of allyl bromide over a 10 min. period. The solution was boiled for an additional 4 hr. After cooling, the precipitated NaBr was filtered off and the filtrate concentrated under reduced pressure. The residue was digested with 10% NaOH solution and extracted with Et_2O. The ethereal extract was washed with H_2O and dried over $MgSO_4$. After removal of the solvent, the oily residue (1.38 g.) was distilled to obtain a colorless oil, b.p$_{0.1}$ 115~116°, identical with Ia prepared in (a) by the IR spectrum.

4-Methallyloxyquinaldine (Ib)——A mixture of 7.95 g. of 2-methyl-4-quinolinol, 4.5 g. of methallyl chloride, and EtONa (prepared from 1.15 g. of Na) in 150 ml. of abs. EtOH was treated in the same way as described in (b) for Ia. The resulting oily residue (6.3 g.) was distilled to yield a colorless oil (Ib), b.p$_{0.18}$ 140~141°. UV: see Fig. 1. It gave a picrate of yellow needles, m.p. 182~183° from benzene. *Anal.* Calcd. for $C_{14}H_{15}ON \cdot C_6H_3O_7N_3$: C, 54.30; H, 4.10; N, 12.67. Found: C, 54.28; H, 4.32; N, 12.49.

4-Crotyloxyquinaldine (Ic)——a) A mixture of 26.6 g. of Ag salt of 2-methyl-4-quinolinol and 13.5 g. of crotyl bromide in 150 ml. of abs. EtOH was treated in the same way as described in (a) for Ia. The resulting oily residue (10.7 g.) was chromatographed on alumina to afforded 8.3 g. of white crystals. Recrystallization from petr. benzin gave colorless prisms (Ic), m.p. 79~80°. *Anal.* Calcd. for $C_{14}H_{15}ON$: C, 78.84; H, 7.09; N, 6.57. Found: C, 78.87; H, 7.16; N, 6.36. IR: $\nu_{\max}^{\text{Nujol}}$ 964 cm^{-1} (-CH=CH-). UV: see Fig. 1. NMR: 8.22 τ (-CH=CH-C$\underline{H}_3$), 5.40 τ (O-C$\underline{H}_2$-), 4.19 τ (-C$\underline{H}$=C$\underline{H}$-).

b) A mixture of 15.9 g. of 2-methyl-4-quinolinol, 13.5 g. of crotyl bromide, and EtONa (prepared from 2.3 g. of Na) in 300 ml. of abs. EtOH was treated in the same way as described in (b) for Ia. The resulting oily residue (14.43 g.) was purified by alumina chromatography to give 9.3 g. of white crystals. Recrystallization from petr. benzin afforded 6.4 g. of colorless prisms, m.p. 79~80°, identical with Ic described in (a) by mixed melting point and IR spectrum.

c) To a boiling suspension of 7.95 g. of 2-methyl-4-quinolinol and 7.5 g. of the burnt K_2CO_3 in 100 ml. of dry Me_2CO, 7.0 g. of crotyl bromide was added with stirring over a 20 min. period. The mixture was refluxed for an additional 16 hr. with stirring. After cooling, the insoluble crystals were filtered off and the filtrate was concentrated under reduced pressure. The oily residue was extracted with Et_2O and the ethereal extract was washed with 5% NaOH solution and H_2O and dried over $MgSO_4$. After removal of the solvent, the residue was subjected to alumina chromatography to yield 6.81 g. of white crystals, which were recrystallized from petr. benzin to afford 4.39 g. of colorless prisms (Ic), m.p. 79~80°, identical with Ic described above by mixed melting point and IR spectrum.

Thermal Rearrangement of the Allyl Ether (Ia)——The allyl ether was rearranged in quantities of 3 to 5 g. without solvent by heating as indicated in Table I. The reaction mixture was allowed to cool and digested with benzene. The benzene-insoluble crystals were collected by filtration to yield white crystals (IIa), m.p. 283~284°. Recrystallization from 70% EtOH gave colorless pillars, m.p. 284~285°, which were identified with an authentic sample of 2-methyl-3-allyl-4-quinolinol[2)] prepared from ethyl 2-allyl-3-anilinocrotonate (IVa) by mixed melting point and IR spectra comparison.

The filtrate (the benzene-soluble part of the reaction mixture) was passed through a column of alumina and eluted with benzene. The first fraction*[9] gave a colorless oil which was identical with

---

*[7] All melting points were determined by a micro-melting point apparatus (Yanagimoto Co., Ltd., Kyoto) and are uncorrected. NMR spectra were measured in $CDCl_3$ with a Varian A-60 spectrometer at 60 Mc. using tetramethylsilane as an internal standard.

*[8] A part of the ether undergoes rearrangement during the distillation and the rearranged products remain as undistilled residue in the distillation flask.

*[9] This fraction was not obtained in the reaction at the reaction temperature over 200°.

the starting material. The second fraction afforded white crystals, which was recrystallized from petr. benzin to give colorless needles (A), m.p. 68.5~69.5°. *Anal.* Calcd. for $C_{13}H_{13}ON$: C, 78.36; H, 6.58; N, 7.03. Found : C, 78.27; H, 6.64; N, 6.79. A was identical by direct comparison (mixed melting point and IR and UV spectra) with 2,4-dimethyl-2,3-dihydrofuro[3,2-*c*]quinoline (IIIa) derived from IIa. The results are listed in Table I.

Thermal Rearrangement of the Methallyl Ether (Ib)——The rearrangement was carried out in the same general way as that used for the allyl ether (Ia) described above. The benzene-insoluble crystals were recrystallized from 70% EtOH to yield colorless pillars (IIb), m.p. 283~284°. *Anal.* Calcd. for $C_{14}H_{15}ON$: C, 78.84; H, 7.09; N, 6.57. Found : C, 79.05; H, 7.21; N, 6.59. This compound was identical with 2-methyl-3-methallyl-4-quinolinol derived from ethyl 2-methallyl-3-anilinocrotonate (IVb) by comparison of IR and UV spectra.

The benzene-soluble part was subjected to alumina chromatography to give the recovered starting material*[9] and colorless needles (B), m.p. 96.5~97° (from petr. benzin). *Anal.* Calcd. for $C_{14}H_{15}ON$: C, 78.84; H, 7.09; N, 6.57. Found : C, 78.99; H, 7.23; N, 6.77. On admixture with 2,2,4-trimethyl-2,3-dihydrofuro[3,2-*c*]quinoline (IIIb) prepared from IIb no depression of melting point was observed and IR and UV spectra of these two substances could be superimposed.
The results are listed in Table I.

Thermal Rearrangement of the Crotyl Ether (Ic)——The rearrangement of Ic was examined in the same way as above. Recrystallization of the benzene-insoluble crystals from 70% EtOH afforded 2-methyl-3-(1-methylallyl)-4-quinolinol (IIc) as colorless scales, m.p. >300°. *Anal.* Calcd. for $C_{14}H_{15}ON$: C, 78.84; H, 7.09; N, 6.57. Found : C, 79.07; H, 7.16; N, 6.49. IR $\nu_{\max}^{\text{Nujol}}$ cm^{-1} : 3285 (NH), 1638 (lactam C=O), 995, 910 (-CH=CH$_2$). UV $\lambda_{\max}^{\text{EtOH}}$ mμ (log ε) : 213 (4.48), 241 (4.47), 248 (4.47), 281 (3.36), 292 (3.50), 321.5 (4.05), 334.5 (4.06).

The benzene-soluble part was separated by alumina chromatography to the unreacted compound*[9] and white crystals (C). C was recrystallized from petr. benzin to give colorless prisms, m.p. 74.5~75.5°. *Anal.* Calcd. for $C_{14}H_{15}ON$: C, 78.84; H, 7.09; N, 6.57. Found : C, 78.75; H, 7.18; N, 6.73. On admixture with 2,3,4-trimethyl-2,3-dihydrofuro[3,2,-*c*]quinoline (IIIc) derived from IIc no depression of melting point was observed and IR and UV spectra of these two substances were identical.
The results are listed in Table I.

2-Methyl-3-methallyl-4-quinolinol (IIb)——Ethyl 2-acetyl-4-methyl-4-pentenoate, b.p$_9$ 87~88°, was prepared by the reaction of ethyl acetoacetate and methallyl chloride in abs. EtOH in the presence of EtONa. A mixture of freshly distilled aniline (8.8 g.), this ester (17.5 g.) and few drops of conc. HCl was allowed to stand for several days at room temperature, whereby H_2O was separated. The reaction mixture was dissolved in Et_2O, the ethereal solution was washed with H_2O and dried over $MgSO_4$. After removal of the solvent, the residue was distilled to give 6.5 g. of ethyl 2-methallyl-3-anilinocrotonate (IVb) as a slightly yellow oil, b.p$_{0.2}$ 130~132°. To 17 g. of liquid paraffin preheated at 250°, 5.5 g. of IVb was added dropwise over a 10 min. period with stirring and then the mixture was heated at 260° for 15 min., during which time a large proportion of the cyclization product crystallized. After cooling to 100°, the deposited crystals were collected by filtration and washed with hot benzene and Me_2CO to remove the remained paraffin and the major portion of colored impurities. The resulting crystals were dissolved in 10% HCl, treated with charcoal and neutralized with K_2CO_3 to give 3.1 g. of IIb, m.p. 283~283.5°. Recrystallization from 70% EtOH gave colorless pillars, m.p. 283~284°. *Anal.* Calcd. for $C_{14}H_{15}ON$: C, 78.84; H, 7.09; N, 6.53. Found : C, 78.96; H, 7.22; N, 6.53. IR $\nu_{\max}^{\text{Nujol}}$ cm^{-1} : 3280 (NH), 1641 (lactam C=O), 894 (>C=CH$_2$). UV $\lambda_{\max}^{\text{EtOH}}$ mμ (log ε) : 213 (4.48), 240 (4.46), 247 (4.44), 281 (3.38), 292.5 (3.53), 321 (4.05), 335.5 (4.06).

2-Methyl-3-*sec*-butyl-4-quinolinol (IIc′)——a) From IVc : Ethyl 2-acetyl-3-methylpentanoate, b.p$_{5.5}$ 77°, was prepared from ethyl acetoacetate and *sec*-butyl bromide by the usual manner. Treatment of 30 g. of this ester and 15 g. of freshly distilled aniline by the method described above gave 9.21 g. of ethyl 2-*sec*-butyl-3-anilinocrotonate (IVc), as a slightly yellow oil, b.p$_4$ 136~138°. Cyclization of this anil compound (IVc) (8 g.) in liquid paraffin (25 g.) at 250~260° afforded 5.2 g. of crystals, which were recrystallized from EtOH to give colorless pillars (IIc′), m.p. >300°. *Anal.* Calcd. for $C_{14}H_{17}ON$: C, 78.10; H, 7.96; N, 6.51. Found : C, 77.83; H, 7.65; N, 6.62.

b) From IIc : A solution of 0.5 g. of IIc in 20 ml. of EtOH was subjected to hydrogenation over 0.2 g. of 10% Pd-C. After one molar equivalent of H_2 was absorbed, the catalyst was filtered off and the solvent was evaporated. The residue was recrystallized from EtOH to afford 0.45 g. of colorless pillars, m.p. >300°. This compound was identical with IIc′ derived from IVc by comparison of IR spectra.

2,4-Dimethyl-2,3-dihydrofuro[3,2-*c*]quinoline (IIIa)——A mixture of 0.5 g. of IIa and 0.35 g. of pyridine·HCl was heated at 220~225° for 15 min., the reaction mixture was digested with 5% NaOH, extracted with Et_2O, and the extract was washed with H_2O and dried over $MgSO_4$. Removal of the solvent afforded 0.45 g. of crystalline product, which was recrystallized from petr. benzin to give colorless pillars (IIIa), m.p. 68.5~69.5°. *Anal.* Calcd. for $C_{13}H_{13}ON$: C, 78.36; H, 6.58; N, 7.03. Found : C, 78.12; H, 6.64; N, 6.79. IR $\nu_{\text{max}}^{\text{CHCl}_3}$ cm^{-1}: 1259, 1087, 1037 (C-O-C). UV $\lambda_{\text{max}}^{\text{EtOH}}$ mμ (log ε): 214 (4.29), 229.5 (4.69), 286 (3.72), 292 (3.75), 302.5 (3.66), 310 (3.50), 316 (3.36). NMR: see Fig. 3.

2,2,4-Trimethyl-2,3-dihydrofuro[3,2-*c*]quinoline (IIIb)——A mixture of 0.4 g. of Ⅱb and 0.25 g. of pyridine·HCl was treated as above and the resulting crystalline product was recrystallized from petr. benzin to yield 0.35 g. of colorless pillars, m.p. 96~97°. *Anal.* Calcd. for $C_{14}H_{15}ON$: C, 78.84; H, 7.09; N, 6.57. Found: C, 78.99; H, 7.23; N, 6.77. IR $\nu_{\text{max}}^{\text{CHCl}_3}$ cm^{-1}: 1287, 1080, 1020 (C-O-C). UV $\lambda_{\text{max}}^{\text{EtOH}}$ mμ (log ε): 214 (4.51), 229.5 (4.73), 285 (3.76), 292 (3.80), 302.5 (3.71), 309.5 (3.59), 315.5 (3.42). NMR: see Fig. 3.

2,3,4-Trimethyl-2,3-dihydrofuro[3,2-*c*]quinoline (IIIc)——A mixture of 0.4 g. of Ⅱc and 0.25 g. of pyridine·HCl was treated as above and the resulting crystals were recrystallized from petr. benzin to give 0.41 g. of colorless prisms (Ⅲc), m.p. 74.5~75.5°. *Anal.* Calcd. for $C_{14}H_{15}ON$: C, 78.84; H, 7.09; N, 6.57. Found: C, 78.75; H, 7.18; N, 6.73. IR $\nu_{\text{max}}^{\text{CHCl}_3}$ cm^{-1}: 1253, 1090, 1020 (C-O-C). UV $\lambda_{\text{max}}^{\text{EtOH}}$ mμ (log ε): 214 (4.48), 230 (4.75), 285.5 (3.76), 291.5 (3.79), 302 (3.69), 308 (3.57), 315 (3.37). NMR: see Fig. 3.[*6]

The author expresses his gratitude to Prof. Emeritus E. Ochiai of the University of Tokyo, Dr. K. Takeda, Director of this Laboratory, and Dr. H. Kano, for their encouragement. Thanks are also due to Mr. S. Notzumoto for his technical assistance, to the members of the Physical Chemistry Department for the IR, UV, and NMR spectral measurements, and to the members of the Analysis Room for the elementary analysis.

Summary

The thermal rearrangement of allyl, methallyl, and crotyl ethers (Ia, Ib, and Ic) of 2-methyl-4-quinolinol was investigated and the *ortho*-Claisen rearrangement products (Ⅱa, Ⅱb, and Ⅱc) with the inversion of the migrating group and their consecutive intramolecular cyclization products, the 2,3-dihydro[3,2-*c*]quinoline derivatives (Ⅲa, Ⅲb, and Ⅲc) were obtained. No detectable amounts of the 1-allyl-2-methyl-4(1*H*)-quinolones resulting from the alkyl rearrangement were formed. The different results between the thermal rearrangement of the allyl 2-methyl-4-quinolyl ethers and that of the 7-allyloxy-*s*-triazolo[1,5-*a*]pyrimidines were discussed.

(Received March 13, 1964)

[Chem. Pharm. Bull.
12 (7) 796 ~ 803]

UDC 547.979.02 : 582.28

113. Kenya Kawashima,[*1] Koji Nakanishi,[*2] and Hidejiro Nishikawa[*3]: Structure of Tauranin and a Note on the "C_{16}-Acids" obtained from Di- and Triterpenoids.[*4]

(*Department of Chemistry, Tokyo Kyoiku University,*[*1] *Department of Chemistry, Tohoku University,*[*2] *and College of Agriculture and Veterinary Medicine, Nihon University*[*3])

One of us (H.N.) had isolated three crystals, designated oosporin, aurantin,[1] and tauranin[2] from the mycelium of *Oospora aurantia* (Cooke) Sacc. et Vogl., a mold that grows on seeds of *Thea japonica*. The evidence given below enables one to establish

---

[*1] Ohotsuka-kubomachi, Bunkyo-ku, Tokyo. Present address: Research Laboratories, Takeda Chemical Industries, Osaka (川島健也).

[*2] Kita-4-bancho, Sendai, Japan; to whom reprints should be requested (中西香爾).

[*3] Setagaya, Tokyo (西川英次郎).

[*4] Part of the present studies has been reported in a preliminary communication: K. Kawashima, K. Nakanishi, M. Tada, H. Nishikawa: Tetrahedron Letters, **1964**, 1227.

1) H. Nishikawa: Proc. Imp. Acad. (Tokyo), **10**, 414 (1934).

2) *Idem*: Trans. Tottori Soc. Agr. Sci., **9**, 1 (1949).