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54. **Nobusuke Kawano**: The Structure of Kayaflavone[*1]

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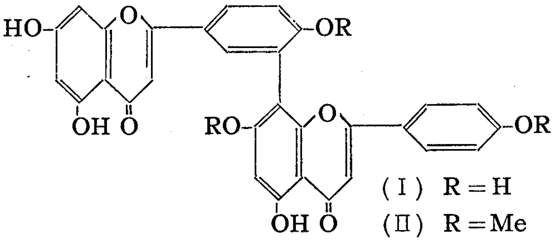
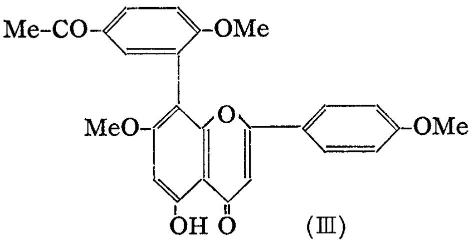
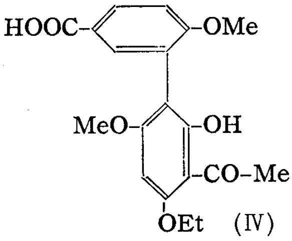
Kayaflavone, $C_{30}H_{12}O_4(OH)_3(OCH_3)_3$, was fisrt isolated by Kariyone and Sawada,[1] and found to be a bisflavonoid having a carbon skeleton which is the same as that of ginkgetin and sciadopitysin.[2] They also reported that kayaflavone gave a ketoflavone, $C_{23}H_{12}O_3(OCH_3)_3OH$, when treated with potassium hydroxide solution.[3] Recently, the skeleton of these bisflavonoids was established to have the formula (I).[4,5] Shortly after that (I) was verified through total synthesis by Nakazawa.[6] Consequently, it is obvious that the structure of kayaflavone must be represented by formula (II), because no formula except (III) can explain the characters of the ketoflavone reported by Kariyone and Sawada. The structure (II) was also confirmed by Baker and co-workers by the additional evidences of its oxidation and absorption spectra.[7]



(I) R=H
(II) R=Me



(III)



(IV)

In this laboratory, position of the methoxyl groups in these bisflavonoids was determined through barium hydroxide degradation method,[8~10] which is considered to be the most relevant experiment to distinguish the structures of these bisflavonoids. The degradation of kayaflavone triethyl ether with methanolic barium hydroxide solution was carried out in order to confirm the structure (II) for kayaflavone and a phenolic acid, 2-hydroxy-4,6-diethoxyacetophenone (IV), $C_{19}H_{20}O_7$, m.p. 287~288°, and anisic acid were obtained in a considerably good yield. This observation was entirely compatible with formula (II).

[*1] This constitutes Part XLVIII of a series entitled "Chemical Constituents of the Plants of Coniferae and Allied Orders" by T. Kariyone. Part XLVII: Yakugaku Zasshi, **81**, 236 (1961).

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1) T. Kariyone, T. Sawada: Yakugaku Zasshi, **78**, 1010 (1958).
2) T. Kariyone, N. Kawano: *Ibid.*, **76**, 448 (1956).
3) T. Kariyone, T. Sawada: *Ibid.*, **78**, 1016 (1958).
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5) W. Baker, A.C.M. Finch, W.D. Ollis, K.W. Robinson: Proc. Chem. Soc., **1959**, 91.
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8) N. Kawano: This Bulletin, **7**, 821 (1959).
9) Y. Fukui, N. Kawano: J. Am. Chem. Soc., **81**, 6331 (1959).
10) N. Kawano, M. Yamada: *Ibid.*, **82**, 1505 (1960).

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Though Kariyone and Sawada extracted plant materials with methanol in order to obtain kayaflavone,[1] satisfactory results were also obtained by extraction with trichloroethylene, which had been used in the case of sciadopitysin.[2]

Experimental[*3]

Kayaflavone Triethyl Ether——Dried leaves (2.7 kg.) of *Torreya nucifera* were boiled for 3 hr. with sufficient volume of trichloroethylene to cover all the leaves. Since kayaflavone is confined to the epidermis with wax, there is no advantage in cutting the leaves. The decoction (ca. 18 L.) filtered while warm was concentrated to about 700 cc. and left standing for 2 days. Brownish green deposit which slowly formed during that time was collected, washed with trichloroethylene, and dried (7 g.). Successive extraction of the leaves following the same procedure as above gave 0.9 g. of the same grey substance. The dried deposit was combined, dissolved in 5% NaOH solution, filtered, and acidified. The yellow precipitate obtained was washed with H_2O, dried, dissolved in hot pyridine (ca. 150 cc.), and filtered. One-half or less volume of warm EtOH was added to the filtrate without causing any immediate precipitation and allowed to stand overnight to give minute yellow crystals (3.5 g., kayaflavone). The same crystals (0.6 g.) were obtained from the mother liquor on standing with the addition of EtOH.

The ethylation of these yellow crystals (1 g.) was carried out by the same procedure as described for sciadopitysin.[8] After recrystallization from AcOH (25 cc.) with the addition of EtOH (25 cc.), the product formed yellow prisms (0.83 g.), m.p. 232~233°, which became pale yellow prisms, m.p. 236~237°, on further recrystallization from a large quantity of EtOH. This was identified with kayaflavone triethyl ether by admixture.

Barium Hydroxide Degradation of Kayaflavone Triethyl Ether——A mixture of kayaflavone triethyl ether (m.p. 232~233°, 700 mg.), $Ba(OH)_2 \cdot 8H_2O$ (140 g.), and MeOH (850 cc.) was refluxed on a steam bath for 40 hr., during which time the substance dissolved gradually. The separation of degradation products was carried out along the lines described in the preceding paper[8] and following three compounds were isolated : (i) A phenolic compound of m.p. 65~75° (130 mg.), which was very soluble in organic solvents and recrystallized from 50% EtOH to colorless needles, m.p. 81~83°. It was identified with synthetic 2-hydroxy-4,6-diethoxyacetophenone by admixture.
(ii) A phenolic acid of m.p. 275~278° (240 mg.), which was recrystallized three times from Me_2CO to minute colorless prisms, m.p. 287~288°. *Anal.* Calcd. for $C_{19}H_{20}O_7$ (IV) : C, 63.33; H, 5.59. Found : C, 63.16; H, 5.30.
(iii) An acid of m.p. 176~178° (140 mg.), which was recrystallized from H_2O to colorless needles, m.p. 180~182°, and identified with anisic acid by admixture.

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Summary

Formula (II) for the structure of kayaflavone was confirmed through the degradation of its triethyl ether with barium hydroxide, which afforded 2-hydroxy-4,6-diethoxyacetophenone, a phenolic acid (IV) of m.p. 287~288°, and anisic acid.

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[*3] All melting points are uncorrected.