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Naphthoquinone Derivatives from the Ebenaceae. IV.[1] Naphthoquinone Derivatives from *Diospyros kaki* Thunb. and *D. kaki* Thunb. var. *sylvestris* Makino

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From the roots of *Diospyros kaki* 7-methyljuglone (I), isodiospyrin (II), mamegakinone (III), plumbagin (IV), diospyrin (VIII), and a new 7-methyljuglone dimer (IX), named neodiospyrin, were isolated besides lupeol, betulinic acid, and four uncharacterized compounds (VII, X, XI, and XII). The structure of IX was elucidated. Formation of 3-methoxy-(V) and 2-methoxy-7-methyljuglone (VI) from I in the course of extraction with methanol was examined.

From the roots and woods of *D. kaki* var. *sylvestris* I, II, III, shinanolone (XIII), the binaphthyl-1,1′-quinone (XIV), and an unknown phenolic (XV) were isolated besides VII, XI, XII, lupeol, betulin, and betulinic acid.

As a part of our survays[1,3,4] on naphthoquinones and the related compounds in the genus *Diospyros* (Ebenaceae) the examinations on the constituents of the roots of the two plants were carried out.

Diospyros kaki Thunb. (Japanese name, kakinoki) is widely cultivated in Japan and the presence of triterpenoids, leucoanthocyanins, and flavonoids in calyx, fruit juice and leaves has been reported.[5-7] The roots were chipped without drying and extracted with methanol. Chromatographic separation of the extract afforded six naphthoquinones, 7-methyljuglone[4] (I), isodiospyrin[4] (II), mamegakinone[3,4] (III), plumbagin(IV), and two new quinones of mp 209—210° (V) and mp 212—213° (VI), besides two triterpenoids, lupeol and betulinic acid, and orange crystals of mp 300° (VII).

The quinone (V) has a molecular formula, $C_{12}H_{10}O_4$ (M^+ 218.057 *m/e*, calcd. 218.058). The infrared (IR) (ν_{max}^{KBr} cm^{-1}: 1655 (sh), 1638, 1599) and the ultraviolet (UV) spectra ($\lambda_{max}^{CHCl_3}$ mμ: 249, 290, 420) of V showed the characteristics of juglone derivatives. The quinone formed monomethyl ether (V′). Nuclear magnetic resonance (NMR) spectra of V and V′ clearly disclosed the presence of one each of methoxyl, hydrogen-bonded hydroxyl, aromatic methyl, and quinonoid proton and two *m*-coupled aromatic protons in V (Table I). The bathochromic shift of the UV spectrum of V in alkaline solution was compared with those of 2- and 5-hydroxynaphthoquinone derivatives (Table II) and the presence of the hydroxyl at the *peri*-position was suggested. These spectral data showed that the quinone is either 2-methoxy-7-methyljuglone (VI) or 3-methoxy-7-methyljuglone (V). Since there exist no decisive method for

1) A part of the work was reported in the preliminary communication (K. Yoshihira, M. Tezuka, C. Takahashi, and S. Natori, *Chem. Pharm. Bull.* (Tokyo), **19**, 851 (1971)). Part III: M. Kuroyanagi, K. Yoshihira, and S. Natori, *Chem. Pharm. Bull.* (Tokyo), **19**, 2314 (1971).

2) Location: *Kamiyoga-1-chome, Setagaya-ku, Tokyo.*

3) K. Yoshihira, S. Natori, and P. Kanchanapee, *Tetrahedron Letters*, **1967**, 4857; K. Yoshihira, M. Tezuka, P. Kanchanapee, and S. Natori, *Chem. Pharm. Bull.* (Tokyo), **19**, 2271 (1971).

4) K. Yoshihira, M. Tezuka, and S. Natori, *Tetrahedron Letters*, **1970**, 7; *idem*, *Chem. Pharm. Bull.* (Tokyo), **19**, 2308 (1971).

5) S. Iseda and K. Yagishita, *Yakugaku Zasshi*, **75**, 230 (1955).

6) S. Ito and Y. Oshima, *Agric. Biol. Chem.* (Tokyo), **26**, 156 (1962).

7) T. Nakaoki and N. Morita, *Yakugaku Zasshi*, **60**, 1298 (1960).

Table I. NMR Spectra of the Naphthoquinones[a)]

Compound	2- and 2′-H, CH_3, OH or OCH_3	3- and 3′-H, OH or OCH_3	5- and 5′-OH or OCH_3	6- and 6′-H or OCH_3	7- and 7′-H, CH_3 or OCH_3	8- and 8′-H
7-Methyljuglone (I)	6.98(1H) s	6.98(1H) s	11.91(1H) s	7.14(1H) d, J=1.5	2.36(3H) s	7.50(1H) d, J=1.5
Plumbagin (IV)	2.13(3H) d, J=1.5	6.66(1H) q, J=1.5	11.73(1H) s	7.07(1H)[b)] dd	7.39(1H)[b)] dd	7.47(1H) dd
3-Methoxy-7-methyljuglone (V)	6.35(1H) s	3.97(3H) s	11.80(1H) s	7.10(1H) d, J=1.5	2.46(3H) s	7.50(1H) d, J=1.5
3,5-Dimethoxy-7-methyl-naphthoquinone (V′)	6.00(1H) s	3.84(3H)[b)] s	3.96(3H)[b)] s	7.00(1H) d, J=1.5	2.45(3H) s	7.50(1H) d, J=1.5
3,5-Dihydroxy-7-methyl-naphthoquinone (V″)	6.25(1H) s	not observed[c)]	10.90(1H) s	6.98(1H) d, J=1.5	2.44(3H) s	7.44(1H) d, J=1.5
2-Methoxy-7-methyljuglone (VI)	3.84(3H) s	5.98(1H) s	11.90(1H) s	6.98(1H) d, J=1.5	2.37(3H) s	7.39(1H) d, J=1.5
2,5-Dihydroxy-7-methyl-naphthoquinone (VI″)	not observed[c)]	6.20(1H) s	12.15(1H) s	7.08(1H) d, J=1.5	2.41(1H) s	7.46(1H) d, J=1.5
5-Hydroxynaphthoquinone	6.97(1H) s	6.97(1H) s	11.94(1H) s	7.27—7.93(3H)		
3,5-Dihydroxy-naphthoquinone[c)]	6.33(1H) s	not observed	11.06(1H) s	—	—	—
2,5-Dihydroxy-naphthoquinone[c)]	not observed	6.28(1H) s	12.31(1H) s	—	—	—
3-Hydroxy-5,6,7-trimethoxy-naphthoquinone[d)]	6.27(1H) s	7.80(1H) broad	4.06(3H) s	3.98(3H)[b)] s	4.01(3H)[b)] s	7.59(1H) s
2-Hydroxy-5,6,7-trimethoxy-naphthoquinone[d)]	not observed[c,e)]	6.24(1H) s	4.05(3H) s	3.97(3H)[b)] s	4.04(3H)[b)] s	7.56(1H) s
Diospyrin dimethyl ether (VIII′)	—	6.69(1H) s	3.98(3H)[b)] s	7.05(1H) d, J=1.5	2.47(3H)[b)] s	7.52(1H) d, J=1.5
	6.81(1H) s	6.81(1H) s	3.65(3H)[b)] s	—	2.26(3H)[b)] s	7.74(1H) s
Neodispyrin dimethyl ether (IX′)	6.57(1H)[b)] d, J=10	6.71(1H)[b)] d, J=10	3.99(3H)[b)] s	7.18(1H) s	2.30(3H)[b)] s	—
	6.45(1H)[b)] s	—[b)]	3.91(3H)[b)] s	7.06(1H) d, J=1.5	2.49(3H)[b)] s	7.56(1H) d, J=1.5

a) δ in ppm from the internal standard TMS in $CDCl_3$ at 60 MHz coupling constant in Hz
b) The assignment is tentative.
c) *cf.* R.E. Moore and P.J. Scheuer, *J. Org. Chem.*, **31**, 3272 (1966)
d) S. Natori and Y. Kumada, *Chem. Pharm. Bull.* (Tokyo), **13**, 1472 (1965)
e) At −40° the signal was observed at δ 8.00.

Table II. Bathochromic Shift of UV Spectra of Hydroxynaphthoquinones in Alkaline Solution (λ_{max} mμ (log ε))

	In MeOH				In 0.05N KOH–MeOH				
Juglone (5-Hydroxy-naphthoquinone)	249 (4.06)	412 (3.46)			285 (3.90)	510 (3.20)			
7-Methyljuglone (I)	253 (4.18)	428[a)] (3.60)			224 (4.37)	286 (3.98)	518 (3.39)		
3-Methoxy-7-methyljuglone (V)	249 (3.86)	290 (4.11)	420[b)] (3.52)		287 (4.18)	510 (3.74)			
2-Methoxy-7-methyljuglone (VI)	248 (4.11)	289 (4.09)	426 (3.65)		288 (4.15)	520 (3.66)			
2-Hydroxynaphthoquinone	244 (4.20)	250 (4.24)	274 (4.21)	332 (3.41)	232 (4.17)	238 (4.10)	270 (4.36)	452 (3.43)	
3,5-Dihydroxy-7-methyl-naphthoquinone (V″)	248 (4.04)	291 (4.17)	412[a)] (3.66)		222 (4.17)	273 (4.30)	317 (4.03)	470 (4.06)	
2,5-Dihydroxy-7-methyl-naphthoquinone (VI″)	249 (4.15)	291 (4.09)	422[a)] (3.60)		229 (4.28)	265 (4.27)	298 (3.90)	390 (3.46)	480 (3.57)
3-Hydroxy-5,6,7-trimethoxy-naphthoquinone	270 (4.36)	307 (4.10)			223 (4.24)	273 (4.40)	317 (4.13)	465 (3.09)	
2-Hydroxy-5,6,7-trimethoxy-naphthoquninone	267 (4.33)	307 (4.07)			224 (4.20)	274 (4.37)	323 (4.02)	475 (3.06)	

a) in EtOH *b*) in $CHCl_3$

the distinction between the two, the synthesis of the both compounds was carried out. The Thiele acetylation of 7-methyljuglone (I), followed by hydrolysis,[8] afforded two products, mp 196—200° and mp 197—207°, and they were respectively assigned as 2-hydroxy-[9](VI″) and 3-hydroxy-7-methyljuglone (V″) by the comparison of the chemical shifts of the quinonoid protons and hydrogen-bonded hydroxyls[10] (Table I) and the bathochromic shifts of the UV in alkaline solution[11] (Table II) with those of 2-hydroxy- and 3-hydroxy-juglone and the related compounds. Methylation of VI″ and V″ with diazomethane afforded the monomethyl ethers (VI and V) and the latter was proved to be identical with the quinone, mp 209—210°.[12]

The other quinone of mp 212—213° showed the similar UV, IR, and NMR (Table I) spectra to those of V and was assumed to be the isomer of V. Actually the direct comparison with the synthetic sample of 2-methoxy-7-methyljuglone (VI) showed the identity.

Since the quinones (V and VI) were isolated from the methanol extract of the roots and there was no sign of the presence of V and VI in the chloroform extract of the same material (*vide infra*), there arised the possibility of the formation of these compounds from the congener, 7-methyljuglone (I), in the course of methanolic extraction. Thus I was kept standing in methanol solution for a long time or boiled with methanol. Actually the formation of the both quinones (V and VI), accompanied by mamegakinone (III) in the latter condition, was demonstrated. Thus the quinones (V and VI) are assumed to be artefacts formed in the course of methanolic extraction.

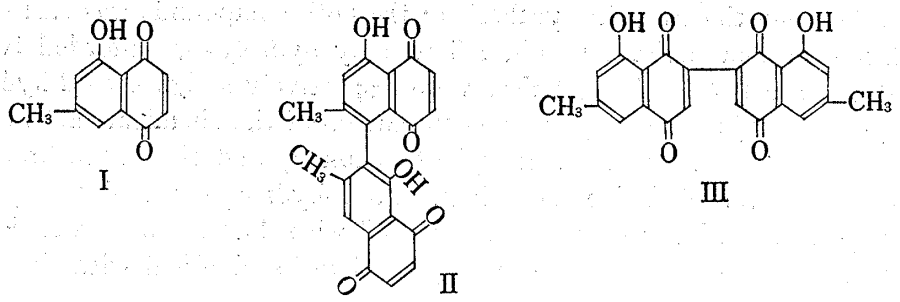
The compound (VII) is an aromatic compounds (from IR and UV) of a molecular formula, $C_{30}H_{18}O_8$ (from mass spectrum), with three aromatic methyls (from NMR). It formed two monomethyl ethers. Due to the scarcity of the sample further work has not been carried out.

The same roots were then extracted with chloroform after drying. Chromatographic separation of the extract afforded I, II, III, VII, a mixture of two quinones (VIII and IX), a colorless compound of mp 210—217° (X), a dark violet compound of mp 310—320° (XI), orange crystals of mp>310° (XII), lupeol and betulinic acid.

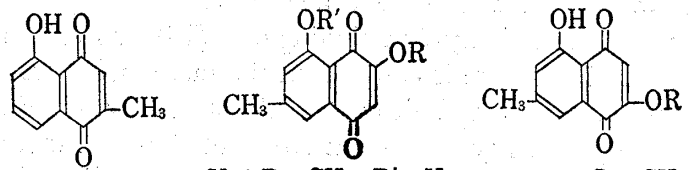
Since the separation of the mixture was unsuccessful due to the similar properties of the two compounds (VIII and IX), they were derived to the methyl ethers (VIII′ and IX′) and separated by preparative layer chromatography. One of the two (VIII′), mp 305°, was suggested to be dimethyl ether of an unsymmetrical dimer of 7-methyljuglone from the spectral data and was identified with the authentic sample of diospyrin dimethyl ether.[13–15] Diospyrin (VIII) has been isolated from *Diospyros montana* Roxb., *D. chloroxylon* Roxb., and *D. mespiliformis* Hochst. and proved to be a 6-2′ or 6-3′ dimer of 7-methyljuglone,[13–15] in which the former has been favoured.[16]

The other methyl ether (IX′), mp 245—247°, showed the molecular formula, $C_{24}H_{18}O_6$ (M^+ 402.110 *m/e*, calcd. 402.107). The UV (λ_{max}^{EtOH} mμ (log ε): 253, 281, 404 (4.36, 3.82, 3.89)),

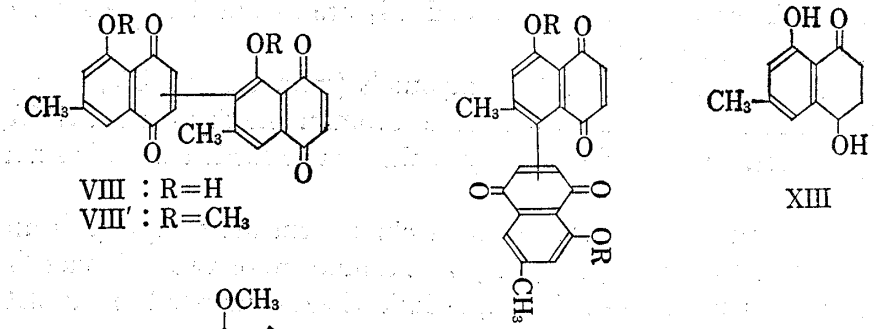
8) H. Singh, T.L. Folk, and P.J. Scheuer, *Tetrahedron*, **25**, 5301 (1969).
9) The compound was synthesized by an unequivocal method and reported to be mp 200° (decomp.) (J. E. Davies and J.C. Roberts, *J. Chem. Soc.*, **1956**, 2173). Since the authentic sample is now inavailable (Dr. J.C. Roberts, University of Nottingham, private communication), the direct comparison has not been carried out.
10) R.E. Moore and P.J. Scheuer, *J. Org. Chem.*, **31**, 3272 (1966).
11) I. Singh, R.T. Ogata, R.E. Moore, C.W.J. Chang, and P.J. Scheuer, *Tetrahedron*, **24**, 6053 (1968).
12) A compound, mp 110—111°, assigned as 3-methoxy-7-methyljuglone, was obtained as the by-product of the oxidation of 1,2,4-trimethoxy-6-methyl-8-hydroxynaphthalene (E. Widmer, J.M. Meyer, A. Walser, and H. Hardegger, *Helv. Chim. Acta*, **48**, 538 (1965) but the mp is very much different from that of our specimen.
13) A.K. Ganguly and T.R. Govindachari, *Tetrahedron Letters*, **1966**, 3373.
14) G.S. Sidhu and M. Pardhasaradhi, *Tetrahedron Letters*, **1967**, 1313, 4263.
15) A.L. Fallas and R.H. Thomson, *J. Chem. Soc.*, **1968**, 2279.
16) G.S. Sidhu and M. Pardhasaradhi, *Indian J. Chem.*, **8**, 569 (1970).



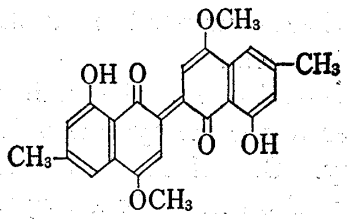
I II III



IV V : R=CH_3, R′=H; V′ : R=CH_3, R′=CH_3; V″ : R=H R′=H VI : R=CH_3 VI″ : R=H



VIII : R=H VIII′ : R=CH_3 IX : R=H IX′ : R=CH_3 XIII



XIV

IR (ν_{max}^{KBr} cm^{-1}: 1660, 1621, 1602), and NMR spectra (Table I) suggested the compound (IX′) is also the dimethyl ether of an unsymmetrical dimer of 7-methyljuglone or the isomers. In the NMR spectrum signals for three quinonoid protons were observed, two of which appeared in an AB-quartet. In the case of isodiospyrin (II) bearring a 7-methyljuglone moiety at C-8, C-2 and C-3 protons showed different chemical shifts and appeared in an AB-quartet.[4] Of the three aromatic ring protons, two showed *m*-coupling while the other appeared in rather high field, indicating the absence of the proton at *peri*-position. Thus the linking positions of the new dimer (IX) was suggested to be at 8-2′ or 8-3′ position. The alternative formulations to satisfy the NMR observations, in which the positions of the methyls, the methoxyls and the C-C likages were reversed, were excluded from the biogenetical point of view. Thus the quinone was formulated as the third unsymmetrical dimer (IX) of 7-methyljuglone from the genus *Diospyros* next to II and VIII and designated as neodiospyrin.

The compound (X) is a phenolic compound of the molecular formula $C_{22}H_{18}O_6$ (from mass spectrum) and its IR and NMR (see Experimental) suggested the presence of two 3- or 6-substituted *o*-hydroxybenzophenone groups, two aromatic methyls, and one CH_3-CH= group. The compound (XI) is a highly conjugated compound with three aromatic methyls and forms diacetate, $C_{39}H_{26}O_{12}$. The compound (XII) is again a quinonoid (from IR and UV) of a

molecular formula, $C_{31}H_{20}O_9$, with three aromatic methyls and formed triacetate and three isomeric trimethyl ethers. The structural elucidation of these compounds would need further works.

Diospyros kaki THUNB. var. *sylvestris* MAKINO (Japanese name, yamagaki) is a closely related shrub growing in southern part of this country. The dried roots were extracted with chloroform to afford 7-methyljuglone (I), isodiospyrin (II), mamegakinone (III), shinanolone (XIII), the tetralone previously isolated from *D. japonica* SIEB.,[1] a blue quinonoid of mp> 300° (XIV), the compound (VII), the compound (XI), and the compound (XII), besides three triterpenoids, lupeol, betulin, and betulinic acid. The methanolic extract of the same material gave, besides I and lupeol, colorless compound of mp 267—269° (XV). The woods of the same species were also treated in the same manner to afford I, II, and lupeol. All these compounds except XIII, XIV, XV, and betulin are common constituents with the mother species.

The compound (XIV) has a molecular formula, $C_{24}H_{20}O_6$ (M^+ 404.127 *m/e*, calcd. 404.126) and the presence of a highly conjugated system in the molecule was shown by the UV ($\lambda_{max}^{CHCl_3}$ (log ε): 293, 440, 683 (4.46, 3.73, 4.72)). The determination of the NMR was impossible due to the slight solubility and instability in the ordinary solvents. When the methylation of XIV with methyl iodide and silver oxide was attempted, demethylation and aerial oxidation probably due to the alkaline in silver oxide occurred and mamegakinone dimethyl ether[3,4] (III, OCH_3 in stead of OH) was formed. At this stage of the work a blue quinone was isolated from *D. buxifolia* and the structure as 4,4′-dimethoxy-6,6′-dimethyl-8, 8′-dihydroxy-2, 2′-binaphthyl-1,1′-quinone (XIV) was elucidated by spectral examination and synthesis.[17] The direct comparison of our compound with the authentic sample showed the identity.

The compound (XV), $C_{21}H_{16}O_6$ (from mass spectrum), showed similar spectral properties with those of the compound (X) except CH_3-CH= in X was assumed to be replaced by CH_2=. Due to the scarcity of the sample further work has not been carried out.

Experimental[18]

Extraction of the Roots of *Diospyros kaki*——The roots (1.2 kg), collected at Tokyo in November 1968, were, without drying, powdered and immersed in MeOH for 6 months and then refluxed with the same solvent. The extract was passed through a column of active charcoal and eluted successively with MeOH, acetone, and benzene. The benzene extract (8.0 g) was chromatographed on a column of silica gel (400 g) using benzene (fraction 1—7) and benzene–EtOAc (20:1) (fraction 8) as the developer. Each fraction was examined by thin-layer chromatography (TLC) and, if necessary, the column and preparative layer chromatographies were repeated. The following compounds were separated and, in the case of the known compounds, were identified with the authentic samples by TLC, IR, and mixed fusions.[19]

(i) Plumbagin (IV), mp 73°, orange-red needles from hexane (3 mg). IR ν_{max}^{KBr} cm^{-1}: 1659, 1641, 1608, 1441, 1332, 1254, 1160, 899, 892, 831, 745. NMR (Table I).

(ii) 7-Methyljuglone (I), mp 113°, dark-orange needles from hexane (12 mg).

(iii) Lupeol, colorless needles from MeOH, mp 218° (54 mg). The acetate, colorless needles of mp 208°.

(iv) Mamegakinone (III), orange crystalline powder of mp 245° (decomp.) from $CHCl_3$ (10 mg).

(v) The compound (VII), orange crystalline powder from benzene, mp>300° (60 mg). UV $\lambda_{max}^{CHCl_3}$ mμ (log ε): 262, 320, 462 (4.34, 4.20, 4.08), $\lambda_{max}^{NaOH\text{-}MeOH}$ mμ: 260, 302, 570. IR ν_{max}^{KBr} cm^{-1}: 1735, 1674, 1638, 1600. 1530, 1458, 1380, 1295, 1255, 1198, 944, 785. NMR δ (in $CDCl_3$+CF_3COOD): 2.52 (3H, s), 2.59 (3H, s), 2.83 (3H, s), 6.9—7.9 (8H). Mass Spectrum *m/e*: 506.109 (M^+, calcd. for $C_{30}H_{18}O_8$, 506.100), 360 (base peak, $C_{21}H_{12}O_6$).

(vi) Isodiospyrin (II), red needles from benzene, mp 230° (31 mg).

17) O.C. Musgrave and O. Skoyles, *Chem. Commun.*, **1970**, 1461.

18) The melting points were determined in a Yanagimoto melting point apparatus and not corrected. For column chromatography silica gel (Mallinckrodt) was used and for thin-layer chromatography (TLC) Silica gel G was used unless otherwise specified. For the acid-treatment of silica gel 3% oxalic acid solution was used.

19) The detailed physical data of the known compounds are shown in the previous papers.[1,3,4]

(vii) 3-Methoxy-7-methyljuglone (V), orange needles of mp 209—210° from benzene (19 mg). Mass Spectrum *m/e*: 218.057 (M^+, calcd. for $C_{12}H_{10}O_4$, 218.058). UV (Table II). IR ν_{max}^{KBr} cm^{-1}: 1655 (sh), 1638, 1599, 1368, 1319, 1309, 1235, 1218, 1146, 1037, 859, 812, 753. NMR (Table I). Identification with the synthetic sample was carried out by TLC, IR, and NMR.

(viii) Betulinic acid, colorless needles of mp>300° from MeOH (23 mg).

In another case the same methanolic extract, after immersion for 13 months, was treated with $CHCl_3$ and the chloroform-soluble part was separated as above. Besides the above-mentioned compounds yellow zone was observed between the fractions (vi) and (vii). The fraction was purified by preparative layer chromatography and recrystallization from benzene afforded yellow needles of mp 212—213°, which was identified with the synthetic sample of 2-methoxy-7-methyljuglone (VI) (*vide infra*) (yield, about one tenth of that of V).

The roots, collected at Tokyo in October 1969, were dried and milled. The dried roots (2.0 kg) was extracted with $CHCl_3$ for 20 days at room temperature. The extract (16 g) was applied to a silica gel column (1.6 kg). The elution with benzene and further working up as before afforded the following compounds:

(i) The compound (X), colorless crystals (90 mg) of mp 210—217° from AcOEt. UV λ_{max}^{EtOH} $m\mu$ (log ε): 246, 295, 305, 320 (4.12, 4.41, 4.34, 4.12). IR ν_{max}^{KBr} cm^{-1}: 1660, 1640, 1595, 1550, 1325, 1309, 1224, 789, 745. NMR δ (in $CDCl_3$): 1.85 (3H, d, J=7 Hz,), 2.79 (6H, s), 4.65 (1H, q, J=7 Hz), 7.0—7.5 (6H, two 1,2,3-trisubstituted benzene nucleus), 11.72 (1H, br. s), 12.45 (1H, s). Mass Spectrum *m/e*: 378.112 (M^+, calcd. for $C_{22}H_{18}O_6$, 378.110), 135 (base peak, $C_8H_7O_2$).

(ii) 7-Methyljuglone (I) (12 mg).

(iii) Lupeol (21 mg).

(iv) The compound (XI), dark violet crystals of mp 310—320° from $CHCl_3$–benzene (14 mg). UV $\lambda_{max}^{CHCl_3}$ $m\mu$: 290, 302, 544, 585. IR ν_{max}^{KBr} cm^{-1}: 1618, 1593, 1469, 1388, 1333, 1216, 1179. NMR δ (in $CDCl_3$+CF_3COOD): 2.16 (3H, br. s), 2.47 (6H, br. s).

(v) Mamegakinone (III) (10 mg).

(vi) The compound (VII) (*loc. cit.*) (14 mg).

(vii) Isodiospyrin (II) (8 mg).

(viii) A mixture of diospyrin (VIII) and neodisopyrin (IX) (27 mg) (*vide infra*).

The benzene-insoluble part was dissolved in $CHCl_3$–MeOH and absorbed on silica gel (50 g). The silica gel was applied on the top of a column of silica gel acidified with 3% CH_3COOH (250 g) and eluted with benzene and benzene–EtOAc (9:1). The following compounds were further separated.

(ix) 7-Methyljuglone (I) (6 mg).

(x) Betulinic acid (33 mg).

(xi) The compound (XII), orange needles of mp>310° from $CHCl_3$ (760 mg). UV λ_{max}^{EtOH} $m\mu$ (log ε): 214, 237, 285, 420 (4.96. 4.36, 4.43, 3.78); $\lambda_{max}^{CHCl_3}$ $m\mu$ (log ε): 296, 449 (4.59, 3.82). IR ν_{max}^{KBr} cm^{-1}: 3300, 1693, 1680, 1600, 1555, 1460, 1380, 1258, 1220, 1040, 789. NMR (in $CDCl_3$): δ 2.50 (3H, s), 2.75 (6H, s), 7.2—7.8 (8H). Mass Spectrum *m/e*: 536.111 (M^+, calcd. for $C_{31}H_{20}O_9$, 536.110), 134 (base peak, $C_8H_6O_2$).

3,5-Dimethoxy-7-methyl-1,4-naphthoquinone (V′)——3-Methoxy-7-methyljuglone (V) (20 mg) was methylated with CH_3I (3 ml) and Ag_2O (100 mg) in $CHCl_3$. Purification by preparative layer chromatography and recrystallization from benzene afforded yellow needles (13 mg) of mp 170—172°. IR ν_{max}^{KBr} cm^{-1}: 1660, 1600, 1342, 1240, 1214, 1065, 1031, 856. NMR (Table I).

Synthesis of 2-Methoxy- (VI) and 3-Methoxy-7-methyljuglone (V)——7-Methyljuglone (I) (140 mg) in Ac_2O (3.5 ml) was added with a drop of conc. H_2SO_4 and the mixture was kept standing at room temperature for 24 hr. The mixture was poured into water and the precipitates were collected, washed with water, and then boiled with 2 N HCl for 15 min. The reaction mixture was extracted with ether, the ether layer was shaken with 2 N NaOH, and the alkaline layer was, after acidification, extracted with ether. After evaporation the residue was purified by preparative layer chromatography of acid-treated silica gel. The development with benzene–EtOAc (9:1) afforded two bands; from the upper band yellow needles (39 mg) of mp 196—200° (from benzene) was obtained and identified with 2-hydroxy-7-methyljuglone (VI″), UV (Table II), IR ν_{max}^{KBr} cm^{-1}: 3320, 1638, 1616, 1380, 1353, 1281, 1241, 1190, 875, 785. NMR (Table I). The lower band gave yellow needles (26 mg) of mp 190—207° and identified with 3-hydroxy-7-methyljuglone (V″). UV (Table II). IR ν_{max}^{KBr} cm^{-1}: 3150, 1615, 1370, 1316, 1205, 1188, 965, 859. NMR (Table I).

The quinone (VI″) (30 mg) in MeOH was treated with CH_2N_2 in ether. Preparative layer chromatography and recrystallization from benzene gave yellow needles (VI) (16 mg) of mp 212°. UV (Table II). IR ν_{max}^{KBr} cm^{-1}: 2920, 1690, 1642, 1598, 1485, 1383, 1348, 1279, 1237, 1111, 1085, 862, 790. NMR (Table I).

The quinone (V″) (20 mg) was treated in the same manner and identified with the specimen obtained above.

Diospyrin Dimethyl Ether (VIII′) and Neodiospyrin Dimethyl Ether (IX′)——Attempts for the separation of the mixture of VIII and IX (fraction (viii)) were unsuccessful. The mixture (20 mg) in $CHCl_3$ (5 ml) was refluxed with CH_3I (2 ml) and Ag_2O (100 mg) for 4 hr. The reaction mixture after evaporation was applied to preparative layer chromatography using benzene–EtOAc (9:1) as the developer to afford two bands. The upper band, after recrystallization from benzene, afforded yellow needles (6 mg) of mp 305°. UV λ_{max}^{EtOH} $m\mu$ (log ε): 252, 352, 390 (4.47, 3.74, 3.68). IR ν_{max}^{KBr} cm^{-1}: 1655, 1600, 1580, 1255, 1047, 853.

NMR (Table I). The comparison with the authentic sample of diospyrin dimethyl ether[15] (VIII') showed the identity.

The lower band afforded orange-yellow needles (IX') (9 mg) of mp 245—247° from benzene. UV λ_{max}^{EtOH} mμ (log ε): 253, 281, 404 (4.36, 3.82, 3.89). IR ν_{max}^{KBr} cm^{-1}: 1660, 1621, 1602, 1463, 1330, 1305, 1256, 1213, 1112, 1050, 852. NMR (Table I). Mass Spectrum *m/e*: 402.107 (M$^+$, calcd. for $C_{24}H_{18}O_6$, 402.110), 387 ($C_{23}H_{15}O_6$), 373 ($C_{22}H_{13}O_6$), 359 ($C_{22}H_{15}O_5$), 345 ($C_{22}H_{17}O_4$), 316 ($C_{17}H_{16}O_6$), 301 ($C_{20}H_{13}O_3$), 285 ($C_{20}H_{13}O_2$), 213 ($C_{13}H_9O_3$), 201 ($C_{12}H_9O_3$).

Formation of 2-Methoxy-(VI) and 3-Methoxy-7-methyljuglone (V) from 7-Methyljuglone (I)——7-Methyljuglone (I) (10 mg) in MeOH (5 ml) was kept standing at room temperature for 1 month. The formation of V was shown by TLC. After 3 months the reaction mixture was separated by preparative layer chromatography and I (4 mg), V (3 mg), and VI (0.4 mg) were isolated and identified.

I (30 mg) in MeOH (15 ml) was refluxed for 15 hr. The dark reaction mixture was filtered off to remove dark brwon precipitates, the precipitates were extracted with $CHCl_3$ (the residue 4 mg), the filtrate and the extract were combined and evaporated. The separation by TLC of the residue afforded I (8 mg), VI (0.3 mg), V (0.8 mg), and mamegakinone (III) (0.3 mg) and they were identified by IR.

Plumbagin (IV) does not form any detectable amount of products under the same treatment.

Extraction of the Roots of *Diospyros kaki* var. *sylvestris*——The dried and chipped roots (1.8 kg) collected at Kiyosumi, Chiba, in October 1969, were extracted with boiling $CHCl_3$ for 8 hr and the extract (20 g) was chromatographed through a column of silica gel using benzene with graduent amount of EtOAc as the developer. Each fraction was checked by TLC and, if necessary, preparative layer chromatography was employed for further separation. The following compounds were separated and identified.

(i) 4,4'-Dimethoxy-6,6'-dimethyl-8,8'-dihydroxy-2,2'-binaphthyl-1,1'-quinone (XIV), blue-green needles of mp>320° (lit.[17] mp 317° (decomp.)) from $CHCl_3$ (20 mg). UV $\lambda_{max}^{CHCl_3}$ mμ (log ε): 293, 440, 683, (4.46, 3.73, 4.72). IR ν_{max}^{KBr} cm^{-1}: 1575 (br), 1484, 1396, 1334, 1256, 1234, 1210, 1184, 1155, 1040, 841. Mass Spectrum *m/e*: 404.127 (M$^+$, calcd. for $C_{24}H_{20}O_6$, 404.126), 389 ($C_{23}H_{17}O_6$), 373 ($C_{23}H_{17}O_5$), 358 ($C_{22}H_{14}O_5$).

(ii) 7-Methyljuglone (I) (420 mg).

(iii) Lupeol (200 mg).

(iv) β-Sitosterol (50 mg).

(v) The compound (XI) (10 mg).

(vi) Mamegakinone (III) (23 mg).

(vii) The compound (VII) (8 mg).

(viii) Isodiospyrin (II) (35 mg).

(ix) Butulinic acid (1.5 g).

(x) The compound (XII) (500 mg).

(xi) Betulin, colorless needles from MeOH, mp 257—259° (250 mg).

(xii) Shinanolone (XIII), colorless needles from benzene, mp 105—107° (10 mg).

The methanolic extract of the same root (300 g) was partitioned between hexane–water and the hexane layer was purified by silica gel chromatography to give three compounds:

(i) Lupeol (60 mg).

(ii) 7-Methyljuglone (I) (20 mg).

(iii) The compound (XV), mp 267—269° from benzene (27 mg). UV λ_{max}^{EtOH} mμ (log ε): 240, 286, 320 (sh) (4.31, 4.30, 4.10). IR ν_{max}^{KBr} cm^{-1}: 3030, 1648, 1599, 1560, 1350, 1300, 1228, 1118, 790. NMR δ (in $CDCl_3$): 1.58 (2H, s, exchangeable with D_2O), 2.80 (6H, s), 3.77 (2H, s), 6.9—7.5 (6H, 1,2,3-trisubstituted benzene), 11.7 (2H, s, exchangeable with D_2O). Mass Spectrum *m/e*: 364.094 (M$^+$, calcd. for $C_{21}H_{16}O_6$, 364.095), 134 (base peak, $C_8H_6O_2$).

Extraction of Woods of *D. kaki* var. *sylvestis*——The woods (1.8 kg) was extracted with boiling $CHCl_3$ and, after the evaporation of the solvent, the residue was again treated successively with benzene and $CHCl_3$. The both fractions were separated by silica gel chromatography. Lupeol (270 mg) and 7-methyljuglone (I) (200 mg) were obtained from the benzene fraction and isodiospyrin (II) (100 mg) from the $CHCl_3$ fraction.

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