Supporting Information-1 (experimental procedures and spectral data)

A Simple Biomimetic Synthesis of *dl*-Chamaejasmine, a Unique 3,3'-Biflavanone

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Experimental

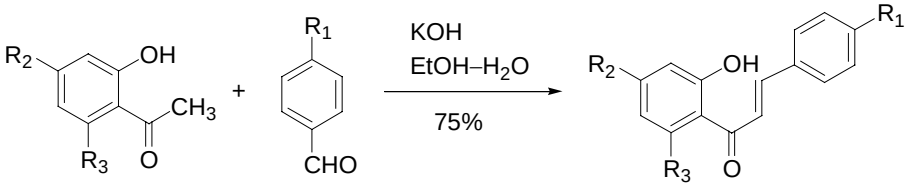
General

For product purification by flash column chromatography, silica gel (200~300 mesh) and light petroleum ether (bp. 60~90 ^{o}C) are used. All solvents were purified and dried by standard techniques, and distilled prior to use. All organic extracts were dried over Na_2SO_4, unless otherwise noted. IR spectra were recorded on a *Nicolet* FT-170SX spectrometer as liquid film. ^{1}H and ^{13}C NMR spectra were taken on a *Bruker* AM-200, AM-400 and Varian mercury 300 MHz spectrometer with TMS as an internal standard and $CDCl_3$ as solvent unless otherwise noted. EI-MS was obtained on HP-5988A GC/MS instrument. FAB-MS was measured on VG ZAB-HS instrument. HRMS were determined on a *Bruker Daltonics* APEXII 47e FT-ICR spectrometer. For liquid secondary ion mass spectrometry (LSIMS), Cs^+ ion beam (2 mA) was used at 10000 V and analytical cell vacuum was 2×10^{-9} mba. Preparative TLC purification was performed on silica gel GF_{254} TLC plates (20 cm × 20 cm, 0.5–1.0 mm). Melting points were measured on *Kofler* hot stage and are uncorrected.

All moisture-sensitive reactions were performed in flame-dried glassware under stream of nitrogen. Other commercially obtained reagents and solvents were used as received without further purification unless indicated otherwise.

Substituted 2-hydroxyl chalcones and the corresponding flavanones were synthesized according to standard literature methods,[1] or by the following general procedures, respectively.

Typical procedure for the preparation of substituted 2-hydroxyl chalcones

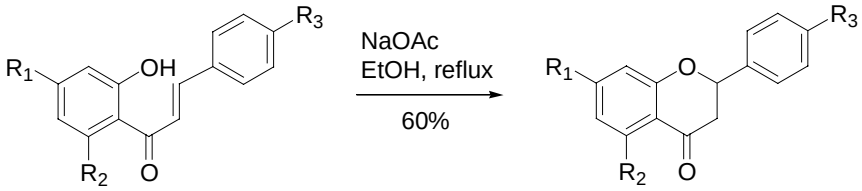


A mixture of substituted acetylphenol substrate (10 mmol) and substituted benzaldehyde derivative (12 mmol) in 20 mL of EtOH was treated with a solution mixture of KOH (ca. 10 g) in H_2O (8 mL) and EtOH (10 mL) at 0 ºC by dropwise

[1] (a) Geissman, T. A.; Clinton, R. O. *J. Am. Chem. Soc.* **1946**, *68*, 697. (b) Seshadri, T. R. In *The Chemistry of Flavonoid Compounds*, Geissman, T. A.; Ed., Chapter 6 (Interconversions of Flavonoid Compounds), p. 156–196; MacMillan: New York, 1962.

addition. The reaction mixture was stirred at rt. for 36 h, then poured onto ice-water (100 mL), acidified with conc. HCl to pH 2, the precipitates were filtered, and dried. Recrystallization of the crude product from EtOH gave the corresponding 2-hydroxy chalcone derivatives as colorless crystals in generally good yield (ca. 75%).

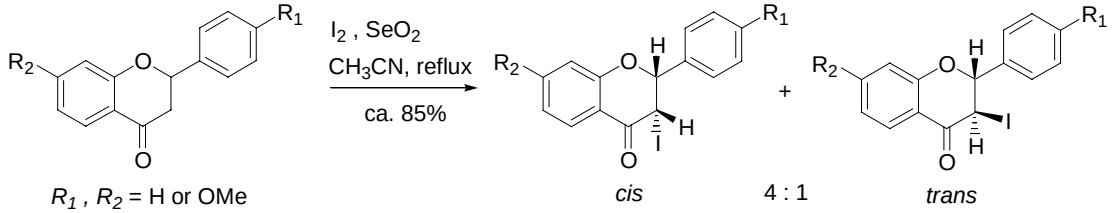
Typical procedure for the preparation of substituted flavanone derivatives from the corresponding chalcone precursors



A mixture of substituted 2-hydroxy chalcone (10 mmol) and anhydrous NaOAc (2.0 g) in 30 mL of 95% ethanol was brought to reflux for ca. 48 h. The reaction mixture was then cooled; 20 mL of water was added, and extracted with EtOAc (50 mL × 3). The organic layer was washed with water, brine and dried. Evaporation of the solvent followed by purification by silica gel chromatography gave flavanone as solids in ca. 60% yield (depending on the conversion of the starting chalcone employed).

Experimental procedures for the preparation of 3-halogenated flavanone derivatives

Method-A[2]



A representative procedure of this method is as follows:

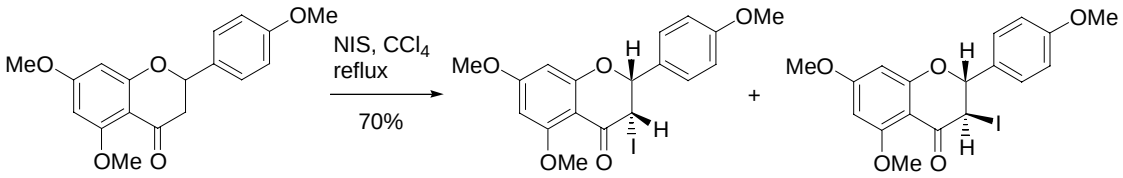
To a solution of flavanone (**5a**, R_1 = R_2 = H, 1.56 g, 6.95 mmol) in anhydrous CH_3CN (10 mL) was added portionwise I_2 (0.77 g, 3.82 mmol, 0.55 equiv) and SeO_2 (0.42 g, 3.82 mmol, 0.55 equiv) successively at room temperature. The reaction mixture was then refluxed for ca. 8 h, cooled to rt., filtered through a pad of silica gel. The filtrate was taken in water and extracted with EtOAc (30 mL × 3). The organic layers were

[2] Bekaert, A.; Barberan, O.; Gervais, M.; Brion, J. –D. *Tetrahedron Lett.* **2000**, *41*, 2903.

combined, washed with aqueous $Na_2S_2O_3$, water, brine, and dried. Evaporation of the solvent in vacuo followed by silica gel chromatographic purification (Petrol. Ether : EtOAc 50:1) gave the corresponding 3-iodoflavanone **5** (*cis* and *trans*) as light-sensitive solids: *trans* isomer (0.55 g) and *cis* isomer (2.23 g) in an overall yield of 85% in a ratio of ca. 1 : 4.

3-Iodoflavanones **7** and **8** (*cis* and *trans* isomers)[3] were prepared by the above procedure, 3-iodoflavanone **9** (*cis* and *trans* isomers) was prepared by the following Method-B.

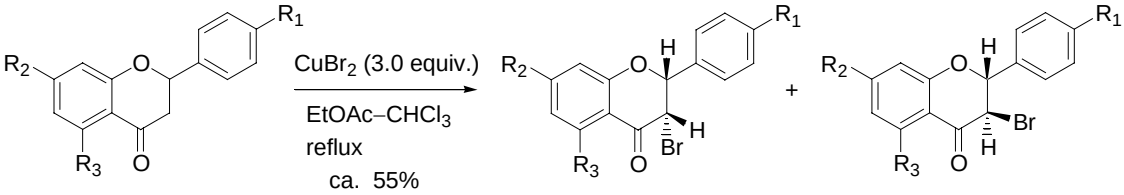
Method-B[4]



9a **9**, *cis* **9**, *trans*

A mixture of naringenin trimethyl ether (**9a**, 0.94 g, 3.0 mmol) and NIS (0.61g, 2.7 mmol, 0.9 equiv) in anhydrous CCl_4 (50 mL) was refluxed for 6 h under N_2. The resulting reaction mixture was cooled and filtered through a pad of Celite. The filtrate was diluted with EtOAc (30 mL), then washed with water, brine, and dried. Evaporation of the solvent followed by silica gel chromatography purification (Petrol. Ether : EtOAc 20:1) gave 3-iodonaringenin trimethyl ethers **9**: *trans* isomer (0.15 g) and *cis* isomer (0.77 g) as solids in an overall yield of 70% in a ratio of ca. 1: 5.

Method-C[5] (preparation of 3-bromoflavanone derivatives)

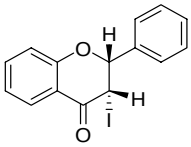


R1, *R2*, *R3* = H or OMe *cis* *trans*

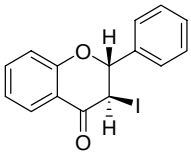
A representative procedure of this method is as follows:

[3] The isomeric ratio varies for different flavanone substrates, but *cis* isomer is predominated.
[4] Khare, V. B.; Kulkarni, A. B. *Indian J. Chem.* **1974**, *12*, 1134.
[5] Mahajan, P. Y.; Kamat, M. S.; Kulkarni, A. B. *Indian J. Chem.* **1970**, *8*, 310.

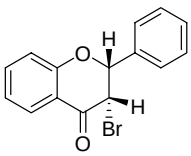
To a stirred mixture of the naringenin trimethyl ether (**9a**, $R_1 = R_2 = R_3 = OMe$, 0.315 g, 1.0 mmol) in 10 mL of ethyl acetate–chloroform (v/v, 3:2) was added cupric bromide (0.67 g, 3.0 mmol, 3 equiv) in one portion and the resulting mixture was brought to reflux for ca. 8 h, cooled to rt., filtered through a pad of Celite, and washed with ethyl acetate. The filtrate was evaporated under reduced pressure and followed by careful silica gel chromatography purification (Petrol. Ether : EtOAc 50:1) to give 3-bromonaringenin trimethyl ethers as light-sensitive solids: *trans* isomer (43 mg) and *cis* isomer (172 mg) in an overall yield of 55% in a ratio of 1 : 4.



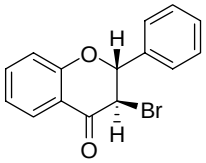
cis-3-Iodoflavanone (*cis*-**5**), mp. 122–123 ºC (EtOAc–petrol. Ether); IR (KBr, cm^{-1}) ν_{max} 2990, 1682, 1303, 1223, 757; ^{1}H-NMR (200 MHz, $CDCl_3$) δ 4.66 (1H, d, *J* = 2.0 Hz, H-3); 4.86 (1H, d, *J* = 2.0 Hz, H-2); 7.05 (2H, dd, *J* = 8.0; 1.4 Hz); 7.65 (5H, m); 8.02 (2H, dd, *J* = 8.0; 1.4 Hz) ppm; ^{13}C-NMR (50 MHz, $CDCl_3$) δ 35.4, 79.6, 118.1, 122.6, 125.5, 128.4, 128.5, 128.7, 136.6, 137.0, 160.2, 187.9 ppm. EIMS (*m/z*, %): 350 (M^+, 10), 223 ($[M–I]^+$, 100), 121(17); HRMS (SIMS) *m/z* 447.1569 ({2[M–I]+H}$^+$); 350.9868 ($[M+H]^+$, calcd for $C_{15}H_{12}O_2I$: 350.9876); 223.0750 ($[M–I]^+$).



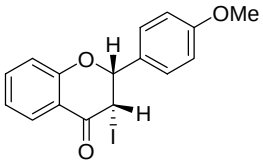
trans-3-Iodoflavanone (*trans*-**5**), mp. 102–103 ºC (EtOAc–petrol. Ether); IR (KBr, cm^{-1}) ν_{max} 2990, 1682, 1461, 1303, 1223, 757; ^{1}H-NMR (200 MHz, $CDCl_3$) δ 5.32 (1H, d, *J* = 6.8 Hz, H-3); 5.63 (1H, d, *J* = 6.8 Hz, H-2); 7.05 (2H, dd, *J* = 8.0; 1.4 Hz); 7.36 (4H, m); 7.56 (2H, dd, *J* = 8.0; 1.4 Hz); 7.91 (1H, dd, *J* = 8.0; 1.4 Hz) ppm; EIMS (*m/z*, %): 350 (M^+, 10), 223 ($[M–I]^+$, 100), 121 (17); HRMS (SIMS) *m/z* 447.1596 ({2[M–I]+H}$^+$); 350.9882 ($[M+H]^+$, calcd for $C_{15}H_{12}O_2I$: 350.9876); 223.0754 ($[M–I]^+$).



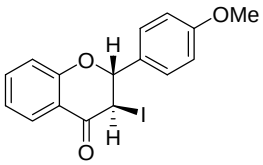
cis-3-Bromoflavanone, mp. 109–111 ºC (EtOAc–petrol. Ether); IR ((KBr, cm^{-1}) ν_{max} 2956, 1698, 1373, 1294, 1193, 848; ^{1}HNMR (200 MHz, $CDCl_3$) δ 4.57 (1H, d, *J* = 1.8 Hz, H-3); 5.43 (1H, s, br, H-2); 7.05 (2H, dd, *J* = 7.8; 1.6 Hz); 7.46 (6H, m); 7.95 (1H, dd, *J* = 8.0; 1.8 Hz) ppm; EIMS (*m/z*, %): 302 (M^+, 8), 223 ($[M–Br]^+$, 61), 121 (100).



trans-3-Bromoflavanone, mp. 90–92 ºC (EtOAc–petrol. Ether); IR ((KBr, cm^{-1}) ν_{max} 2930, 1705, 1459, 1294, 1228, 763; ^{1}H NMR (200 MHz, $CDCl_3$) δ 5.01 (1H, d, *J* = 8.6 Hz, H-3); 5.59 (1H, d, *J* = 8.6 Hz, H-2); 7.08 (2H, d, *J* = 7.8 Hz); 7.41 (5H, m); 7.57 (1H, m, H-6); 7.94 (1H, d, *J* = 7.8 Hz) ppm; ^{13}C NMR (75 MHz, $CDCl_3$) δ 51.5, 83.9, 118.0, 119.0, 122.4, 127.2, 128.1, 128.9, 129.3, 136.2, 137.0, 160.0, 185.3 ppm; HRMS (SIMS) *m/z* 447.1603 ($\{2[M–Br]+H\}^+$); 303.0020 ($[M+H]^+$, calcd for $C_{15}H_{12}O_2Br$: 303.0015); 223.0755 ($[M–Br]^+$).

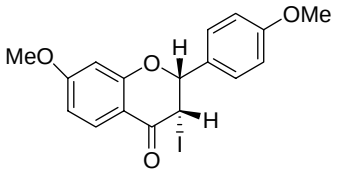


cis-4'-Methoxy-3-iodoflavanone (*cis*-**7**), mp. 121–123 ºC (EtOAc–petrol. Ether); IR ((KBr, cm^{-1}) ν_{max} 2924, 1686, 1462, 1254, 1179, 759; ^{1}H NMR (300 MHz, $CDCl_3$) δ 3.76 (3H, s, OCH_3); 4.57 (1H, s, br, H-3); 4.79 (1H, d, *J* = 2.2 Hz, H-2); 6.86 (2H, d, *J* = 8.8 Hz); 6.99 (2H, t, *J* = 8.8 Hz); 7.28 (2H, dd, *J* = 8.4; 2.0 Hz); 7.53 (1H, dd, *J* = 8.4; 2.0 Hz); 7.90 (1H, dd, *J* = 8.4; 2.0 Hz) ppm; ^{13}C NMR (75 MHz, $CDCl_3$) δ 36.1, 55.2, 79.2, 113.8, 118.0, 122.4, 126.8, 128.3, 129.0, 136.4, 160.0, 160.0, 188.0 ppm; EIMS (*m/z*, %): 380 (M^+, 19), 253 ($[M–I]^+$, 100), 121(33). HRMS (SIMS) *m/z* 507.1783 ($\{2[M–I]+H\}^+$); 380.9970 ($[M+H]^+$, calcd for $C_{16}H_{14}O_3I$: 380.9982); 253.0859 ($[M–I]^+$).

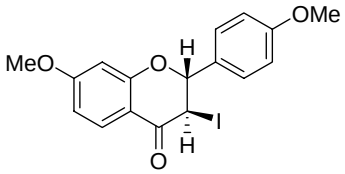


trans-4'-Methoxy 3-iodoflavanone (*trans*-**7**), mp. 106–108 ºC (EtOAc–petrol. Ether); IR ((KBr, cm^{-1}) ν_{max} 2926, 1686, 1461, 1297, 1254, 758; ^{1}H NMR (200 MHz, $CDCl_3$) δ 3.79 (3H,

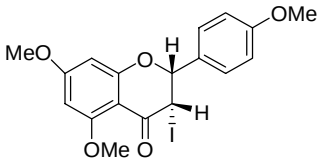
s, OCH_3); 5.31 (1H, d, *J* = 7.2 Hz, H-3); 5.58 (1H, d, *J* = 7.2 Hz, H-2); 6.88 (2H, d, *J* = 8.8 Hz); 7.06 (2H, d, *J* = 8.8 Hz); 7.42 (2H, d, *J* = 8.0 Hz); 7.92 (1H, dd, *J* = 8.0; 1.6 Hz); 7.53 (1H, m) ppm; EIMS (*m/z*, %): 380 (M^+, 19), 253 ($[M–I]^+$, 100), 121 (33).



cis-4', 7-Dimethoxy-3-iodoflavanone (*cis*-**8**), mp. 138–140 ºC (EtOAc–petrol. Ether); IR ((KBr, cm^{-1}) ν_{max} 2925, 1685, 1029, 759; ^1H NMR (300 MHz, $CDCl_3$) δ 3.54 (3H, s, OCH_3); 3.56 (3H, s, OCH_3); 4.59 (1H, s, br, H-3); 4.81 (1H, d, *J* = 2.1 Hz, H-2); 6.98 (2H, d, *J* = 8.8 Hz); 7.05 (2H, d, *J* = 8.8 Hz); 7.42 (1H, d, *J* = 2.0 Hz); 7.53 (1H, dd, *J* = 8.4; 2.0 Hz); 7.94 (1H, dd, *J* = 8.4; 2.0 Hz) ppm; ^{13}C NMR (75MHz, $CDCl_3$) δ 36.1, 55.2, 55.7, 79.7, 100.8, 111.3, 111.5, 113.8, 126.9, 129.2, 130.0, 159.7, 162.3, 166.4, 186.9 ppm; EIMS (*m/z*, %): 410 (M^+, 12), 283 ($[M–I]^+$, 100), 134 (66); HRMS (SIMS) *m/z* 567.1996 ($\{2[M–I]+H\}^+$); 411.0092 ($[M+H]^+$, calcd for $C_{17}H_{16}O_4I$: 411.0088); 283.0968 ($[M–I]^+$).

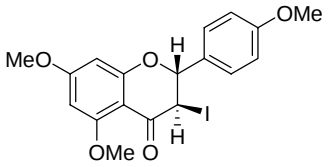


trans-4', 7-Dimethoxy-3-iodoflavanone (*trans*-**8**), mp. 154–156 ºC (EtOAc–petrol. Ether); IR ((KBr, cm^{-1}) ν_{max} 2924, 2362, 1687, 1028, 762; ^1H NMR (400 MHz, $CDCl_3$) δ 3.61 (3H, s, OCH_3); 3.62 (3H, s, OCH_3); 5.32 (1H, d, *J* = 7.4 Hz, H-3); 5,58 (1H, d, *J* = 7.4 Hz, H-2); 6.69 (2H, d, *J* = 8.8 Hz); 7.08 (2H, d, *J* = 8.8 Hz); 7.30 (1H, d, *J* = 2.0 Hz); 7.56 (1H, dd, *J* = 8.4; 2.0 Hz); 7.93 (1H, dd, *J* = 8.4; 2.0 Hz) ppm; EIMS (*m/z*, %): 410 (M^+, 12), 283 ($[M–I]^+$, 100), 134 (66).

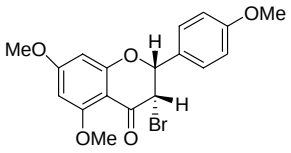


cis-3-Iodonaringenin trimethyl ether (*cis*-**6**), mp. 181–183 ºC (EtOAc–petrol. Ether); IR (KBr, cm^{-1}) ν_{max} 2936, 1669, 1608, 1253, 1159, 831; ^1H NMR (200 MHz, $CDCl_3$) δ 3.78 (3H, s, OCH_3); 3.80 (3H, s, OCH_3); 3.85 (3H, s, OCH_3); 4.46 (1H, br s, H-3); 4.61 (1H, d, *J* = 1.8

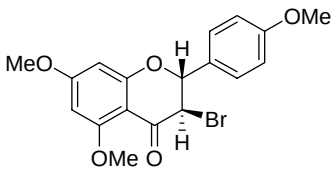
Hz, H-2); 6.09 (1H, d, *J* = 2.0 Hz); 6.20 (1H, br d, *J* = 2.0 Hz); 6.90 (2H, d, *J* = 8.8 Hz); 7.32 (2H, d, *J* = 8.8 Hz) ppm; ^{13}C NMR (50 MHz, $CDCl_3$) δ 38.5, 56.1, 56.4, 56.6, 79.7, 94.4, 94.6, 103.4, 114.6, 115.0, 127.7, 128.5, 130.1, 160.5, 164.1, 164.5, 167.2, 186.3 ppm; EIMS (*m/z*, %): 440 (M^+, 57), 313 ($[M–I]^+$, 80), 121 (100); HRMS (SIMS) *m/z* 627.2133 ({2[M–I]+H}$^+$); 441.0154 ($[M+H]^+$, calcd for $C_{18}H_{18}O_5I$: 441.0193); 313.1036($[M–I]^+$).



trans-3-Iodonaringenin trimethyl ether (*trans*-**9**), mp. 167–169 ºC (EtOAc–petrol. Ether); IR ((KBr, cm^{-1}) ν_{max} 3935, 1670, 1607, 1250, 822; ^{1}H NMR (200 MHz, $CDCl_3$) δ 3.71 (3H, s, OCH_3); 3.76 (3H, s, OCH_3); 3.79 (3H, s, OCH_3); 5.06 (1H, d, *J* = 5.8 Hz, H-3); 5.46 (1H, d, *J* = 5.8 Hz, H-2); 6.01 (1H, d, *J* = 1.8 Hz); 6.10 (1H, d, *J* = 1.8 Hz); 6.78 (2H, d, *J* = 8.6 Hz); 7.20 (2H, d, *J* = 8.6 Hz) ppm; ^{13}C NMR (50 MHz, $CDCl_3$) δ 32.0, 55.2, 55.6, 56.1, 84.0, 93.4, 93.5, 103.4, 113.8, 114.1, 126.8, 128.1, 128.6, 159.9, 162.7, 162.8, 166.6, 183.6 ppm; EIMS (*m/z*, %): 440 (M^+, 16), 313 ($[M–I]^+$, 100), 121 (90); HRMS (SIMS) *m/z* 627.1986 ({2[M–I]+H}$^+$); 441.0162 ($[M+H]^+$, calcd for $C_{18}H_{18}O_5I$: 441.0193); 313.1065 ($[M–I]^+$).

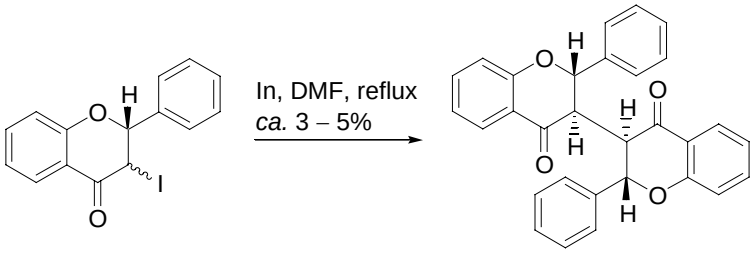


cis-3-Bromonaringenin trimethyl ether, mp. 139–141 ºC (EtOAc–petrol. Ether); IR ((KBr, cm^{-1}) ν_{max} 2938, 1675, 1609, 1253, 1217, 834; ^{1}H NMR (200 MHz, $CDCl_3$) δ 3.84 (3H, s, OCH_3); 3.86 (3H, s, OCH_3); 3.92 (3H, s, OCH_3); 4.39 (1H, d, *J* = 1.6 Hz, H-3); 5.35 (1H, s, br, H-2); 6.15 (1H, d, *J* = 2.2 Hz); 6.26 (1H, d, *J* = 2.2 Hz); 6.97 (2H, d, *J* = 8.8 Hz); 7.43 (2H, d, *J* = 8.8 Hz) ppm; ^{13}C NMR (50 MHz, $CDCl_3$) δ 53.7, 55.2, 55.6, 56.2, 78.7, 93.4, 93.7, 102.8, 113.7, 127.3, 127.7, 159.8, 163.3, 163.8, 166.4, 183.7 ppm; EIMS (*m/z*, %): 392 (M^+, 29), 313 ($[M–Br]^+$, 100). HRMS (SIMS) *m/z* 627.1821 ({2[M–Br]+H}$^+$); 393.0292 ($[M+H]^+$, calcd for $C_{18}H_{18}O_5Br$: 393.0332); 313.1053 ($[M–Br]^+$).



trans-3-Bromonaringenin trimethyl ether, mp. 177–179 ºC (EtOAc–petrol. Ether); IR (KBr, cm^{-1}) ν_{max} 2938, 1679, 1609, 1253, 1218, 821; ^1H NMR (200 MHz, $CDCl_3$) δ 3.79 (3H, s, OCH_3); 3.83 (3H, s, OCH_3); 3,88 (3H, s, OCH_3); 4.81 (1H, d, *J* = 6.8 Hz, H-3); 5.52 (1H, d, *J* = 6.8 Hz, H-2); 6.10 (1H, d, *J* = 2.2 Hz); 6.16 (1H, d, *J* = 2.2 Hz); 6.88 (2H, d, *J* = 8.6 Hz); 7.29 (2H, d, *J* = 8.6 Hz) ppm; ^{13}C NMR (50 MHz, $CDCl_3$) δ 51.8, 55.3, 55.7, 56.2, 82.9, 93.5, 103.9, 114.2, 114.4, 128.3, 160.1, 162.8, 163.0, 166.7, 182.2 ppm; EIMS (*m/z*, %): 392 (M^+, 41), 313 ($[M–Br]^+$, 100). HRMS (SIMS) *m/z* 393.0376 ($[M+H]^+$, calcd for $C_{18}H_{18}O_5Br$: 393.0332); 313.1053 ($[M–Br]^+$).

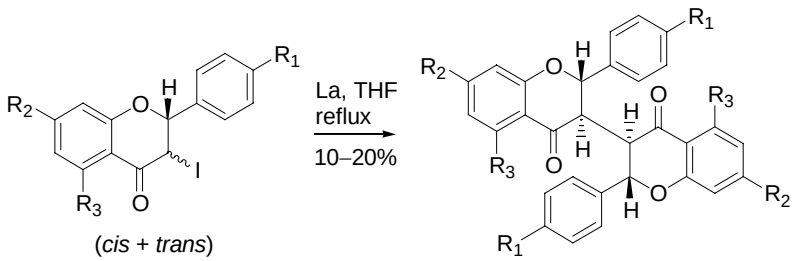
*Reductive dimerization of 3-iodoflavanone **5** to dl-**6** mediated by metallic indium*



5 (*cis* + *trans*) *dl*-**6**

A mixture of *trans*- and *cis*-3-iodoflavanones **5** (700 mg, 2.0 mmol) and indium powder (230 mg, 2.0 mmol) in dry DMF (5 mL) was brought to reflux under nitrogen for 6 h. The reaction mixture was diluted with EtOAc and filtered. The filtrate was washed successively with water, brine, and dried. Evaporation of the solvent followed by silica gel chromatography purification and further preparative TLC purification with benzene as solvent gave the dehalogenated dimer 3,3'-biflavanone *dl*-**6** (23 mg, 0.052 mmol, ca. 5%), along with the corresponding flavanone (25 mg, 5%, reductive dehalogenation), flavone (90 mg, 20%, dehydrohalogenation), and chalcone (110 mg, 25%) derivatives.

*Reductive dimerization of substituted 3-iodoflavanones **5**, **7**, **8** and **9** to the corresponding dl-3,3'-biflavanones **6**, **10**, **11** and **12** respectively induced by metallic lanthanum*



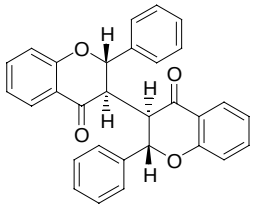
(*cis* + *trans*)

5, $R_1 = R_2 = R_3 =$ H
7, R_1 = OMe, $R_2 = R_3 =$ H
8, $R_1 = R_2$ = OMe, $R_3 =$ H
9, $R_1 = R_2 = R_3$ = OMe

dl-**6**, $R_1 = R_2 = R_3 =$ H
dl-**10**, R_1 = OMe, $R_2 = R_3 =$ H
dl-**11**, $R_1 = R_2$ = OMe, $R_3 =$ H
dl-**12**, $R_1 = R_2 = R_3$ = OMe (*ca.*10%)

Typical experimental procedure is as follows:

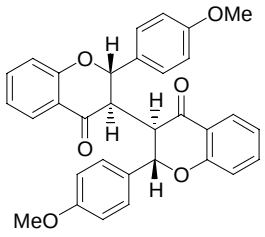
A mixture of *trans*- and *cis*-3-iodoflavanones **5** (1.05 g, 3.0 mmol) and lanthanum turnings (139 mg, 1.0 mmol) in anhydrous THF (3 mL) was refluxed under nitrogen atmosphere for 2 h. The reaction was then quenched by the addition of aqueous HCl (1 M, 3 mL) and extracted with EtOAc (30 mL × 3). The combined organic layers were washed with water, brine, and dried over $MgSO_4$. The solvent was evaporated in vacuo and the residue was purified by silica gel chromatograph (Petrol. Ether : EtOAc 40:1) to give the corresponding reductive dimerization product *dl*-**6** (135 mg, ca. 20%), along with the corresponding flavanone (35 mg, 5%), flavone (65 mg, 10%), and chalcone (164 mg, 25%) derivatives.[6]



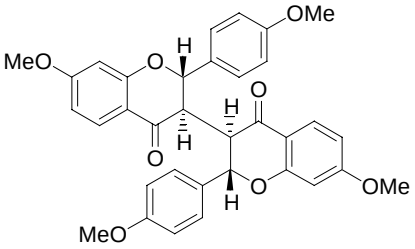
Racemate (*trans*, *trans*, *trans*)-2, 2', 3, 3'-Tetrahydro-2, 2'-bis-phenyl-(3, 3'-Bi-4H-1-benzopyran)-4, 4'-dione (*dl*-**6**), mp. 199–201 ºC (EtOAc–petrol. Ether); IR ((KBr, cm^{-1}) ν_{max} 1728, 1689, 1649, 1607, 1464, 1376, 1270; ^{1}H NMR (300 MHz, $CDCl_3$) δ 2.82 (2H, d, *J* = 12 Hz, H-3, H-3'), 6.10 (2H, d, *J* = 12 Hz, H-2, H-2'), 7.10 (4H, m), 7.30 (10H, m), 6.94 (2H, dd, *J* = 8.0; 1.4 Hz), 7.92 (2H, dd, *J* = 8.0; 1.4 Hz) ppm; ^{13}C NMR (75 MHz, $CDCl_3$) δ 51.3 (C-3, C-3'), 84.0 (C-2, C-2'), 117.9, 121.0, 121.6, 127.0, 127.5, 128.3, 128.9, 129.4, 136.2, 136.8, 161.3, 192.8 ppm; EIMS (*m/z*, %): 446 (M^+, 1), 223 ($[M/2]^+$, 100), 121 (36); FABMS

[6] An *adjusted* yield of 33% for the dimeric product *dl*-**6** was estimated based on the recovered corresponding flavanone, flavone and chalcone derivatives, which in principle could be converted readily to the starting 3-iodoflavanones.

(*m/z*): 447.2 ([M+H]$^+$), 223 ([M/2]$^+$); HRMS (SIMS) *m/z* 447.1594 ([M+H]$^+$), calcd for $C_{30}H_{23}O_4$: 447.1591; 469.1432 ([M+Na]$^+$), calcd for $C_{30}H_{22}O_4Na$: 469.1410; 223.0755 ([M/2]$^+$).



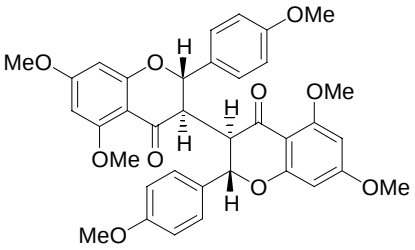
Racemate (*trans*, *trans*, *trans*)-2, 2', 3, 3'-Tetrahydro-2, 2'-bis(4-methoxyphenyl)-[3, 3'-Bi-4H-1-benzopyran]-4, 4'-dione (*dl*-**10**), yield 18% (30%), [7] mp. 176–178 ºC (EtOAc–petrol. Ether); IR ((KBr, cm^{-1}) ν_{max} 1725, 1681, 1606, 1513, 1465, 1253; ^{1}H NMR (300 MHz, $CDCl_3$) δ 2.83 (2H, d, *J* = 12 Hz, H-3, H-3'), 3.85 (6H, s, OMe), 6.06 (2H, d, *J* = 12 Hz, H-2, H-2'), 6.76 (4H, d, *J* = 9.3 Hz), 6.93 (2H, d, *J* = 8.1 Hz), 7.03 (2H, dd, *J* = 7.5; 1.8 Hz), 7.07 (4H, d, *J* = 9.3 Hz), 7.46 (2H, dd, *J* = 7.5; 1.8 Hz), 7.90 (2H, d, *J* = 7.5 Hz) ppm; ^{13}C NMR (75 MHz, $CDCl_3$) δ 51.4 (C-3, C-3'), 55.4, 83.8 (C-2, C-2'), 114.2, 117.8, 121.0, 121.5, 127.4, 129.1, 129.2, 136.1, 160.3, 161.4, 193.0; EIMS (*m/z*, %): 506 (M$^+$), 385, 372, 253 ([M/2]$^+$, 100); HRMS (ESI, *m/z*): 507.1805 ([M+H]$^+$, calcd for $C_{32}H_{27}O_6$: 507.1802); 253.0859 ([M/2]$^+$).



Racemate (*trans*, *trans*, *trans*)-2, 2', 3, 3'-Tetrahydro-7, 7'-dimethoxy-2, 2'-bis(4-methoxyphenyl)-[3, 3'-Bi-4H-1-benzopyran]-4, 4'-dione (*dl*-**11**), yield 15% (25%),[7] mp. 165–167 ºC (EtOAc–petrol. Ether); IR ((KBr, cm^{-1}) ν_{max} 1727, 1671, 1607, 1513, 1247, 1160; ^{1}H NMR (300 MHz, $CDCl_3$) δ 2.75 (2H, d, *J* = 12 Hz, H-3, H-3'), 3.76 (6H, s, OMe), 3.83 (6H, s, OMe), 6.08 (2H, d, *J* = 12 Hz, H-2, H-2'), 6.38 (2H, s), 6.58 (2H, d, *J* = 8.7 Hz), 6.87 (4H, d, *J* = 8.1 Hz), 7.08 (4H, d, *J* = 8.7 Hz), 7.84 (2H, d, *J* = 9.0 Hz) ppm; ^{13}C NMR (75 MHz, $CDCl_3$) δ 50.9 (C-3, C-3'), 55.4, 55.6, 84.1 (C-2, C-2'), 100.6, 110.1, 114.2, 115.0, 128.3,

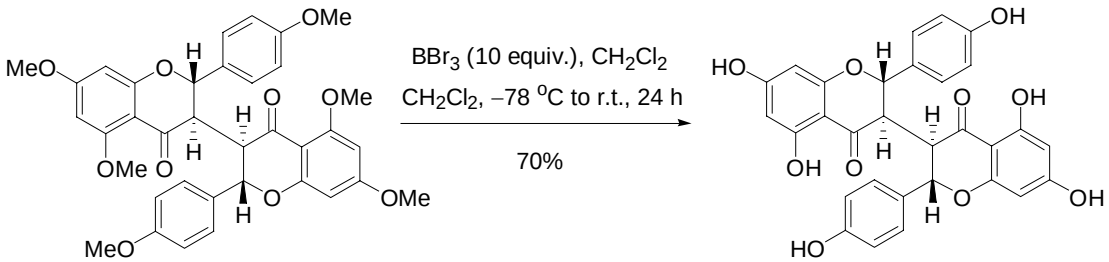
[7] Yield in parentheses refers to the *adjusted* yield (ref. 6).

129.1, 129.2, 160.3, 163.3, 166.1, 191.6 ppm; FABMS (*m/z*): 589.4 ($[M+Na]^+$), 567.4 ($[M+H]^+$), 417.3, 283.2 ($[M/2]^+$); HRMS (SIMS, *m/z*): 567.2021 ($[M+H]^+$, calcd for $C_{34}H_{31}O_8$: 567.2013); 283.0966 ($[M/2]^+$).



Racemate (*trans*, *trans*, *trans*)-2, 2', 3, 3'-Tetrahydro-5, 5', 7, 7'-tetramethoxy-2, 2'-bis(4-methoxyphenyl)-[3, 3'-Bi-4H-1-benzopyran]-4, 4'-dione (*dl*-chamaejasmine hexamethyl ether **12**), yield 10% (17%),[7] mp. 185–187 ºC (EtOAc–petrol. Ether);[8] IR ((KBr, cm^{-1}) ν_{max} 1665, 1607, 1573, 1515, 1461, 1217; ^{1}H NMR (300 MHz, $CDCl_3$) δ 2.68 (2H, d, *J* = 12.3 Hz, H-3, H-3'), 3.76 (6H, s, OMe), 3.85 (6H, s, OMe), 3.88 (6H, s, OMe), 6.03 (2H, d, *J* = 2.4 Hz), 6.04 (2H, d, *J* = 12.3 Hz, H-2, H-2'), 6.07 (2H, d, *J* = 2.4 Hz), 6.86 (4H, d, *J* = 9.0 Hz), 7.10 (4H, d, *J* = 8.7 Hz) ppm; ^{13}C NMR (75 MHz, $CDCl_3$) δ 52.1 (C-3, C-3'), 55.3, 55.5, 56.1, 83.3 (C-2, C-2'), 93.1, 93.2, 106.3, 113.9, 129.3, 129.5, 160.0, 162.5, 164.7, 165.6, 190.1 ppm; FABMS (*m/z*): 627.2 ($[M+H]^+$), 447.2, 312.9 ($[M/2]^+$); HRMS (SIMS, *m/z*): 627.2215 ($[M+H]^+$, calcd for $C_{36}H_{35}O_{10}$: 627.2224); 313.1060 ($[M/2]^+$).

*Global demethylation of dl-**12** to dl-chamaejasmine (**1**) and partial demethylation to dl-**13***



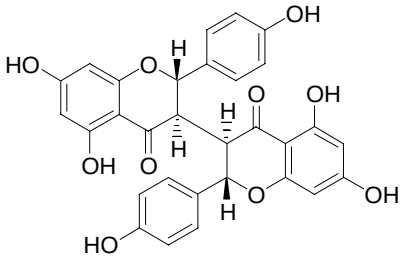
dl-**12** *dl*-**1**

To a stirred solution of BBr_3 (0.5 mL, large excess) in 5 mL of freshly distilled CH_2Cl_2 at –78 ºC was added dropwise a solution of *dl*-**12** (30 mg, 0.048 mmol) in 3 ml of CH_2Cl_2. The resulting reaction mixture was allowed to warm up to room temperature gradually and stirred

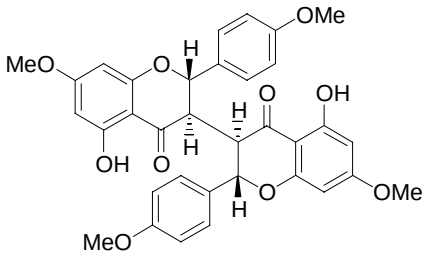
[8] Nyandat, E.; Hassanali, A.; De Vicente, Y.; Multrari, G.; Galeffi, C. *Phytochemistry* **1990**, *29*, 2361. A melting point of 117–119 ºC (from *n*-hexane) was recorded for the partial racemate (enantiomeric ratio ca. 2:1) of (+)-(2*S*, 3*R*)-chamaejasmine hexamethyl ether therein.

for 24 h. The reaction was carefully quenched with 2 mL cold water and stirred vigorously for 2 h, extracted with EtOAc (20 mL x 6) and dried over $MgSO_4$. Evaporation of the solvent in vacuo, the residue was purified by flash chromatograph on silica gel eluting with acetone to give *dl*-chamaejasmine (**1**) as colorless solids (18 mg, yield 70%).

Partially demethylated product *dl*-**13** was obtained (ca. 30%) when the reaction was quenched carefully at –78 ºC after 1 h of addition of BBr_3 and usual extractive workup and chromatographic purification on silica gel. The unreacted hexamethyl ether *dl*-**12** (ca. 70%) was fully recovered.



Racemate (*trans*, *trans*, *trans*)-2, 2', 3, 3'-Tetrahydro-5, 5', 7, 7'-tetrahydroxy-2, 2'-bis (4-hydroxyphenyl)-[3, 3'-Bi-4H-1-benzopyran]-4, 4'-dione (*dl*-chamaejasmine, **1**), mp. 293–295 ºC (acetone);[9] IR (KBr, cm^{-1}) ν_{max} 3198, 1688, 1636, 1515, 1643, 1158; ^1H NMR (300 MHz, d_6-acetone) δ 2.94 (d, 2 H, J = 12.3 Hz, H-3, H-3'), 5.86 (d, 2 H, J = 12.3 Hz, H-2, H-2'), 5.88 (s, 2 H), 5.96 (2 H, d, J = 1.8 Hz), 6.86 (4 H, d, J = 8.4 Hz), 7.02 (4 H, d, J = 8.4 Hz), 7.36 (s, OH), 8.70 (s, OH), 9.72 (s, OH), 11.92 (s, 2 H) ppm; ^{13}C NMR (75 MHz, d_6-acetone) δ 49.9 (C-3, C-3'), 83.9 (C-2, C-2'), 95.2, 96.4, 102.6, 115.7, 127.8, 129.6, 158.6, 163.4, 164.7, 166.9, 197.2 ppm; FABMS (*m/z*): 543.2 ($[M+H]^+$), 271.1 ($[M/2]^+$). HRMS (SIMS) *m/z* observed 543.1280 for $[M+H]^+$, calcd 543.1286 for $C_{30}H_{23}O_{10}$; observed 271.0619 for $[M/2]^+$, calcd 271.0603 for $C_{15}H_{11}O_5$.



[9] Huang, W. –K.; Zhang, Z. –J. *Kexue Tongbao* **1979**, *24*, 24; *Chem. Abstr.* **1979**, *90*, 135086m. A melting point of 309 ºC (uncorrected, crystallized from ethanol) was recorded therein.

Racemate (*trans*, *trans*, *trans*)-2, 2', 3, 3'-Tetrahydro-5, 5'-dihydroxy-7, 7'-dimethoxy-2, 2'-bis(4-methoxyphenyl)-[3, 3'-Bi-4H-1-benzopyran]-4, 4'-dione (*dl*-**13**), mp. 118–120 ºC (as trihydrate from petrol. Ether–acetone); IR (KBr, cm^{-1}) ν_{max} 3118, 1700, 1654, 1574, 1514, 1251, 1155; ^{1}H NMR (300 MHz, $CDCl_3$) δ 2.82 (d, 2 H, *J* = 12 Hz, H-3, H-3'), 3.77 (s, 6 H, OMe), 3.85 (s, 6 H, OMe), 5.93 (d, 2 H, *J* = 12 Hz, H-2, H-2'), 5.94 (d, 2 H, *J* = 1.8 Hz), 6.06 (d, 2 H, *J* = 1.8 Hz), 6.87 (d, 4 H, *J* = 8.4 Hz), 7.04 (d, 4 H, *J* = 8.4 Hz); 11.87 (s, 2 H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 49.7 (C-3, C-3'), 55.4, 55.7, 83.5 (C-2, C-2'), 94.0, 95.2, 103.1, 114.3, 124.5, 129.2, 160.4, 162.6, 164.1, 167.9, 196.6 ppm; FABMS (*m/z*): 621.4 ($[M+Na]^+$), 599.3 ($[M+H]^+$), 299.1 ($[M/2]^+$). HRMS (SIMS) *m/z* observed 599.1914 for $[M+H]^+$, calcd 599.1912 for $C_{34}H_{31}O_{10}$; observed 299.0959 for $[M/2]^+$, calcd 299.0917 for $C_{17}H_{15}O_5$.

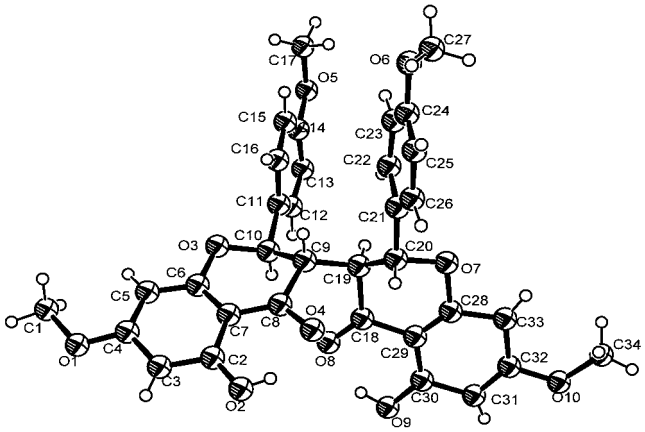
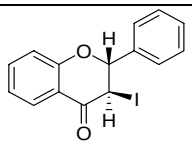
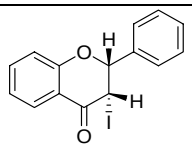
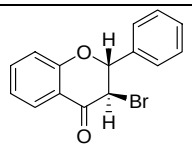
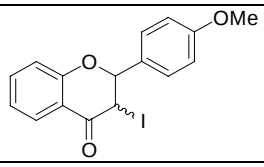
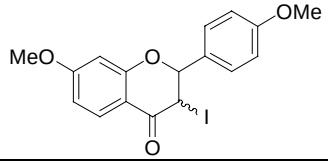
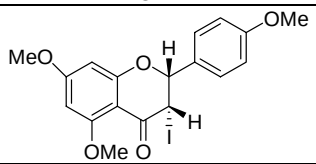
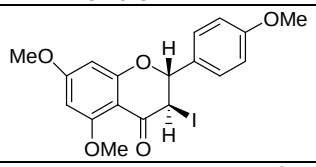
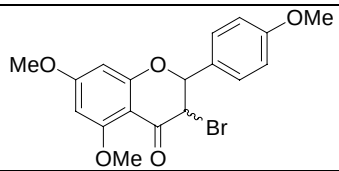
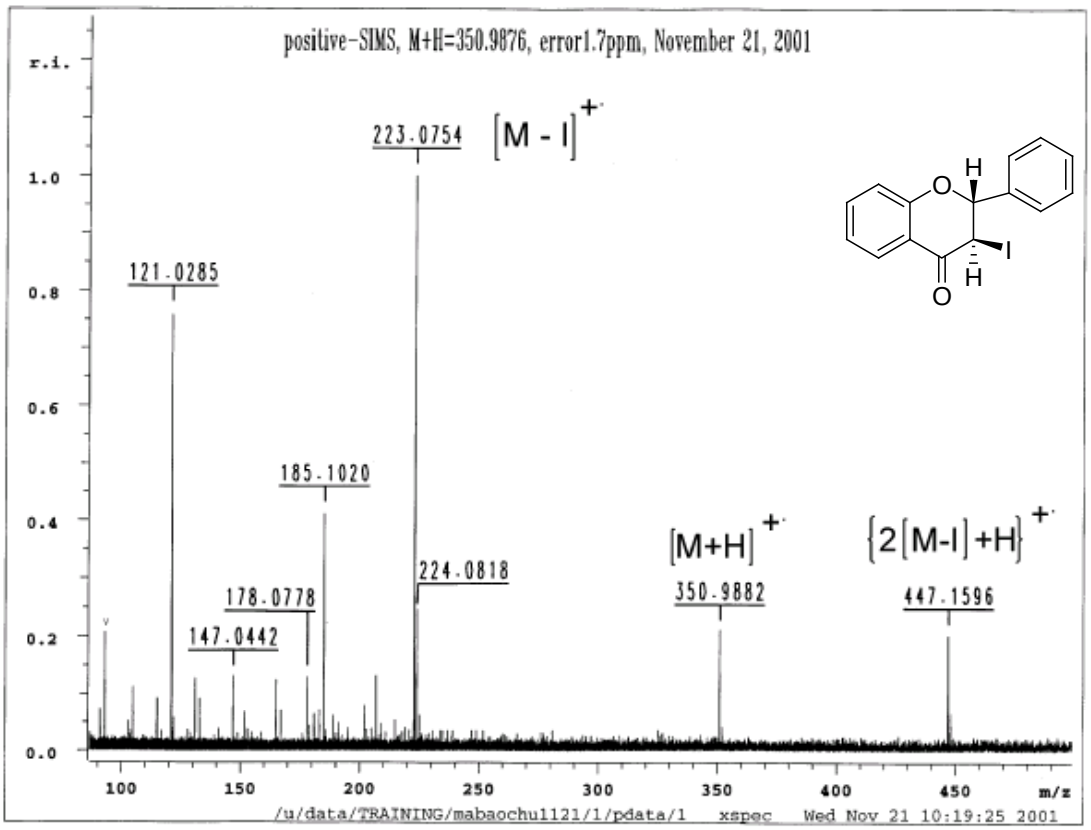


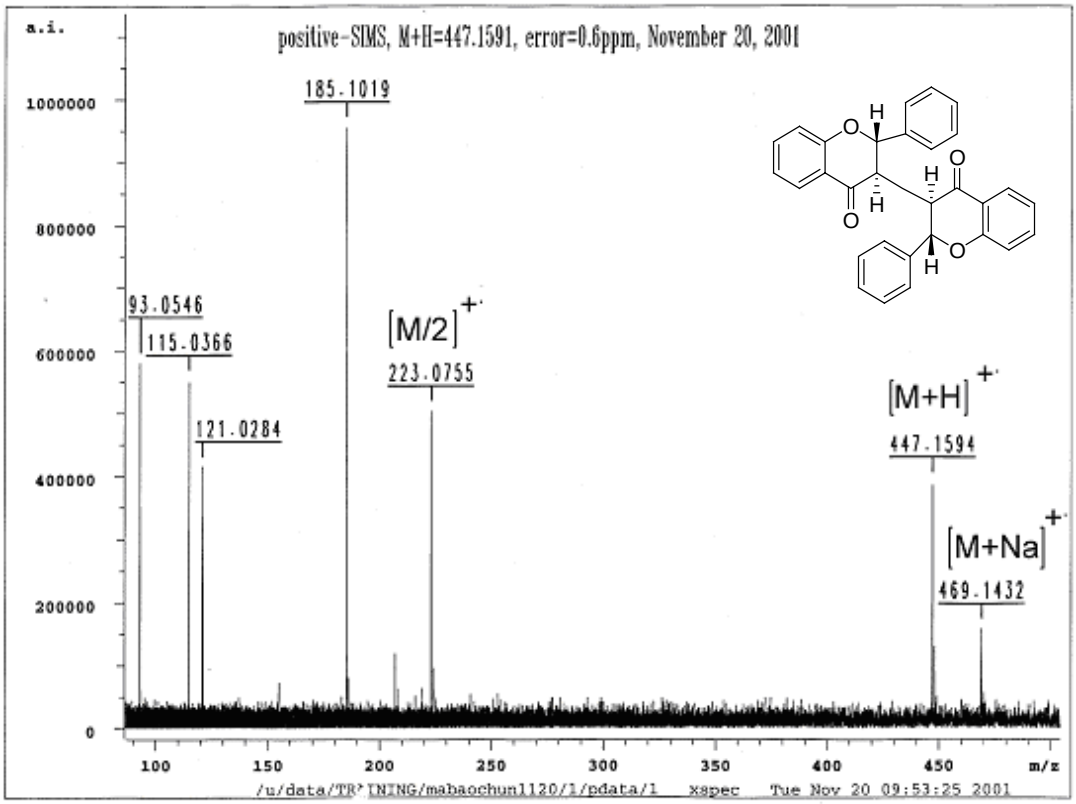
Table 1. X-ray crystallographic data of *dl*-**13**

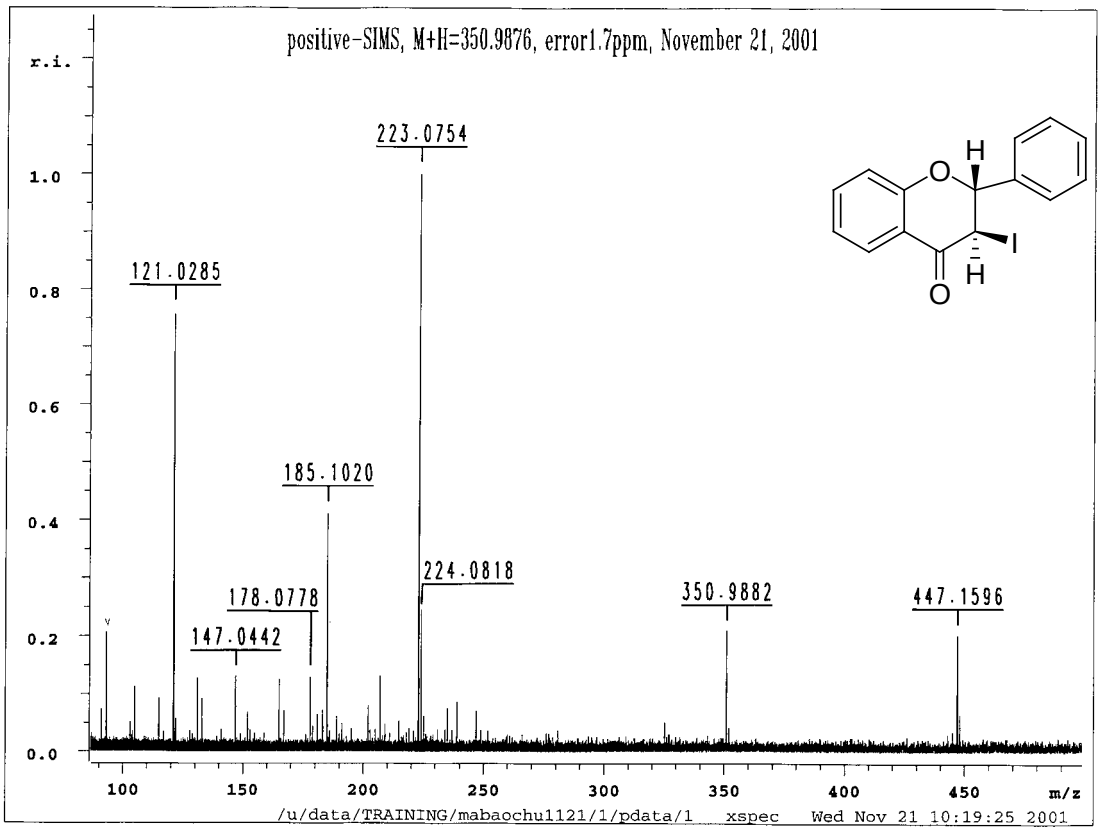
Color/shape	Colorless/block	
Crystal dimension (mm^3)	$0.4\times0.3\times0.2$	
Chemical formula	$C_{34}H_{30}O_{10}\cdot3H_2O$	
Formula weight	652.63	
Temperature (K)	293 (2)	
Crystal system	Triclinic	
Space group	P1	
Unit cell dimension	a =11.143 (2) Å	α = 72.17 (3) ^{o}
	b =11.274 (2) Å	β = 74.90 (3) ^{o}
	c =14.362 (3) Å	γ = 76.96 (3) ^{o}
Volume ($Å^3$)	1637.3 (5)	
Z	2	
Density (Mg/m^3)	1.324	
Absorption coefficient	0.102	
Diffractometer	Enraf-Nonius CAD4	
Scan	$\omega/2\theta$	
θ range (^{o})	1.52~18.50	
Reflections measured	2595	
Independent reflections (R_{int})	2421 (0.1915)	
Observed reflections ($I> 2\sigma I$)	687	
Data/restraints/parameters	2421/0/425	
Extinction coefficient	0.0259 (16)	
Goodness of fit on F^2	0.799	
R_1 ($I> 2\sigma$ (I))	0.0523	
WR_2 (all data)	0.1189	

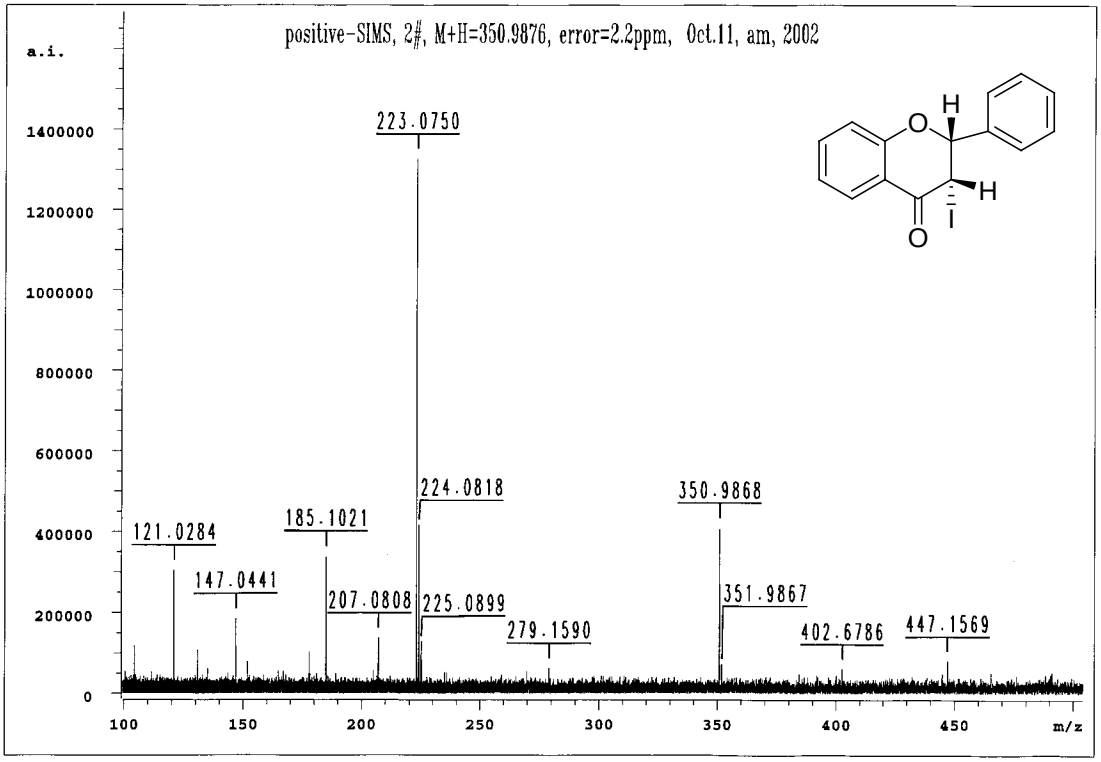
Table 2. HRMS (SIMS) data of a series of 3-haloflavanones measured on a *Bruker Daltonics* APEXII 47e FT-ICR spectrometer−observation of dehalogenative dimmers.

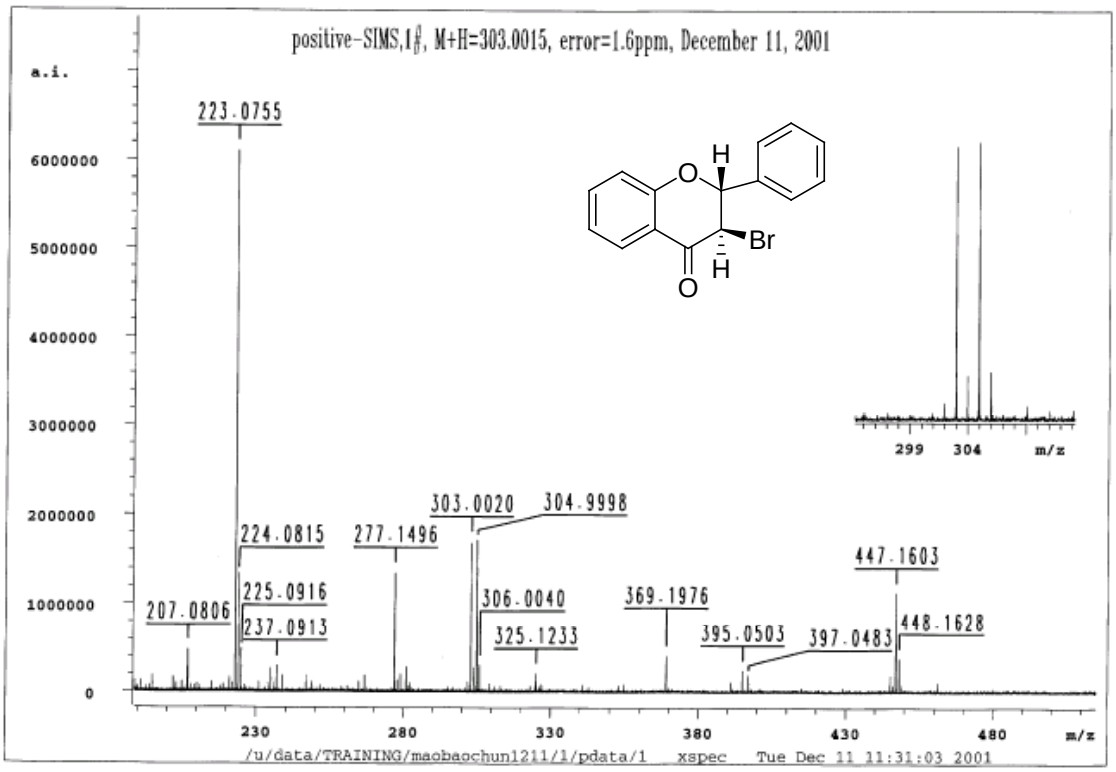
entry	3-haloflavanones	$[M+H]^{+\cdot}$ (error, ppm)	$[M-X]^{+\cdot}$ (Br, I)	$\{2\,[M-X]+H\}^{+\cdot}$ (error, ppm)
1		350.9882 (1.7 ppm) $C_{15}H_{12}O_2I$	223.0754	447.1596 (1.1 ppm) $C_{30}H_{23}O_4$
2		350.9868 (2.2 ppm) $C_{15}H_{12}O_2I$	223.0750	447.1569 (4.9 ppm) $C_{30}H_{23}O_4$
3		303.0020 304.9998 (1.6 ppm) $C_{15}H_{12}O_2Br$	223.0755	447.1603 (2.7 ppm) $C_{30}H_{23}O_4$
4		380.9970 (3.1 ppm) $C_{16}H_{14}O_3I$	253.0859	507.1783 (3.8 ppm) $C_{32}H_{27}O_6$
5		411.0092 (0.9 ppm) $C_{17}H_{16}O_4I$	283.0968	567.0996 (7.3 ppm) $C_{34}H_{31}O_8$
6		441.0154 (8.8 ppm) $C_{18}H_{18}O_5I$	313.1036	627.2133 (14.6 ppm) $C_{36}H_{35}O_{10}$
7		441.0085 (2.4 ppm) $C_{18}H_{18}O_5I$	313.1034	627.2274 (7.8 ppm) $C_{36}H_{35}O_{10}$
8		393.0292 395.0269 (10 ppm) $C_{18}H_{18}O_5Br$	313.1053	627.1821 (64 ppm) $C_{36}H_{35}O_{10}$

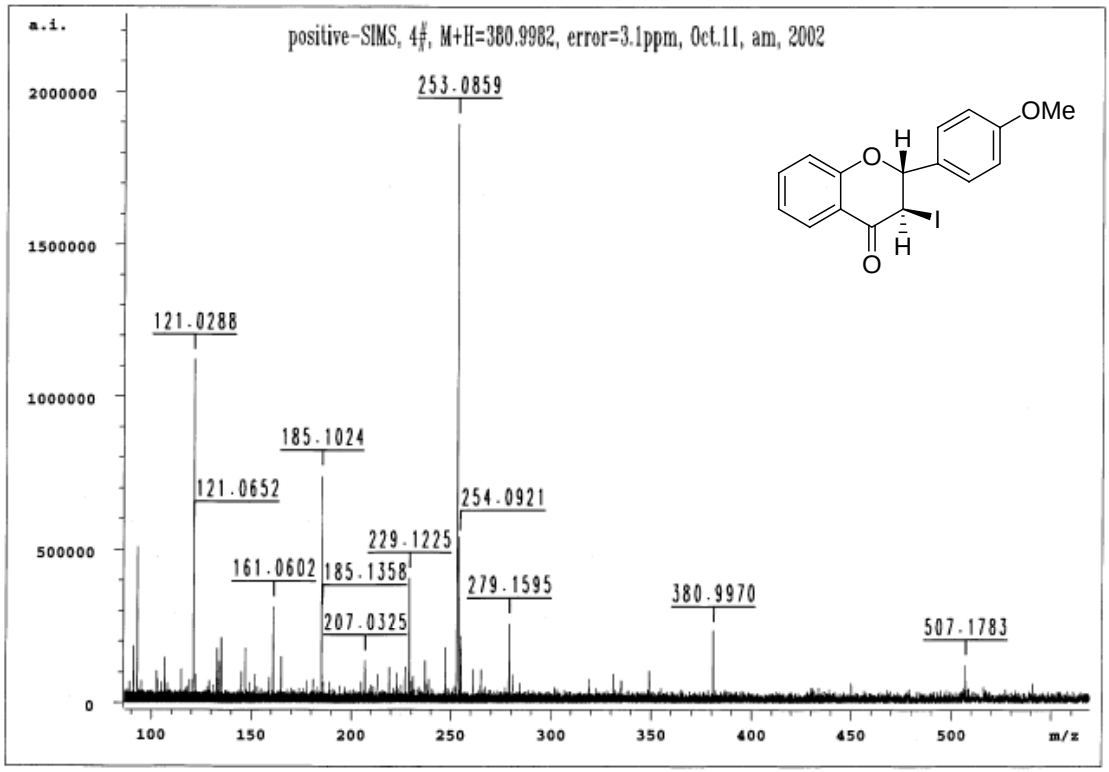

positive-SIMS, M+H=350.9876, error1.7ppm, November 21, 2001
r.i.
223.0754
[M - I]+·
121.0285
185.1020
224.0818
178.0778
147.0442
[M+H]+·
350.9882
{2[M-I]+H}+·
447.1596
m/z
/u/data/TRAINING/mabaochul121/1/pdata/1 xspec Wed Nov 21 10:19:25 2001

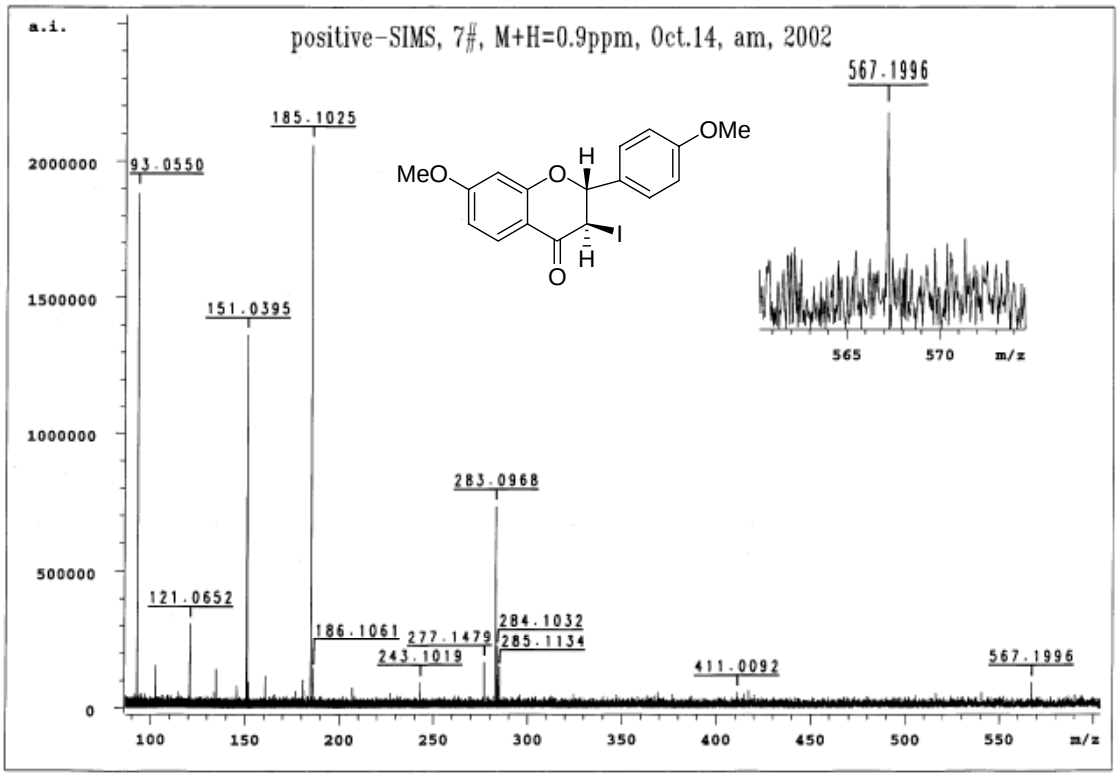

positive-SIMS, M+H=447.1591, error=0.6ppm, November 20, 2001
a.i.
185.1019
93.0546
115.0366
121.0284
[M/2]+·
223.0755
[M+H]+·
447.1594
[M+Na]+·
469.1432
m/z
/u/data/TRAINING/mabaochun1120/1/pdata/1 xspec Tue Nov 20 09:53:25 2001


positive-SIMS, M+H=350.9876, error1.7ppm, November 21, 2001
r.i.
1.0
0.8
0.6
0.4
0.2
0.0
223.0754
121.0285
185.1020
224.0818
178.0778
147.0442
350.9882
447.1596
100
150
200
250
300
350
400
450
m/z
/u/data/TRAINING/mabaochu1121/1/pdata/1 xspec Wed Nov 21 10:19:25 2001

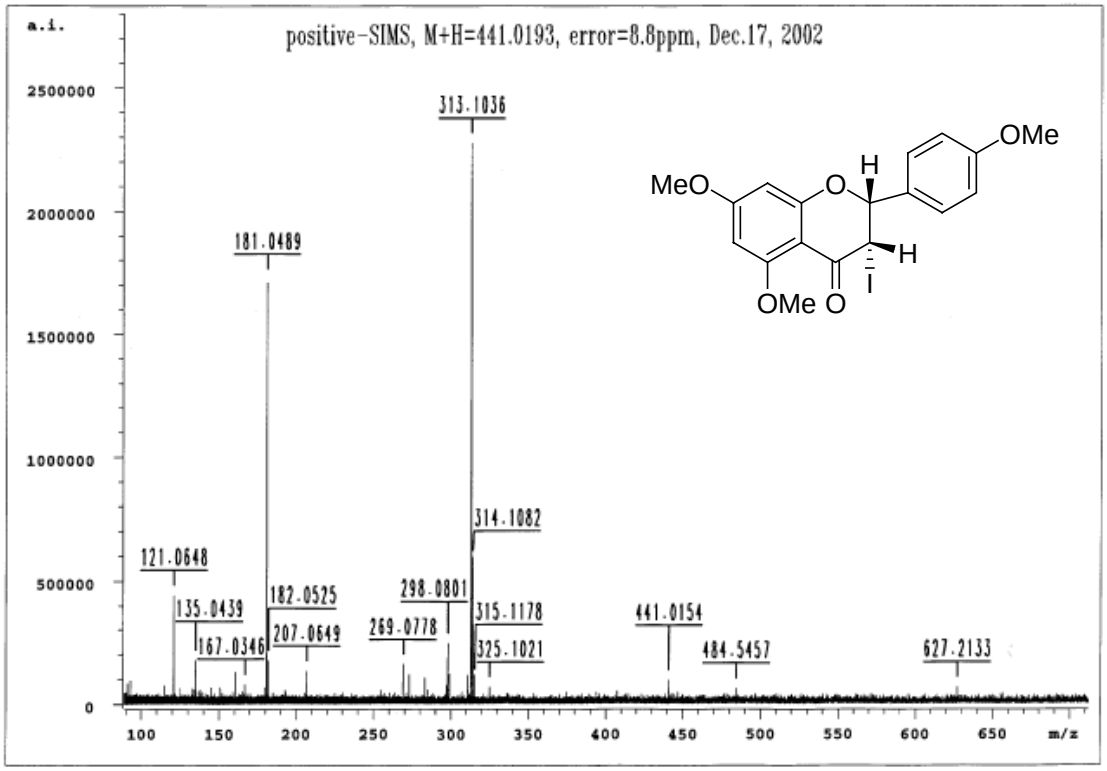

positive-SIMS, 2#, M+H=350.9876, error=2.2ppm, Oct.11, am, 2002
a.i.
1400000
1200000
1000000
800000
600000
400000
200000
0
223.0750
224.0818
350.9868
121.0284
185.1021
147.0441
207.0808
225.0899
351.9867
279.1590
402.6786
447.1569
100
150
200
250
300
350
400
450
m/z
/u/data/TRAINING/mabaochun1011/2/pdata/1 xspec Fri Oct 11 11:40:08 2002


positive-SIMS,1#, M+H=303.0015, error=1.6ppm, December 11, 2001
a.i.
223.0755
224.0815
277.1496
303.0020
304.9998
207.0806
225.0916
237.0913
306.0040
325.1233
369.1976
395.0503
397.0483
447.1603
448.1628
O
H
Br
H
O
299
304
m/z
/u/data/TRAINING/maobaochun1211/1/pdata/1 xspec Tue Dec 11 11:31:03 2001

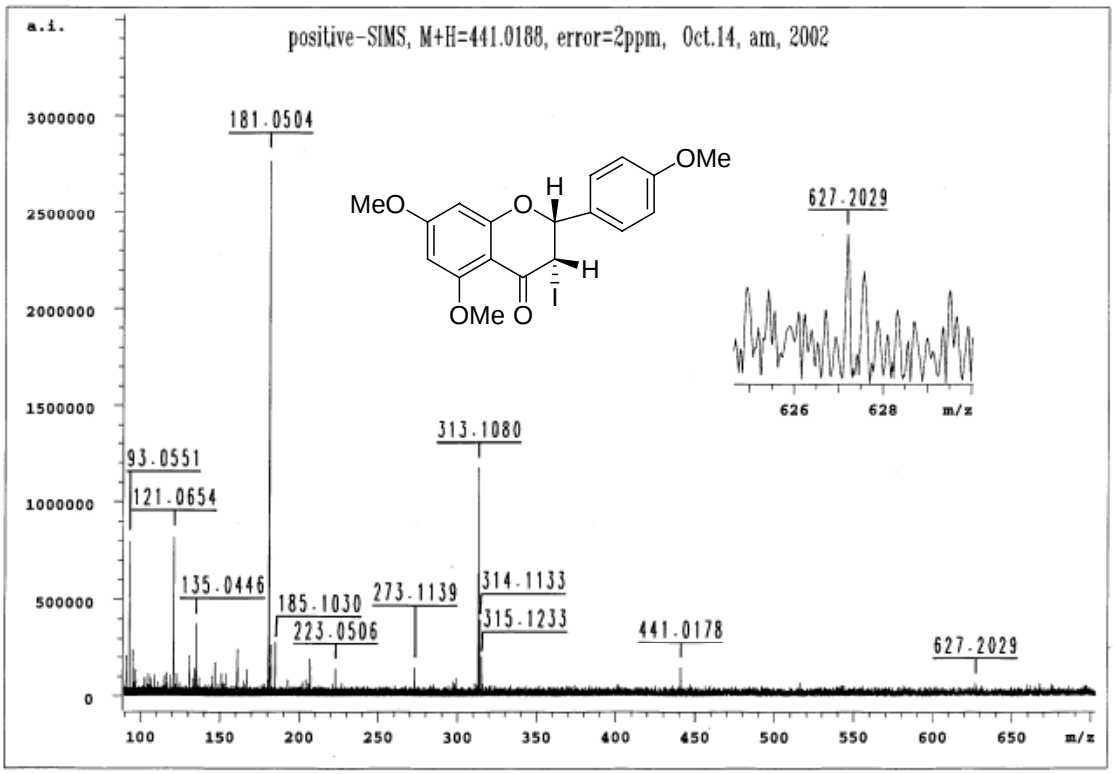

positive-SIMS, 4#, M+H=380.9982, error=3.1ppm, Oct.11, am, 2002
a.i.
253.0859
121.0288
185.1024
121.0652
254.0921
229.1225
161.0602
185.1358
279.1595
207.0325
380.9970
507.1783
OMe
O
H
I
H
O
/u/data/TRAINING/mabaochun1011/4/pdata/1 xspec Fri Oct 11 17:31:50 2002



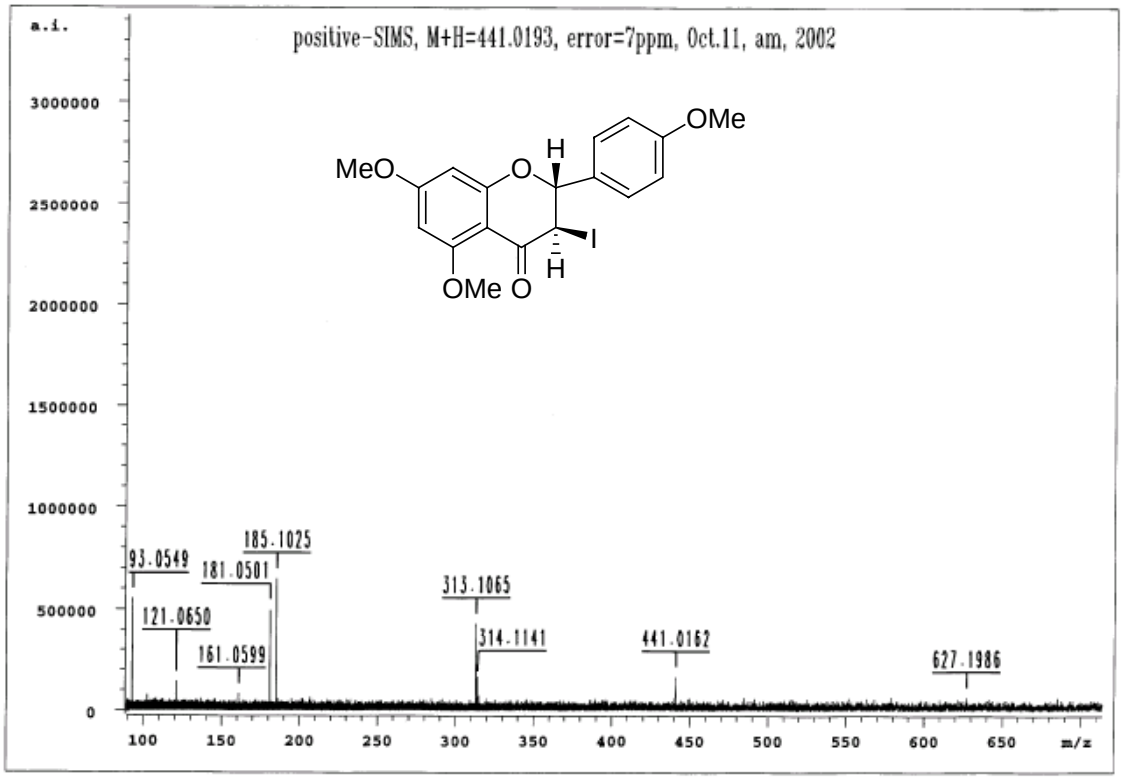
/u/data/TRAINING/mabaochun1011/7/pdata/1 xspec Mon Oct 14 16:19:48 2002



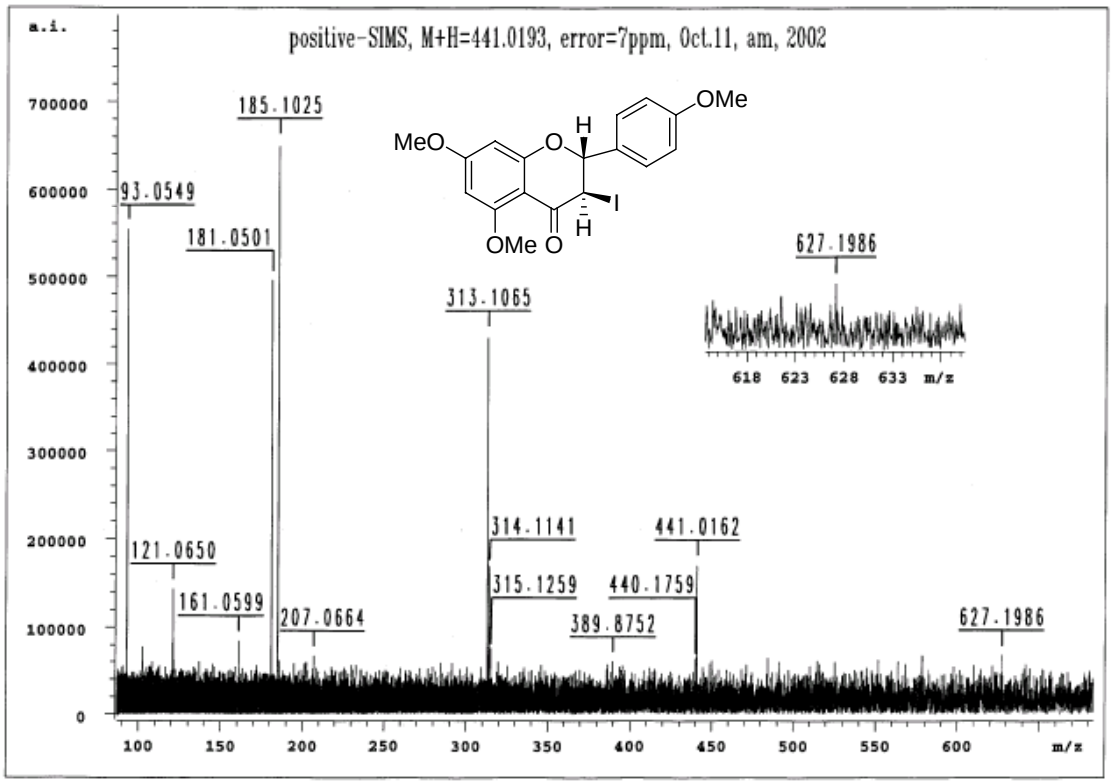
/u/data/TRAINING/mabaochun1217/1/pdata/1 xspec Tue Dec 17 15:54:14 2002



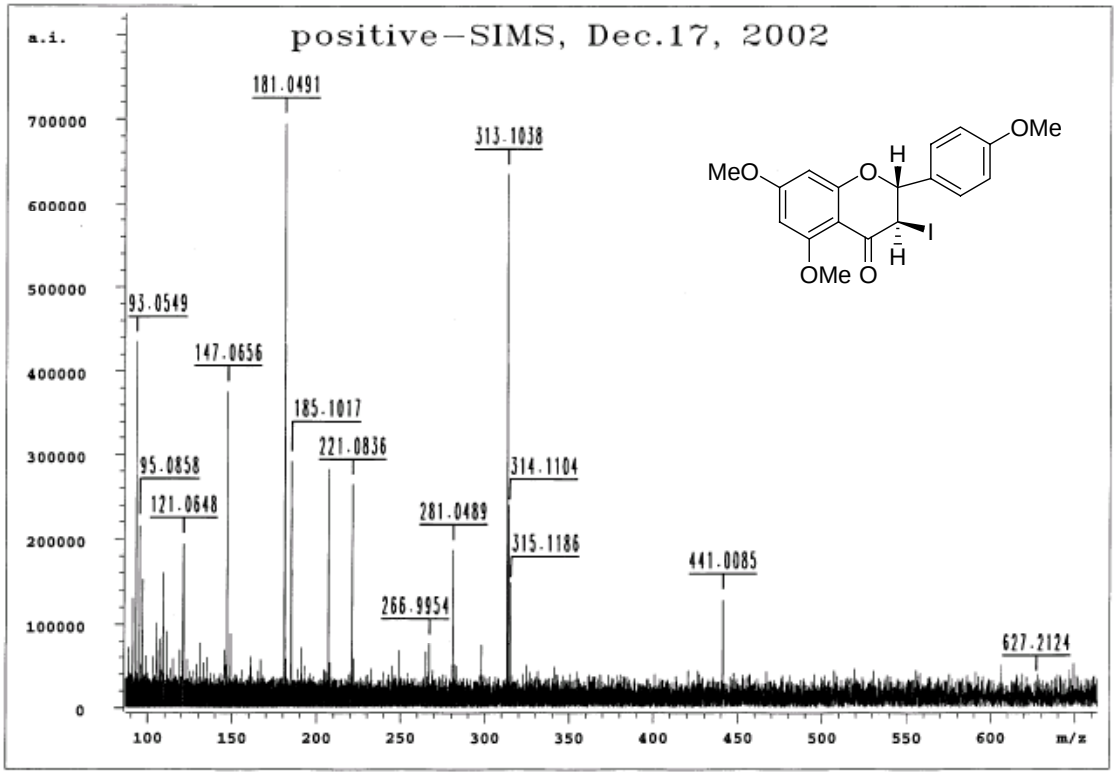
/u/data/TRAINING/mabaochun1011/10-1/pdata/1 xspec Mon Oct 14 17:53:54 2002



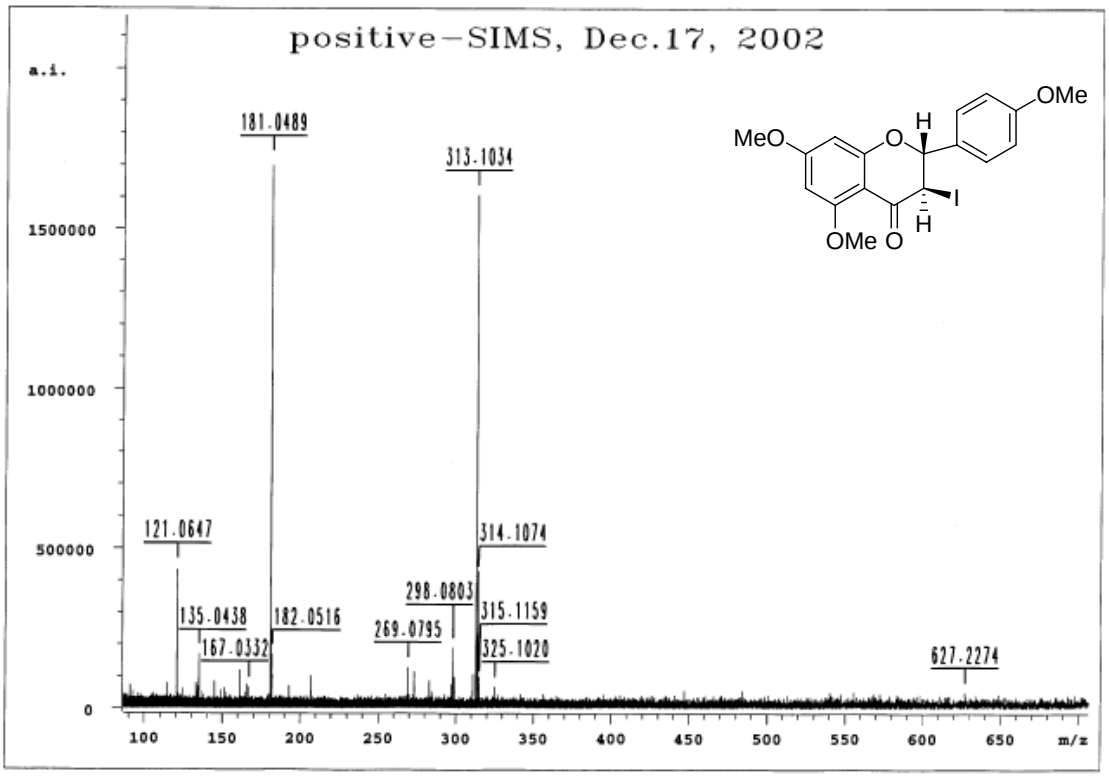
/u/data/TRAINING/mabaochun1011/6-1/pdata/1 xspec Tue Dec 17 16:10:59 2002



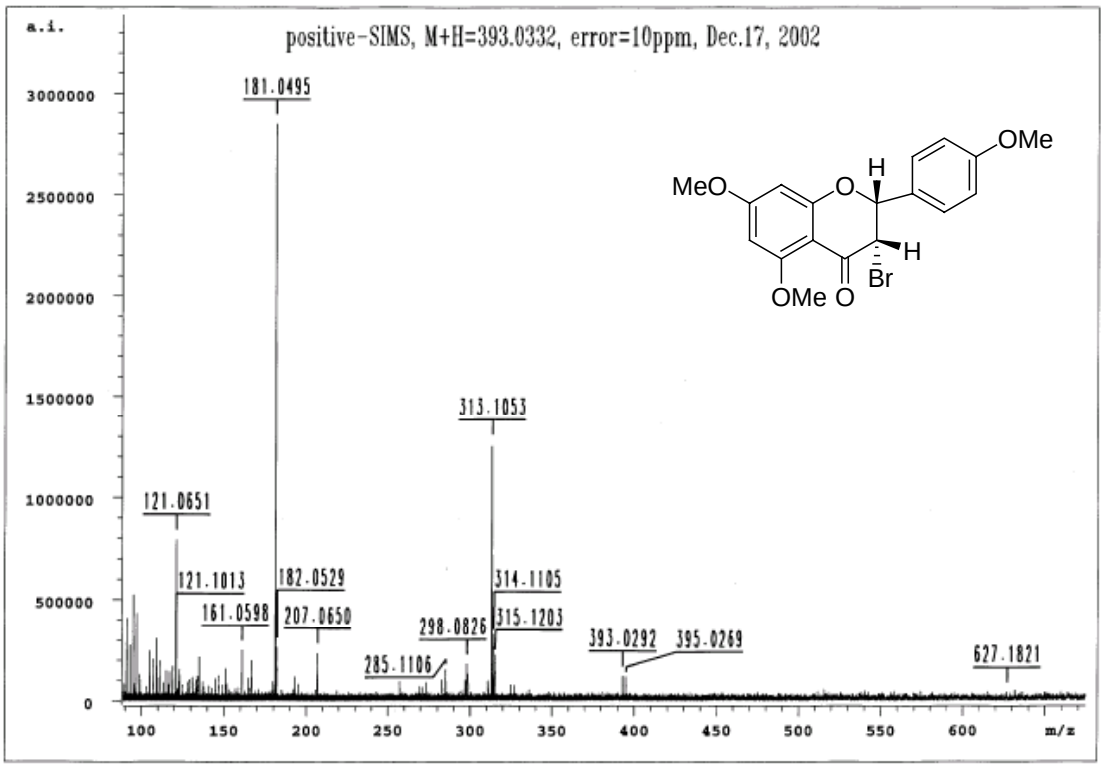
/u/data/TRAINING/mabaochun1011/6-1/pdata/1 xspec Fri Oct 11 18:13:26 2002



/u/data/TRAINING/mabaochun1217/5/pdata/1 xspec Tue Dec 17 16:03:58 2002



/u/data/TRAINING/mabaochun1217/2/pdata/1 xspec Tue Dec 17 15:56:36 2002



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