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Synthesis of lupiwighteone via a *para*-Claisen–Cope rearrangement

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Abstract—The lanthanide catalysed *para*-Claisen–Cope rearrangement has been used as the key step in a short synthesis of the prenylated isoflavone, lupiwighteone. The Mitsunobu reaction was employed for the 5-*O*-prenylation of the acid/base sensitive acetylated isoflavone to afford the allyl aryl ether precursor, which was then rearranged under mild conditions in good yield. Rearrangement of the isoflavone gave the 8-prenylisoflavone as a single product, in good yield.

1. Introduction

Prenylated flavonoids are a unique class of naturally occurring flavonoids characterised by the presence of a prenylated side chain (i.e. prenyl, geranyl) on the flavonoid skeleton. The majority of prenylated flavonoids have been reported from leguminous and moraceae plants.[1,2] Such compounds, especially complex isoflavones, exhibit phytoalexin, insect feeding and antifungal activities.[1] Additionally they show anti-inflammatory, anticancer and anti-lipid properties both in vitro and in vivo.[1,2] Prenylflavonoids are also useful as precursors for the synthesis of naturally occurring flavonoids containing, for example, pyrano or furano substituents.[1,3,4] The isoflavone 5,7,4′-trihydroxy-8-prenylisoflavone (lupiwighteone) **1** was isolated from the pods and seeds of white lupin,[5] roots of yellow lupin (*Lupinos Luteus*)[6] and the leaves of *Glycyrrhiza glabra*.[7] In order to study the biological activities of **1** the development of a facile and efficient synthetic approach was required. Previously, lupiwighteone **1** has been prepared via the palladium-catalysed coupling reaction of 5,7,4′-tris(benzyloxy)-8-iodoisoflavone with 2-methyl-3-butyn-2-ol, employing 15 steps in 7% overall yield.[8] This methodology proved to be time consuming, low yielding and not suitable for the planned preparation of **1** containing three ^{13}C-atoms as an internal standard for analysis of biological samples by LC–MS.[9]

Claisen rearrangements are an efficient method for the regioselective prenylation of phenolic natural products[10] and have recently been employed in the synthesis of the flavanones, 8-prenylnaringenin[11] and a 7-protected-8-prenylchrysin.[12] However to date there is no report of this methodology being employed for the synthesis of prenylated isoflavones. Herein we demonstrate a facile and efficient four-step synthesis of **1** in 45% overall yield starting from genistein **2** via a lanthanide catalysed *para*-Claisen–Cope rearrangement. This represents a suitable procedure for the synthesis of ^{13}C-labelled derivatives as we already have access to both [4-^{13}C]-genistein[13] and [3,4,1′-$^{13}C_3$]-genistein.[9]

2. Results and discussion

Lupiwighteone **1** was prepared as outlined in Figure 1. Based on our knowledge of the chemistry of flavonoids, the 5-hydroxy group in genistein **2** is hydrogen bonded to the adjacent carbonyl group, and thus not readily acetylated. Chemoselective 4′-*O*- and 7-*O*-acetylation of **2** was therefore readily achieved using two equivalents of acetic anhydride in pyridine at rt, to afford the corresponding 7,4′-diacetoxy-5-hydroxyisoflavone **3** in 92% yield. Preparation of the 5-prenyl ether **4** was then carried out using the classical Mitsunobu reaction.[14] Thus condensation of **3** with 3-methyl-2-buten-1-ol in the presence of triphenylphosphine and diethyl azodicarboxylate in dry THF gave the desired ether 7,4′-diacetoxy-5-(3-methyl-but-2-enyloxy)isoflavone **4** in 83% yield.

Once the prenyl ether **4** was available, attention was focused on the *para*-Claisen–Cope rearrangement[10] to convert the C–O into C–C regiochemistry. The Claisen rearrangement[11] of 7,4′-diacetyl-5-(3-methyl-but-2-enyloxy)naringenin at 188°C was reported to give a 3:1 ratio of the *para*-rearranged product, 7,4′-diacetyl-8-prenylnaringenin, to the *ortho*-rearranged product, 7,4′-diacetyl-

Keywords: lupiwighteone; Claisen–Cope rearrangement; Mitsunobu reaction.

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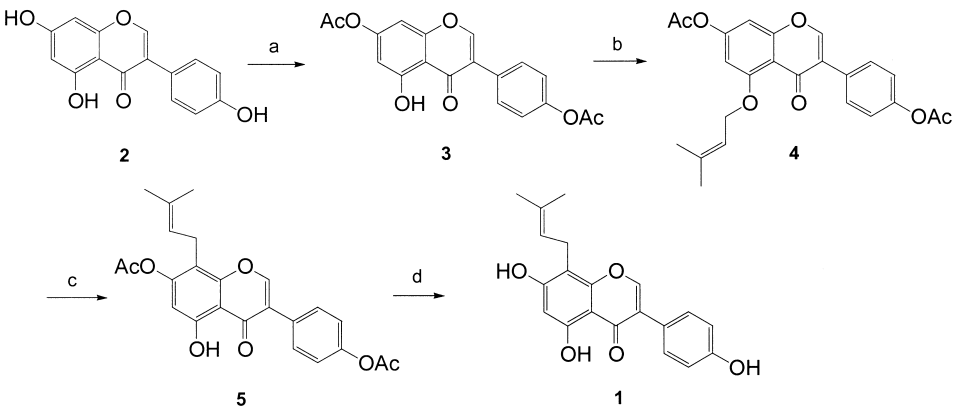

Figure 1. *Reagents and conditions*: (a) Ac_2O, pyridine, 24 h, rt, 92%; (b) DEAD, PPh_3, 3-methyl-2-buten-1-ol, THF, −10°C to rt 15 h, 83%; (c) $Eu(fod)_3$, $CHCl_3$, 60°C, 20 h, 68%; (d) 10% aq. $NaHCO_3$, 60°C to rt overnight, 84%.

6-(1,1dimethylallyl)naringenin after 2 h, but after extended reaction times only the *para*-rearranged product was observed in 62% yield.[11] At lower temperatures with 10% $Eu(fod)_3$ catalyst the yields were improved but the selectivity was much reduced. More recently, the Claisen rearrangement of 7-MEM-5-(3-methyl-but-2-enyloxy)-chrysin was also examined.[12] Under microwave irradiation in *N*,*N*-diethylaniline the *para*-rearranged product was obtained selectively in 83% yield, while conventional heating, in *N*,*N*-diethylbutylamine at 160°C, was more selective for the *ortho*-rearranged product giving a 16:1 ratio in its favour and an 86% yield.

As there was no previous report of this procedure being employed for an isoflavone we decided to investigate the $Eu(fod)_3$ catalysed rearrangement of the prenyl ether **4**. The compound was dissolved in minimal dry $CHCl_3$ as solvent and heated at 60°C. This afforded the *para*-rearrangement product, 7,4′-diacetoxy-5-hydroxy-8-prenylisoflavone **5** in 68% isolated yield and it was the only product observed in the ^1H NMR spectrum of the crude product. This low temperature europium (III) catalysed *para*-Claisen–Cope rearrangement thus appears to proceed with high selectivity.

The target compound lupiwighteone **1** was then obtained in 86% yield following hydrolysis of **5** with 10% aqueous $NaHCO_3$ at 60°C.

For our biological studies we also required a synthetic route to ^{13}C-labelled 8-prenylapigenin **6** and so it was synthesised using the same methodology although less selectivity was observed under our mild conditions (Fig. 2). The prenyl ether **7** was synthesised as for the isoflavone analogue. Rearrangement was then achieved using catalytic $Eu(fod)_3$ to furnish an intractable 1:1 mixture of 7,4′-diacetoxy-5-hydroxy-8-(3-methylbut-2-enyl)flavone **8** and 7,4′-diacetoxy-5-hydroxy-6-(1,1-dimethylallyl)flavone **9** in 82% yield. The two regioisomers showed well separated signals for the $-CH_2-CH{=}C(CH_3)_2$ in **8** at δ=3.32 (2H, d) and $-C(CH_3)_2CH{=}CH_2$ in **9** at δ=4.98 and 5.05 (2H, 2dd) (300 MHz, ^1H NMR) to allow an unambiguous determination of product ratio. Increasing the regioselectivity towards the desired product **8** was achieved by extending the reaction time up to 36 h, where a 2:1 ratio of **8** to **9** was obtained. However, preparative separation of the mixture of **8** and **9** proved to be significantly difficult. To tackle this problem, the mixture was subjected to hydrolysis using 10%

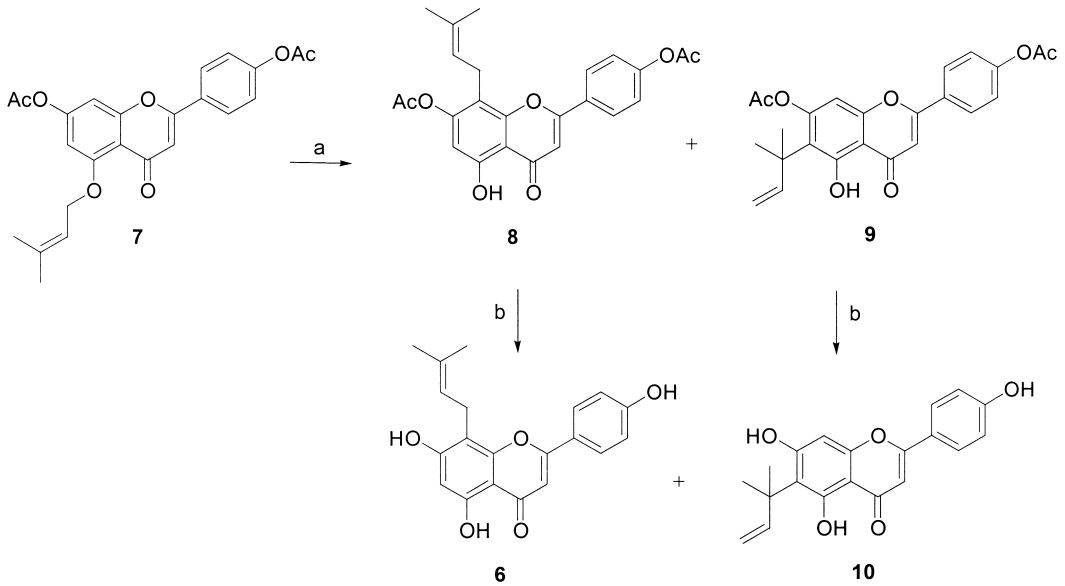

Figure 2. (a) $Eu(fod)_3$, $CHCl_3$, 60°C, 36 h, 82% (**8**:**9** in 2:1 ratio); (b) 10% aq. $NaHCO_3$, 60°C to rt overnight.

aqueous $NaHCO_3$ in MeOH/THF solution at 60°C to afford the desired 8-prenylapigenin **6** and 6-(1,1-dimethylallyl)-apigenin **10** in 62 and 24% yield, respectively, after separation by flash column chromatography.

In conclusion, the mild lanthanide catalysed *para*-Claisen–Cope rearrangement represents an excellent method for the synthesis of lupiwighteone and gives a simple and high yielding procedure suitable for our ^{13}C-labelling proposes. It is particularly interesting that this first example of a lanthanide catalysed *para*-Claisen–Cope rearrangement with an isoflavone derivative shows much higher selectivity at lower temperatures for the *para*-rearranged product than has previously been observed with other flavonoids both in our laboratory and in previous literature.[11,12]

3. Experimental

3.1. General

The genistein[13] and apigenin[15] were prepared according to literature procedures. Melting points were determined in open capillary tubes with electrothermal apparatus and are uncorrected. For ^1H NMR (300 MHz) spectra the residual peak of $CHCl_3$ (7.26 ppm) and CH_3COCH_3 (2.05 ppm) were used as the internal reference, while for ^{13}C NMR (75 MHz) spectra the central peak of $CDCl_3$ (77.0 ppm) and the central peak CD_3COCD_3 (29.95 ppm) were used as the reference. Chemical shifts are given in δ and J values in Hz. Silica gel was used for flash column chromatography. Tetrahydrofuran was distilled under nitrogen from sodium/benzophenone. $CHCl_3$ was flashed through basic alumina.

3.1.1. 7,4′-Diacetoxy-5-hydroxyisoflavone (3). Acetic anhydride (0.35 ml, 3.70 mmol) was added dropwise to a well stirred solution of genistein **2** (0.50 g, 1.85 mmol) in dry pyridine (10 ml) at ambient temperature under a nitrogen-atmosphere. The dark solution was stirred for 24 h at ambient temperature and poured into ice-cold water. The yellow solid precipitate was filtered, dried and recrystallised from ethanol/acetone to afford the title compound **3** as a white solid (0.60 g, 92%). Mp 200–201°C (lit.[16] mp 200–203°C); ν_{max}/cm^{-1} (nujol) 3500–2900br (OH), 1754, 1652, 1622, 1220, 1198, 1054, 1020; ^1H NMR ($CDCl_3$) δ 2.33 (s, 3H, CH_3COO), 2.34 (s, 3H, CH_3COO), 6.60 (d, 1H, J=2.1 Hz, H-8), 6.77 (d, 1H, J=2.1 Hz, H-6), 7.19 (d, 2H, J=8.7 Hz, H-3′, 5′), 7.55 (d, 2H, J=8.7 Hz, H-2′, 6′), 7.97 (s, 1H, H-2), 12.84 (s, 1H, 5-OH); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 21.15 (2×CH_3COO), 100.91 (C-8), 105.58 (C-6), 109.43 (C-4a), 121.88 (C-3′,5′), 123.63 (C-3), 127.91 (C-1′), 129.97 (C-2′,6′), 150.93 (C-4′), 153.80 (C-8a), 156.00 (C-7), 156.82 (C-2), 162.38 (C-5), 168.18 (−$CO$$CH_3$), 169.28 (−$CO$$CH_3$), 180.87 (C-4); EIMS m/z (%) 354 (M^+, 27), 312 (M^+−OAc, 42), 284 (24), 270 (100), 153 (8), 118 (6).

3.1.2. 7,4′-Diacetoxy-5-(3-methylbut-2-enyloxy)isoflavone (4). A solution of diethyl azodicarboxylate (0.58 ml, 3.77 mmol) in dry THF (2 ml) was added dropwise over 30 min to a well stirred suspension of **3** (0.84 g, 2.37 mmol), triphenylphosphine (0.81 g, 3.09 mmol) and 3-methyl-2-buten-1-ol (0.36 ml, 3.56 mmol) in dry THF (25 ml) at −10°C under a nitrogen atmosphere. The resulting suspension was stirred for 2 h at −10°C, then allowed to warm gradually to ambient temperature. After the mixture had been stirred for 15 h at ambient temperature (the suspension turn to a clear yellow solution after 1 h), the solvent was removed under reduced pressure, the yellow viscous oil was dissolved in CH_2Cl_2 and subjected to flash chromatography on silica gel (ethyl acetate/petroleum ether 1:2) to give a white solid. Recrystallisation from EtOH gave the title compound **4** as a white solid (0.83 g, 83%). Mp 186–187°C; ν_{max}/cm^{-1} (nujol) 1760, 1652, 1613, 1580, 1251, 1200, 1080, 1046; ^1H NMR ($CDCl_3$) δ 1.73 (s, 3H, H-4″), 1.77 (s, 3H, H-5″), 2.31 (s, 3H, CH_3COO), 2.34 (s, 3H, CH_3COO), 4.65 (d, 2H, J=6.6 Hz, H-1″), 5.57 (m, 1H, J=1.5, 6.6 Hz, H-2″), 6.58 (d, 1H, J=2.4 Hz, H-8), 6.84 (d, 1H, J=2.4 Hz, H-6), 7.13 (d, 2H, J=8.7 Hz, H-3′, 5′), 7.54 (d, 2H, J=8.7 Hz, H-2′, 6′), 7.81 (s, 1H, H-2); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 18.62 (C-4″), 21.38 (C−CH_3COO), 21.46 (C−CH_3COO), 26.00 (C-5″), 66.98 (C-1″), 102.62 (C-8), 103.03 (C-6), 113.66 (C-4a), 119.10 (C-2″), 121.64 (C-3′, 5′), 126.11 (C-3), 129.60 (C-1′), 130.53 (C-2′, 6′), 138.32 (C-3″), 150.75 (C-4′), 151.10 (C-8a), 154.58 (C-7), 158.84 (C-2), 160.89 (C-5), 168.50 (CH_3COO), 169.55 (CH_3COO), 175.08 (C-4); EIMS m/z (%) 422 (M^+, 13), 354 ($M^+-C_6H_8$, 39), 312 (32), 270 (100), 254 (9), 241 (13), 153 (5). Anal. calcd for $C_{24}H_{22}O_7$: C, 68.24; H, 5.25. Found: C, 67.98; H, 5.31.

3.1.3. *para*-Claisen rearrangement of prenyl ether 4 to 7,4′-diacetoxy-5-hydroxy-8-*C*-prenylisoflavone (5). A suspension of **4** (0.5 g, 1.185 mmol) and $Eu(fod)_3$ (0.123 g, 0.118 mmol) in dry $CHCl_3$ (1 ml) was stirred at gentle reflux for 20 h under nitrogen atmosphere. The resulting orange oil was subjected to flash chromatography (ethyl acetate/hexane 1:3) to furnish 7,4′-diacetoxy-5-hydroxy-8-*C*-prenylisoflavone **5** as a light yellow solid (0.34 g, 68%). Mp 139–140°C; ν_{max}/cm^{-1} (nujol) 3244br (OH), 1746, 1649, 1623, 1583, 1442, 1206, 1031, 836; ^1H NMR ($CDCl_3$) δ 1.69 (s, 3H, H-4″), 1.78 (s, 3H, H-5″), 2.33 (s, 3H, CH_3COO), 2.34 (s, 3H, CH_3COO), 3.38 (d, 2H, J=7.2 Hz, H-1″), 5.23 (m, 1H, J=1.5, 7.2 Hz, H-2″), 6.59 (s, 1H, H-6), 7.19 (d, 2H, J=8.7 Hz, H-3′, 5′), 7.56 (d, 2H, J=8.7 Hz, H-2′, 6′), 8.03 (s, 1H, H-2), 12.63 (s,1H, 5-OH); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 17.85 (C-5″), 20.89 (C-CH_3COO), 21.16 (C−CH_3COO), 22.52 (C-1″), 25.67 (C-4″), 106.42 (C-6), 109.92 (C-4a), 112.94 (C-8), 120.89 (C-2″), 121.88 (C-3′, 5′), 123.45 (C-1′), 128.03 (C-3), 129.98 (C-2′, 6′), 132.70 (C-3″), 150.92 (C-4′), 153.70 (C-8a), 154.17 (C-7), 154.84 (C-2), 159.86 (C-5), 168.35 (CH_3COO), 169.29 (CH_3COO), 181.28 (C-4); EIMS m/z (%) 422 (M^+, 100), 379 (M^+−OAc, 59), 338 (82), 283 (25), 270 (65), 153 (9), 118 (9). Anal. calcd for $C_{24}H_{22}O_7$: C, 68.24; H, 5.25. Found: C, 68.47; H, 4.93.

3.1.4. Lupiwighteone (1). 10% Aqueous $NaHCO_3$ (10 ml) was added to a well stirred suspension of **5** (0.2 g, 0.474 mmol) in a mixture of MeOH/THF (1:1, 5 ml) under nitrogen atmosphere. After the reaction mixture had been stirred at 60°C for 2 h, it was allowed to stir at rt overnight, then half of the solvent was removed under reduced pressure, 2% aq. HCl (5 ml) was added and extracted with EtOAc (3×20 ml). The combined organic layers were dried ($MgSO_4$), and the solvent was removed at

reduced pressure. The yellow solid was subjected to flash chromatography on silica gel (CH_2Cl_2/MeOH 50:1) to afford the title compound **1** as a white solid (0.135 g, 84%). Mp 133–134°C (lit.[8] mp 133–135°C); ^{1}H NMR (acetone-d_6) δ 1.66 (s, 3H, H-4″), 1.81 (s, 3H, H-5″), 3.45 (d, 2H, J=6.9 Hz, H-1″), 5.23 (m, 1H, J=1.5, 6.9 Hz, H-2″), 6.37 (s, 1H, H-6), 6.90 (d, 2H, J=9.0 Hz, H-3′, 5′), 7.47 (d, 2H, J=9.0 Hz, H-2′, 6′), 8.25 (s, 1H, H-2), 8.47 (4′-OH), 8.60 (7-OH), 12.97 (5-OH); ^{13}C NMR (acetone-d_6, 75 MHz) δ 17.37 (C-5″), 21.52 (C-1″), 25.32 (C-4″), 98.85 (C-6), 105.71 (C-4a), 106.66 (C-8), 115.41 (C-3′, 5′), 122.54 (C-2″), 122.66 (C-3), 123.16 (C-1′), 130.61 (2′, 6′), 131.54 (3″), 153.82 (C-8a), 155.73 (C-2), 157.80 (C-4′), 160.94 (C-5), 161.60 (C-7), 181.41 (C-4); EIMS m/z (%) 338 (M^+, 96), 323 (100), 283 (32), 270 (48), 118 (9). Anal. calcd for $C_{20}H_{18}O_5.H_2O$: C, 67.41; H, 5.66. Found: C, 67.40; H, 5.78.

3.1.5. 7,4′-Diacetoxy-5-hydroxyflavone. Treatment of apigenin (0.50 g, 1.85 mmol) with acetic anhydride (0.35 ml, 3.70 mmol) gave, after recrystallisation from ethanol/acetone, the title compound 7,4′-diacetoxy-5-hydroxyflavone as a white solid (0.54 g, 82%). Mp 201–202°C (lit.[17] mp 203–204°C); ^{1}H NMR ($CDCl_3$) δ 2.34 (s, 3H, CH_3COO), 2.35 (s, 3H, CH_3COO), 6.58 (d, 1H, J=2.1 Hz, H-6), 6.70 (s, 1H, H-3), 6.85 (d, 1H, J=2.1 Hz, H-8), 7.28 (d, 2H, J=9.0 Hz, H-3′, 5′), 7.91 (d, 2H, J=9.0 Hz, H-2′, 6′), 12.69 (s, 1H, 5-OH); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 21.10 and 21.15 (2×CH_3COO), 100.92 (C-8), 105.46 (C-6), 106.01 (C-3), 108.76 (C-4a), 122.40 (C-3′, 5′), 127.69 (C-2′, 6′), 128.36 (C-1′), 153.56 (C-4′), 155.89 (C-7), 156.58 (C-8a), 161.81 (C-5), 163.71 (C-2), 168.22 (CH_3COO), 168.73 (CH_3COO), 182.61 (C-4); EIMS m/z (%) 354 (M^+, 44), 312 (20), 270 (100), 153 (10).

3.1.6. 7,4′-Diacetoxy-5-(3-methylbut-2-enyloxy)flavone (7). Reaction of 7,4′-diacetoxy-5-hydroxyflavone (0.37 g, 1.045 mmol) and 3-methyl-2-buten-1-ol (0.149 ml, 1.467 mmol) in the presence of diethyl azodicarboxylate (0.273 ml, 1.568 mmol) and triphenylphosphine (0.33 g, 1.26 mmol) in dry THF (25 ml), as described for the preparation of **4**, afforded after purification using silica gel (EtOAc/hexane 2:3) 7,4′-diacetoxy-5-(3-methyl-but-2-enyloxy)flavone **7** as a white solid (0.31 g, 70%). Mp 140–142°C (from diethyl ether); ν_{max}/cm^{-1} (nujol) 1753, 1698, 1658, 1532, 1224, 1168, 1144, 1049, 1018; ^{1}H NMR ($CDCl_3$) δ 1.76 (s, 3H, H-4″), 1.80 (s, 3H, H-5″), 2.34 (s, 3H, CH_3COO), 2.35 (s, 3H, CH_3COO), 4.80 (d, 2H, J=6.6 Hz, H-1″), 5.69 (m, 1H, J=1.5, 6.6 Hz, H-2″), 6.69 (d, 1H, J=2.1 Hz, H-8), 6.76 (s, 1H, H-3), 7.06 (d, 1H, J=2.1 Hz, H-6), 7.36 (d, 2H, J=8.7 Hz, H-3′, 5′), 7.95 (d, 2H, J=8.7 Hz, H-2′, 6′); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 18.42 (C-4″), 21.15 (CH_3COO), 21.24 (CH_3COO), 25.80 (C-5″), 66.76 (C-1″), 102.50 (C-8), 102.97 (C-6), 109.86 (C-3), 112.85 (C-4a), 118.90 (C-2″), 122.22 (C-3′, 5′), 127.34 (C-2′, 6′), 128.86 (C-1′), 138.13 (C-3″), 152.96 (C-4′), 154.38 (C-8a), 158.53 (C-7), 160.01 (C-2), 160.18 (C-5), 168.44 (CH_3COO), 168.99 (CH_3COO), 177.23 (C-4); EIMS m/z (%) 422 (M^+, 9), 354 (23), 312 (M^+−OAc, 61), 270 (M^+−2OAc, 100), 153 (9), 118 (9). Anal. calcd for $C_{24}H_{22}O_7$: C, 68.24; H, 5.25. Found: C, 67.96; H, 5.37.

3.2. *para*-Claisen rearrangement of prenyl ether (7)

Reaction of **7** (0.15 g, 0.355 mmol) with Eu(fod)$_3$ (0.038 g, 0.0356 mmol) for 36 h, as described above for the preparation of compound **5** gave an intractable mixture of the desired product 7,4′-diacetoxy-5-hydroxy-8-*C*-prenylflavone **8** and 7,4′-diacetoxy-5-hydroxy-6-*C*-(1,1-dimethylallyl)flavone **9** (0.123 g, 82% in 2:1 ratio) as light yellow solid.

3.2.1. Hydrolysis of the mixture containing 8 and 9 to 8-prenylapigenin (6) and 6-(1,1-dimethylallyl)apigenin (10). Treatment of the mixture of **8** and **9** (0.30 g, 7.11 mmol) with 10% aq. $NaHCO_3$ in MeOH/THF (5:5 ml), as described above for preparation of compound **1**, gave after purification using flash chromatography (CH_2Cl_2/MeOH 50:1) compounds **6** and **10**. Compound **6** was obtained as a light yellow solid (0.057 g, 24%). Mp 173–174°C (decompose) (from $CHCl_3$); ν_{max}/cm^{-1} (nujol) 3500–2800br (OH), 1652, 1609, 1557, 1243, 1179, 832; ^{1}H NMR (acetone-d_6) δ 1.62 (s, 6H, H-4″, 5″), 4.87 (dd, 1H, J=1.6, 10.6 Hz, H-3a″), 4.97 (dd, 1H, J=1.6, 17.7 Hz, H-3b″), 6.38 (dd, 1H, J=10.6, 17.7 Hz, H-2″), 6.54 (s, 1H, H-8), 6.62 (s, 1H, H-3), 7.02 (d, 2H, J=8.7 Hz, H-3′, 5′), 7.92 (d, 2H, J=8.7 Hz, H-2′, 6′), 9.16 (4′-OH), 9.22 (7-OH), 14.09 (5-OH); ^{13}C NMR (acetone-d_6, 75 MHz) δ 28.81 (C-4″, 5″), 41.39 (C-1″), 94.88 (C-8), 103.65 (C-3), 103.75 (4a), 108.35 (C-6), 116.41 (C-3″), 116.50 (C-3′, 5′), 122.89 (C-1′), 128.84 (C-2′, 6′), 150.36 (2″), 156.23 (C-8a), 161.48 (C-4′), 162.13 (C-7), 163.35 (C-2), 164.15 (C-5), 183.15 (C-4); EIMS m/z (%) 338 (M^+, 47), 323 (100), 283 (15), 270 (12); HRMS (negative ion). Found 337.1073 $C_{20}H_{17}O_5$ requires 337.1076. Compound **10** was obtained as yellow solid (0.149 g, 62%). Mp 177–178°C (from $CHCl_3$); ν_{max}/cm^{-1} (nujol) 3500–2800br (OH), 1645, 1610, 1277, 1252, 1184, 830; ^{1}H NMR (acetone-d_6) δ 1.66 (s, 3H, H-4″), 1.82 (s, 3H, H-5″), 3.57 (d, 2H, J=6.9 Hz, H-1″), 5.34 (m, 1H, J=1.5, 6.9 Hz, H-2″), 6.34 (s, 1H, H-6), 6.63 (s, 1H, H-3), 7.05 (d, 2H, J=9.0 Hz, H-3′, 5′), 7.96 (d, 2H, J=9.0 Hz, H-2′, 6′), 9.22 (1H, br s, 4′-OH), 9.58 (1H, br s, 7-OH), 12.96 (5-OH); ^{13}C NMR (acetone-d_6, 75 MHz) δ 18.22 (C-5″), 22.47 (C-1″), 25.94 (C-4″), 99.38 (C-6), 104.01 (3), 105.47 (4a), 107.45 (C-8), 116.95 (C-3′, 5′), 123.63 (C-1′), 123.77 (C-2″), 129.31 (C-2′, 6′), 132.11 (3″), 156.07 (C-8a), 161.06 (C-5), 161.87 (C-4′), 162.19 (C-7), 165.08 (C-2), 183.46 (C-4); EIMS m/z (%) 338 (M^+, 27), 283 (8), 270 (25), 86 (100). Anal. calcd for $C_{20}H_{18}O_5.H_2O$: C, 67.41; H, 5.66. Found: C, 67.44; H, 5.42.

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