Syntheses of 4-Alkoxy-3-methoxy-5*H*-benzocycloheptenes and 2-Alkoxy-3-methoxy-5*H*-benzocycloheptenes from Isovanillin *via* Claisen Rearrangement and Ring-closing Metathesis

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New syntheses of 4-alkoxy-3-methoxy-5*H*-benzocycloheptenes and 2-alkoxy-3-methoxy-5*H*-benzocycloheptenes were studied. Based on Claisen rearrangement, *O*-alkylation, nucleophilic addition of allyl magnesium bromide, ring-closing metathesis, and dehydration, a series of new 4-alkoxy-3-methoxy-5*H*-benzocycloheptenes and 2-alkoxy-3-methoxy-5*H*-benzocycloheptenes were respectively synthesized from isovanillin in good overall yields.

Keywords: Benzocycloheptenes; Isovanillin; Claisen rearrangement; RCM.

INTRODUCTION

In the past decades, compounds, which are related to benzocycloheptene and have exhibited various biological activities, have been intensively studied. For example, derivatives of 6-aminobenzocycloheptene have dopamine-like activity,[1] 6-amino-6,7,8,9-tetrahydro-5*H*-benzocyclohepten-5-ols and related derivatives have anti-inflammatory activity,[2] and 1-hydroxy-5,6,7,8-tetrahydro-*N*,*N*-9*H*-benzocyclohepten-8-ylamine has a stereoselective interaction with 5-HT_{1A} receptor in the brain.[3] Nevertheless, information about the chemistry of 5*H*-benzocycloheptenes was quite insufficient in the contemporary literature. Until the present, only a few studies were reported, such as it could be transferred into benzonorcaradiene by photolysis[4] or used as substrate for singlet oxygen and PTAD.[5] However their synthetic strategies were paid little attention. Major synthetic methods utilized include (1) dehydrobromination of 9-bromo-6,7-dihydrobenzocycloheptene under potassium *tert*-butoxide;[6] (ii) reduction of 7-bromobenzocycloheptene with *n*-butyl lithium;[7] or with potassium *tert*-butoxide;[8] (iii) rearrangement of the radical anions of 1,6-bridged[10]annulenes;[9] and (iv) oxidation of tetrahydrobenzotropilidene with DDQ.[10] Even though, there still exist some disadvantages such as the difficulty to prepare the substituted congeners, the tedious reaction conditions, the commercially unavailable starting materials, and the low yields. Thus it is necessary to develop a more efficient and versatile method for those substituted compounds. Since Grubbs et al.[11] discovered in 1995 a novel alkylidene ruthenium complex as a catalyst for ring closing metathesis (RCM), it has been widely and rapidly applied in organic synthesis in many aspects.[12] Until the present, no attention has been paid to apply this RCM reaction to the synthesis of substituted 5*H*-benzocycloheptenes. In continuation of studies, herein we would like to disclose a versatile and new method for the preparation of substituted 5*H*-benzocycloheptenes by the following protocols. The key intermediates, 2-allyl-3-alkoxy-4-methoxybenzaldehydes (**1a-e**) and 5-alkoxy-2-crotyl-4-methoxybenzaldehydes (**1f-h**) prepared from isovanillin, were respectively reacted with allyl magnesium bromide to give a series of corresponding alcohols (**2a-h**), followed by RCM with Grubbs' catalyst to afford substituted 5*H*-benzocyclohepten-5-ols (**3a-h**), and then dehydration with a catalytic amount of concentrated sulfuric acid to lead to the desired substituted 5*H*-benzocycloheptenes (**4a-h**) in good yields. The synthetic scheme is shown in Scheme I.

RESULTS AND DISCUSSION

Compound **1a-h**, prepared from allylisovanillin *via*

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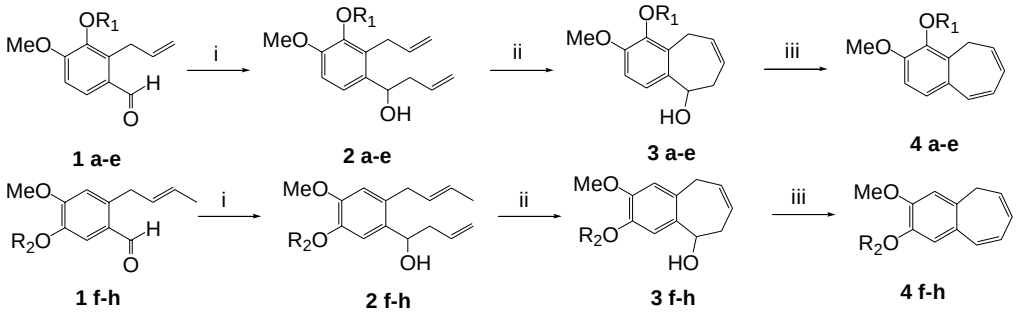
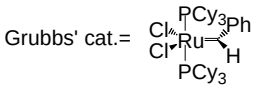
Scheme I



a. $R_1 = CH_3$; b. $R_1 = C_2H_5$; c. $R_1 = CH(CH_3)_2$; d. $R_1 = n\text{-}C_4H_9$; e. $R_1 = CH_2C_6H_5$;
f. $R_2 = CH_3$; g. $R_2 = C_2H_5$; h. $R_2 = CH_2C_6H_5$;

Reagents and conditions : (i) AllylMgBr, dry THF, rt, 2 h ; (ii) 5% mol. Grubbs' cat., 0.05 M dry CH_2Cl_2, rt, 8 h ; (iii) *conc*-H_2SO_4, THF, rt, 1 h.

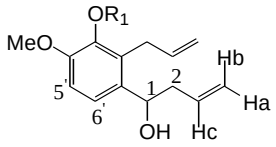


Claisen rearrangement and *O*-alkylation,[12g] underwent the nucleophilic addition of allyl magnesium bromide to give allylalcohols, **2a-h** in yields of 74-86%, respectively. The structures of **2a-h** are supported by their ^{1}H, ^{13}C-NMR and EI-MS spectra. For example, 1-(2-allyl-3,4-dimethoxyphenyl)-3-buten-1-ol (**2a**) showed a new set of allyl signals at 2.47 ppm (2H), 4.88 ppm (1H), 5.12 ppm (1H), 5.16 ppm (1H), 5.84 ppm (1H) and one additional hydroxyl proton at 1.96 ppm, and the disappearance of the formyl proton signal at 9.95 ppm, compared to the starting material, **1a**. The ^{13}C-NMR spectra showed the disappearance of the formyl carbon, and 15 lines (carbons) were found, which matched the structure of **2a**. Furthermore the molecular ion, M^+ = *m/z* 248 of **2a** in EI-MS was found, which was coincident with the calculated one of **2a**. To gather further evidence to support formation of **2a**, high-resolution mass spectroscopy showed the desired molecular formula, $C_{15}H_{20}O_3$. The selected ^{1}H-NMR spectral data of compounds **2a-e** and **2f-h** are summarized in Table 1.

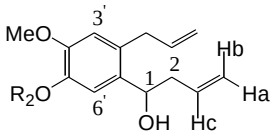
Compounds **2a-h** respectively subjected to cyclize with 5% mole Grubbs' catalyst gave a series of benzocyclohepten-5-ols **3a-h** in yields of 55-88%. The structure of **3a-h** can be supported by their NMR spectra and EI-MS. For example, 6,9-dihydro-1,2-dimethoxy-5*H*-benzocyclohepten-5-ol (**3a**) showed only two olefinic protons at 5.51 ppm and 5.78 ppm in ^{1}H-NMR, and 13 lines (carbons) in ^{13}C-NMR were observed. Furthermore, the loss of one ethylene molecule (28 amu) from **2a** (M^+ = 248) to give **3a** (M^+ = 220) was observed in a molecular ion peak in EI-MS. The selected ^{1}H-NMR spectral data of compounds **3a-e** and **3f-h** are summarized in Table 2.

Finally, compound **3a-h** was respectively dehydrated by concentrated sulfuric acid in anhydrous THF to give a series of new substituted benzocycloheptenes **4a-h** in yields of 86-94%. The evidence of this transformation can easily be observed from either ^{1}H-NMR or ^{13}C-NMR spectra. For example, compound **4a**, showed a doublet signal of benzylic protons at δ 3.14, and two methoxy signals at δ 3.84, and 3.88. No other sp^3-proton was observed, but six sp^2-proton signals with three doublets at δ 6.81 (d, *J* = 8.5 Hz, 1H, ArH), 7.04 (d, *J* = 11.4 Hz, 1H, ArC<u>H</u>=CH), 7.05 (d, *J* = 8.5 Hz, 1H, ArH), two doublet-doublets at δ 6.10 (dd, *J* = 9.6 Hz, *J* = 5.4 Hz, 1H, $ArCH_2CH$=C<u>H</u>), 6.37 (dd, *J* = 11.4 Hz, *J* = 5.4 Hz, 1H, ArCH=C<u>H</u>), and one doublet-triplet signal at δ 5.79 (dt, *J* = 9.6 Hz, 6.9 Hz, 1H, $ArCH_2C$<u>H</u>=CH) matched the structure of **4a**. In ^{13}C-NMR spectra 13 lines (carbons) observed also matched the structure of **4a**. Furthermore, the loss of one water molecule (18 amu) from **3a** (M^+ = 220) to give **4a** (M^+ = 202) was observed in a molecular ion peak in EI-MS. High-resolution mass spectroscopy showed the desired molecular ion at *m/z* 202.0993 ($C_{13}H_{14}O_2$ requires *M*, 202.0994). Further structural proof for the 5*H*-benzocycloheptenes came from the 2D NMR spectroscopy. The relative configuration of **4g** was established from the following NOESY correlations: (a) H-5 ↔ H-6, H-4; (b) CH_3C<u>H_2</u>O-2 ↔ H-1, C<u>H_3</u>CH_2O-2; (c) CH_3O-3 ↔ H-4; and (d) H-8 ↔ H-9, H-7.

Table 1. The selected ^{1}H-NMR spectral data of 1-(2-allyl-4-methoxyphenyl)-3-buten-1-ol (**2a-h**)



2 a-e

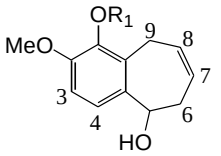


2 f-h

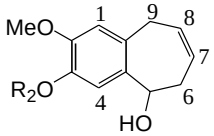
a. $R_1 = CH_3$; b. $R_1 = C_2H_5$; c. $R_1 = CH(CH_3)_2$; d. $R_1 = n\text{-}C_4H_9$; e. $R_1 = CH_2C_6H_5$;
f. $R_2 = CH_3$; g. $R_2 = C_2H_5$; h. $R_2 = CH_2C_6H_5$;

	OH	H-2	H-1	Ha	Hb	Hc
2a	1.96 (d)	2.47 (t)	4.88 (td)	5.12 (ddt)	5.16 (ddt)	5.84 (ddt)
2b	1.90 (br. s)	2.46 (t)	4.88 (t)	5.12 (dd)	5.16 (dd)	5.84 (ddt)
2c	2.03 (br. s)	2.44 (t)	4.88 (t)	5.08 (dd)	5.13 (dd)	5.82 (ddt)
2d	2.06 (br. s)	2.45 (t)	4.84 (t)	5.09 (dd)	5.13 (dd)	5.83 (ddt)
2e	2.00 (br. s)	2.43 (t)	4.86 (t)	5.08 (dd)	5.13 (dd)	5.80 (ddt)
2f	2.09 (d)	2.45 (t)	4.96 (td)	5.14 (dd)	5.17 (dd)	5.84 (ddt)
2g	2.07 (d)	2.44 (t)	4.93 (td)	5.12 (dd)	5.16 (dd)	5.84 (ddt)
2h	2.00 (br. s)	2.36 (t)	4.89 (t)	5.07 (dd)	5.11 (dd)	5.74 (ddt)

Table 2. The selected ^{1}H-NMR spectra of substituted 6,9-dihydro-5*H*-benzocyclohepten-5-ols (**3a-h**)



3 a-e



3 f-h

a. $R_1 = CH_3$; b. $R_1 = C_2H_5$; c. $R_1 = CH(CH_3)_2$; d. $R_1 = n\text{-}C_4H_9$; e. $R_1 = CH_2C_6H_5$;
f. $R_2 = CH_3$; g. $R_2 = C_2H_5$; h. $R_2 = CH_2C_6H_5$;

	OH	Ha-6	Hb-6	Ha-9	Hb-9	H-5	H-7	H-8
3a	2.00 (d)	2.34 (dm)	2.66 (m)	3.38 (dquint.)	3.68 (dd)	5.30 (dt)	5.51 (m)	5.78 (m)
3b	2.04 (br. s)	2.37 (dm)	2.66 (m)	3.36 (dquint.)	3.80 (dd)	5.29 (dt)	5.51 (m)	5.74 (m)
3c	2.03 (br. s)	2.32 (dm)	2.66 (m)	3.33 (dquint.)	3.72 (dd)	5.30 (dt)	5.49 (m)	5.72 (m)
3d	2.03 (br. s)	2.33 (dm)	2.65 (m)	3.35 (dquint.)	3.70 (dd)	5.29 (dt)	5.48 (m)	5.76 (m)
3e	1.94 (br. s)	2.32 (dm)	2.67 (m)	3.28 (dquint.)	3.65 (dd)	5.28 (dt)	5.48 (m)	5.61 (m)
3f	2.88 (br. s)	2.33 (dm)	2.61 (m)	3.12 (dd)	3.55 (dt)	5.24 (dd)	5.49 (ddt)	5.74 (m)
3g	2.41 (br. s)	2.33 (dm)	2.61 (m)	3.10 (dd)	3.55 (dt)	5.25 (dd)	5.50 (m)	5.75 (m)
3h	1.93 (br. s)	2.24 (dm)	2.52 (m)	3.18 (dd)	3.48 (dt)	5.22 (dt)	5.50 (m)	5.75 (m)

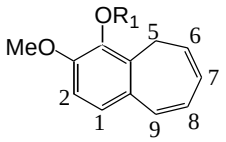
The selected ^{1}H-NMR spectra of **4a-e**, and **4f-h** are compiled in Table 3. The results of percentage yield are summarized in Table 4.

In summary, when it was started from allylisovanillin *via* Claisen rearrangement, *O*-alkylation, nucleophilic addition of allyl Grignard reagent, Grubbs' ring-closing metathesis together with dehydration, a simple, efficient and straightforward route to 4-alkoxy-3-methoxy-5*H*-benzocycloheptenes and 2-alkoxy-3-methoxy-5*H*-benzocycloheptenes was established.

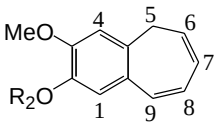
EXPERIMENTAL

^{1}H-NMR spectra were recorded on Varian Gemini-200, Varian Gemini-300 or Varian Unity Plus 400 spectrometers using $CDCl_3$ as solvent, and with TMS as the internal standard. HRMS were recorded on a Chem/hp/middle instrument, and HRMS were recorded on a JEOL, JMSD-200 or on a JEOL, JMS-SX. Elemental analyses were recorded on a Heraeus CHN-O Rapid Analyzer. Silica gel (230-400 mesh) for column chromatography, and precoated silica gel plates

Table 3. The selected ^{1}H-NMR spectra of substituted 5*H*-benzocycloheptenes (**4a-h**)



4 a-e



4 f-h

a. $R_1 = CH_3$; b. $R_1 = C_2H_5$; c. $R_1 = CH(CH_3)_2$; d. $R_1 = n\text{-}C_4H_9$; e. $R_1 = CH_2C_6H_5$; f. $R_2 = CH_3$; g. $R_2 = C_2H_5$; h. $R_2 = CH_2C_6H_5$;

	H-5	H-6	H-7	H-8	H-9
4a	3.14 (d)	5.79 (dt)	6.10 (dd)	6.37 (dd)	7.04 (d)
4b	3.15 (d)	5.76 (dt)	6.09 (dd)	6.36 (dd)	7.03 (d)
4c	3.14 (d)	5.79 (dt)	6.10 (dd)	6.37 (dd)	7.04 (d)
4d	3.15 (d)	5.76 (dt)	6.09 (dd)	6.36 (dd)	7.03 (d)
4e	3.09 (d)	5.54 (dt)	6.04 (dd)	6.36 (dd)	7.03 (d)
4f	2.98 (d)	5.74 (dt)	6.06 (dd)	6.41 (dd)	7.00 (d)
4g	2.98 (d)	5.73 (dt)	6.05 (dd)	6.39 (dd)	6.98 (d)
4h	2.98 (d)	5.60 (dt)	6.05 (dd)	6.37 (dd)	6.92 (d)

Table 4. Yields (%) for compounds **2**,* **3**,* and **4*** in Scheme I

Substituents	Allyl alcohols **2**	Cycloheptenols **3**	5*H*-Benzocycloheptenes **4**
a $R_1 = CH_3$	82	82	92
b $R_1 = C_2H_5$	74	81	92
c $R_1 = CH(CH_3)_2$	78	85	94
d $R_1 = n\text{-}C_4H_9$	80	81	89
e $R_1 = CH_2C_6H_5$	75	88	86
f $R_2 = CH_3$	86	55	94
g $R_2 = C_2H_5$	84	60	93
h $R_2 = CH_2C_6H_5$	83	68	93

*All compounds are new compounds.

(60F-254) for TLC were purchased from E. Merck. UV light (254 nm) was used to detect spots on TLC plates after development. 3-Hydroxy-4-methoxybenzaldehyde (isovanillin) purchased from TCI (Tokyo Kasei Industry) was used directly without purification. Grubbs' catalyst (1st generation) was purchased from Fluca Company.

General procedure for the preparation of 1-(2-allyl-3-alkoxy-4-methoxyphenyl)-3-buten-1-ols (2a-e) and 1-[5-alkoxy-2-(2-butenyl)-4-methoxyphenyl]-3-buten-1-ol (2f-h)

To each of compound **1a-h** (5 mmol) dissolved in anhydrous THF, was added allyl magnesium bromide (1.0 M, 5.5 mL), and stirred at room temperature for 2 hr. Then the solution was quenched with saturated NH_4Cl solution, and extracted with ethyl acetate (15 mL × 5). The extracted solution was washed with brine (10 mL × 2), and dried over anhydrous $MgSO_4$, and filtered. The filtrate was concentrated under vacuum, and the given residue was subjected to chromatographic column (silica gel, *n*-hexane/EA = 3/1) to give the pure **2a-h**.

1-(2-Allyl-3,4-dimethoxyphenyl)-3-buten-1-ol (2a)

Pure **2a** (1.02 g, 82%) was obtained as colorless liquid; R_f 0.33 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 400 MHz) δ 1.96 (d, *J* = 2.8 Hz, 1H, OH), 2.47 (t, *J* = 7.2 Hz, 2H, CH_2=CHC$\underline{H}_2$CH(OH)Ar), 3.45, 3.57 (each ddt, *J* = 15.6 Hz, 5.6 Hz, 2.0 Hz, 1H, CH_2=CHC$\underline{H}_2$Ar), 3.80, 3.86 (each s, 3H, OC$\underline{H}_3$), 4.88 (td, *J* = 7.2 Hz, 2.8 Hz, 1H, CH_2=CHCH_2C$\underline{H}$-(OH)Ar), 4.91 (ddt, *J* = 15.6 Hz, 2.0 Hz, 2.0 Hz, 1H, C$\underline{H}_2$=CHCH_2Ar), 5.02 (ddt, *J* = 10.4 Hz, 2.0 Hz, 2.0 Hz, 1H, C$\underline{H}_2$=CHCH_2Ar), 5.12 (ddt, *J* = 11.6 Hz, 2.0 Hz, 2.0 Hz, 1H, C$\underline{H}_2$=CHCH_2CH(OH)Ar), 5.16 (ddt, *J* = 17.2 Hz, 2.0 Hz, 2.0 Hz, 1H, C$\underline{H}_2$=CHCH_2CH(OH)Ar), 5.84 (ddt, *J* = 17.2 Hz, 11.6 Hz, 7.2 Hz, 1H, CH_2=C$\underline{H}$CH_2CH(OH)Ar), 5.99 (ddt, *J* =

15.6 Hz, 10.4 Hz, 5.6 Hz, 1H, CH_2=C<u>H</u>CH_2Ar), 6.85, 7.23 (each d, *J* = 8.4 Hz, 1H, ArH); ^{13}C-NMR ($CDCl_3$, 100 MHz) δ 29.74, 43.03, 55.61, 60.78, 69.17, 110.62, 115.10, 117.88, 121.41, 130.68, 135.05, 135.29, 137.57, 146.92, 151.88; EI-MS (70 eV) *m/z* (rel. intensity, %) 248 (M^+, 43.67), 202 (9.90), 189 (12.12), 161 (10.81), 131 (9.61), 118 (10.99), 91 (100), 65 (10.31); HRMS calcd for $C_{15}H_{20}O_3$: 248.1412. Found: 248.1412.

1-(2-Allyl-3-ethoxy-4-methoxyphenyl)-3-buten-1-ol (2b)

Pure **2b** (0.97 g, 74%) was obtained as colorless liquid; R_f 0.47 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 400 MHz) δ 1.36 (t, *J* = 7.0 Hz, 3H, $OCH_2C\underline{H}_3$), 1.90 (br s, 1H, OH), 2.46 (t, *J* = 7.8 Hz, 2H, CH_2=CHC<u>H</u>$_2$CH(OHAr), 3.37, 3.57 (each dd, *J* = 15.6 Hz, 6.0 Hz, 1H, CH_2=CHC<u>H</u>$_2$Ar), 3.84 (s, 3H, OC<u>H</u>$_3$), 3.98 (q, *J* = 7.0 Hz, 2H, OC<u>H</u>$_2$CH$_3$), 4.88 (t, *J* = 7.8 Hz, 1H, CH_2=CHCH$_2$C<u>H</u>(OH)Ar), 4.91 (dd, *J* = 15.6 Hz, 1.8 Hz, 1H, C<u>H</u>$_2$=CHCH$_2$Ar), 5.01 (dd, *J* = 10.4 Hz, 1.8 Hz, 1H, C<u>H</u>$_2$=CHCH$_2$Ar), 5.12 (dd, *J* = 10.2 Hz, 1.2 Hz, 1H, C<u>H</u>$_2$=CHCH$_2$CH(OH)Ar), 5.16 (dd, *J* = 17.4 Hz, 1.2 Hz, 1H, C<u>H</u>$_2$=CHCH$_2$CH(OH)Ar), 5.84 (ddt, *J* = 17.4 Hz, 10.2 Hz, 7.8 Hz, 1H, CH_2=C<u>H</u>CH$_2$CH(OH)Ar), 5.97 (ddt, *J* = 15.6 Hz, 10.4 Hz, 6.0 Hz, 1H, CH_2=C<u>H</u>CH$_2$Ar), 6.85, 7.21 (each d, *J* = 8.4 Hz, 1H, ArH); ^{13}C-NMR ($CDCl_3$, 75 MHz) δ 15.55, 29.79, 42.96, 55.47, 68.67, 69.09, 110.40, 114.87, 117.53, 121.15, 130.61, 135.04, 135.28, 137.50, 145.94, 151.79; EI-MS (70 eV) *m/z* (rel. intensity, %) 262 (M^+, 4.74), 244 (2.58), 222 (16.68), 221 (100), 193 (3.56), 190 (2.05), 177 (2.28), 161 (2.26); HRMS calcd for $C_{16}H_{22}O_3$: 262.1569. Found: 262.1568.

1-(2-Allyl-3-isoproxy-4-methoxyphenyl)-3-buten-1-ol (2c)

Pure **2c** (1.1 g, 80%) was obtained as colorless liquid; R_f 0.35 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 400 MHz) δ 1.25 (t, *J* = 6.2 Hz, 6H, OCH<u>Me</u>$_2$), 2.03 (br s, 1H, OH), 2.44 (t, *J* = 7.2 Hz, 2H, CH_2=CHC<u>H</u>$_2$CH(OHAr), 3.46, 3.60 (each dd, *J* = 15.6 Hz, 5.6 Hz, 1H, CH_2=CHC<u>H</u>$_2$Ar), 3.81 (s, 3H, OC<u>H</u>$_3$), 4.50 (hept., *J* = 6.2 Hz, 1H, OC<u>H</u>(CH$_3$)$_2$), 4.88 (t, *J* = 7.2 Hz, 1H, CH_2=CHCH$_2$C<u>H</u>(OH)Ar), 4.91 (dd, *J* = 15.6 Hz, 2.0 Hz, 1H, C<u>H</u>$_2$=CHCH$_2$Ar), 4.99 (dd, *J* = 10.4 Hz, 2.0 Hz, 1H, C<u>H</u>$_2$=CH-CH$_2$Ar), 5.08 (dd, *J* = 10.4 Hz, 2.0 Hz, 1H, C<u>H</u>$_2$=CHCH$_2$CH(OH)Ar), 5.13 (dd, *J* = 17.2 Hz, 2.0 Hz, 1H, C<u>H</u>$_2$=CHCH$_2$CH(OH)Ar), 5.82 (ddt, *J* = 17.2 Hz, 10.4 Hz, 7.2 Hz, 1H, CH_2=C<u>H</u>CH$_2$CH(OH)Ar), 5.99 (ddt, *J* = 15.6 Hz, 10.4 Hz, 5.6 Hz, 1H, CH_2=C<u>H</u>CH$_2$Ar), 6.81, 7.19 (each d, *J* = 8.4 Hz, 1H, ArH); ^{13}C-NMR ($CDCl_3$, 100 MHz) δ 22.47, 22.53, 30.10, 43.06, 55.43, 69.08, 74.39, 110.39, 114.92, 117.55, 120.75, 130.92, 135.08, 135.44, 137.43, 144.43, 151.80; EI-MS (70 eV) *m/z* (rel. intensity, %) 276 (M^+, 21.68), 259 (19.27), 235 (100), 193 (83.69), 175 (15.57), 143 (42.86), 115 (13.62); HRMS calcd for $C_{17}H_{24}O_3$: 276.1725. Found: 276.1723.

1-(2-Allyl-3-butoxy-4-methoxyphenyl)-3-buten-1-ol (2d)

Pure **2d** (1.09 g, 75%) was obtained as colorless liquid; R_f 0.51 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 400 MHz) δ 0.96 (t, *J* = 7.4 Hz, 3H, $OCH_2CH_2CH_2C\underline{H}_3$), 1.49 (sixt, *J* = 7.4 Hz, 2H, $OCH_2CH_2C\underline{H}_2CH_3$), 1.74 (quint, *J* = 7.4 Hz, 2H, $OCH_2C\underline{H}_2CH_2CH_3$), 2.45 (t, *J* = 7.4 Hz, 2H, OC<u>H</u>$_2$CH$_2$-CH$_2$CH$_3$), 2.06 (br. s, 1H, OH), 2.45 (t, *J* = 7.0 Hz, 2H, CH_2=CHC<u>H</u>$_2$CH(OH)Ar), 3.44, 3.55 (each dd, *J* = 15.6 Hz, 5.6 Hz, 1H, CH_2=CHC<u>H</u>$_2$Ar), 3.82 (s, 3H, OC<u>H</u>$_3$), 4.84 (t, *J* = 7.0 Hz, 1H, CH_2=CHCH$_2$C<u>H</u>(OH)Ar), 4.89 (dd, *J* = 15.6 Hz, 2.0 Hz, 1H, C<u>H</u>$_2$=CHCH$_2$Ar), 4.99 (dd, *J* = 10.4 Hz, 2.0 Hz, 1H, C<u>H</u>$_2$=CHCH$_2$Ar), 5.09 (dd, *J* = 10.4 Hz, 1.6 Hz, 1H, C<u>H</u>$_2$=CHCH$_2$CH(OH)Ar), 5.13 (dd, *J* = 16.8 Hz, 1.6 Hz, 1H, C<u>H</u>$_2$=CHCH$_2$CH(OH)Ar), 5.83 (ddt, *J* = 16.8 Hz, 10.4 Hz, 7.0 Hz, 1H, CH_2=C<u>H</u>CH$_2$CH(OH)Ar), 5.96 (ddt, *J* = 15.6 Hz, 10.4 Hz, 5.6 Hz, 1H, CH_2=C<u>H</u>CH$_2$Ar), 6.83, 7.20 (each d, *J* = 8.6 Hz, 1H, ArH); ^{13}C-NMR ($CDCl_3$, 100 MHz) δ 13.85, 19.11, 29.78, 32.32, 43.00, 55.54, 69.13, 72.86, 110.52, 114.93, 117.64, 121.13, 130.65, 135.07, 135.31, 137.58, 146.11, 151.89; EI-MS (70 eV) *m/z* (rel. intensity, %) 290 (M^+, 9.46), 250 (15.58), 249 (100), 193 (24.92), 175 (43.35); HRMS calcd for $C_{18}H_{26}O_3$: 290.1882. Found: 290.1880.

1-(2-Allyl-3-benzyloxy-4-methoxyphenyl)-3-buten-1-ol (2e)

Pure **2e** (1.27 g, 78%) was obtained as colorless liquid; R_f 0.42 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 400 MHz) δ 2.00 (br s, 1H, OH), 2.43 (t, *J* = 6.8 Hz, 2H, CH_2=CH C<u>H</u>$_2$CH(OH)Ar), 3.41, 3.51 (each dd, *J* = 15.6 Hz, 5.6 Hz, 1H, CH_2=CHC<u>H</u>$_2$Ar), 3.84 (s, 3H, OC<u>H</u>$_3$), 4.86 (t, *J* = 6.8 Hz, 1H, CH_2=CHCH$_2$C<u>H</u>(OH)Ar), 4.89 (dd, *J* = 15.6 Hz, 2.0 Hz, 1H, C<u>H</u>$_2$=CHCH$_2$Ar), 4.96 (s, 2H, OC<u>H</u>$_2$Ph), 4.98 (dd, *J* = 10.4 Hz, 2.0 Hz, 1H, C<u>H</u>$_2$=CHCH$_2$Ar), 5.08 (dd, *J* = 10.4 Hz, 1.8 Hz, 1H, C<u>H</u>$_2$=CHCH$_2$CH(OH)Ar), 5.13 (dd, *J* = 16.8 Hz, 1.8 Hz, 1H, C<u>H</u>$_2$=CHCH$_2$CH(OH)Ar), 5.80 (ddt, *J* = 16.8 Hz, 10.4 Hz, 6.8 Hz, 1H, CH_2=C<u>H</u>CH$_2$CH(OH)Ar), 5.94 (ddt, *J* = 15.6 Hz, 10.4 Hz, 5.6 Hz, 1H, CH_2=C<u>H</u>CH$_2$Ar), 6.85, 7.23 (each d, *J* = 8.6 Hz, 1H, ArH), 7.29 (t, *J* = 7.2 Hz, 1H, $OCH_2C_6\underline{H}_5$), 7.35 (t, *J* = 7.2 Hz, 2H, $OCH_2C_6\underline{H}_5$), 7.45 (t, *J* = 7.2 Hz, 2H, $OCH_2C_6\underline{H}_5$); ^{13}C-NMR ($CDCl_3$, 75 MHz) δ 29.87, 43.05, 55.59, 69.11, 74.57, 110.61, 115.08, 117.66, 121.56, 127.70, 127.89, 128.24, 130.81, 135.02, 135.41, 137.46, 137.88, 145.62, 151.86; EI-MS (70 eV) *m/z* (rel. in-

tensity, %): 324 (M^+, 3.98), 284 (10.34), 283 (67.22), 265 (3.11), 131 (2.29), 91 (100); HRMS calcd for $C_{21}H_{24}O_3$: 324.1725. Found: 324.1724.

1-[2-(2-Butenyl)-4,5-dimethoxyphenyl]-3-buten-1-ol (2f)

Pure **2f** (1.13 g, 86%) was obtained as colorless liquid; R_f 0.29 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 400 MHz) δ 1.66 (d, *J* = 6.4 Hz, 3H, C<u>H</u>$_3$CH=CHCH$_2$Ar), 2.09 (d, *J* = 1.0 Hz, 1H, OH), 2.45 (t, *J* = 7.2 Hz, 2H, CH$_2$=CHC<u>H</u>$_2$CHOH), 3.29 (t, *J* = 6.0 Hz, 2H, CH$_3$CH=CHC<u>H</u>$_2$Ar), 3.86, 3.88 (each s, 3H, OC<u>H</u>$_3$), 4.94 (td, *J* = 7.2 Hz, 1.0 Hz, 1H, CH$_2$=CHC<u>H</u>OH), 5.14 (dd, *J* = 10.4 Hz, 0.8 Hz, 1H, C<u>H</u>$_2$=CHCHOH), 5.17 (dd, *J* = 17.4 Hz, 0.8 Hz, 1H, C<u>H</u>$_2$=CHCHOH), 5.43 (dq, *J* = 15.2 Hz, 6.4 Hz, 1H, CH$_3$C<u>H</u>=CHCH$_2$Ar), 5.54 (dt, *J* = 15.2 Hz, 6.0 Hz, 1H, CH$_3$CH=C<u>H</u>CH$_2$Ar), 5.84 (ddt, *J* = 17.4 Hz, 10.4 Hz, 7.2 Hz, 1H, CH$_2$=C<u>H</u>CH$_2$CHOH), 6.63, 7.04 (each s, 1H, Ar<u>H</u>); ^{13}C-NMR ($CDCl_3$, 100 MHz) δ 17.75, 35.19, 43.18, 55.77, 55.82, 69.04, 108.77, 112.65, 117.86, 126.08, 129.30, 130.16, 133.87, 134.91, 147.51, 147.89; EI-MS (70 eV) *m/z* (rel. intensity, %) 262 (M^+, 2.05), 244 (3.37), 222 (15.24), 221 (100), 203 (36.53), 189 (8.01), 188 (23.96), 179 (44.30), 177 (11.91), 172 (10.30), 162 (10.14), 151 (40.34), 136 (6.48), 91 (8.25); *Anal. Calcd* for $C_{16}H_{22}O_3$: C, 73.25; H, 8.45. Found: C, 73.25; H, 8.45.

1-[2-(2-Butenyl)-5-ethoxy-4-methoxyphenyl]-3-buten-1-ol (2g)

Pure **2g** (1.16 g, 84%) was obtained as colorless liquid; R_f 0.43 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 400 MHz) δ 1.45 (t, *J* = 7.2 Hz, 3H, OCH$_2$C<u>H</u>$_3$), 1.66 (d, *J* = 6.4 Hz, 3H, C<u>H</u>$_3$CH=CHCH$_2$Ar), 2.07 (d, *J* = 1.2 Hz, 1H, OH), 2.44 (t, *J* = 7.2 Hz, 2H, CH$_2$=CHC<u>H</u>$_2$CHOH), 3.28 (t, *J* = 6.0 Hz, 2H, CH$_3$CH=CHC<u>H</u>$_2$Ar), 3.85 (s, 3H, OC<u>H</u>$_3$), 4.10 (q, *J* = 7.2 Hz, 2H, OC<u>H</u>$_2$CH$_3$), 4.93 (td, *J* = 7.2 Hz, 1.2 Hz, 1H, CH$_2$=CH-C<u>H</u>OH), 5.12 (dd, *J* = 10.4 Hz, 1.6 Hz, 1H, C<u>H</u>$_2$=CHCHOH), 5.16 (dd, *J* = 17.4 Hz, 1.6 Hz, 1H, C<u>H</u>$_2$=CHCHOH), 5.42 (dq, *J* = 15.2 Hz, 6.4 Hz, 1H, CH$_3$C<u>H</u>=CHCH$_2$Ar), 5.53 (dt, *J* = 15.2 Hz, 6.0 Hz, 1H, CH$_3$CH=C<u>H</u>CH$_2$Ar), 5.84 (ddt, *J* = 17.4 Hz, 10.4 Hz, 7.2 Hz, 1H, CH$_2$=C<u>H</u>CH$_2$CHOH), 6.63, 7.03 (each s, 1H, Ar<u>H</u>); ^{13}C-NMR ($CDCl_3$, 100 MHz) δ 14.76, 17.75, 35.20, 43.14, 55.83, 64.26, 69.00, 110.38, 112.91, 117.78, 126.05, 129.35, 130.21, 133.84, 134.94, 146.79, 148.22; EI-MS (70 eV) *m/z* (rel. intensity, %) 276 (M^+, 2.71), 258 (9.71), 236 (14.62), 235 (100), 217 (18.21), 207 (6.48), 205 (6.13), 193 (27.44), 189 (29.91), 175 (10.90), 165 (27.91), 157 (7.80), 137 (20.71), 131 (8.86), 115 (7.62); *Anal. Calcd* for $C_{17}H_{24}O_3$: C, 73.88; H, 8.75. Found: C, 73.86; H, 8.76.

1-[5-Benzyloxy-2-(2-butenyl)-4-methoxyphenyl]-3-buten-1-ol (2h)

Pure **2h** (1.39 g, 83%) was obtained as colorless liquid; R_f 0.46 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 400 MHz) δ 1.65 (d, *J* = 6.4 Hz, 3H, C<u>H</u>$_3$CH=CHCH$_2$Ar), 2.00 (br s, 1H, OH), 2.36 (t, *J* = 7.2 Hz, 2H, CH$_2$=CHC<u>H</u>$_2$CHOH), 3.27 (t, *J* = 6.0 Hz, 2H, CH$_3$CH=CHC<u>H</u>$_2$Ar), 3.85 (s, 3H, OC<u>H</u>$_3$), 4.89 (t, *J* = 7.2 Hz, 1H, CH$_2$=CHC<u>H</u>OH), 5.07 (dd, *J* = 10.4 Hz, 1.8 Hz, 1H, C<u>H</u>$_2$=CHCHOH), 5.11 (dd, *J* = 17.4 Hz, 1.8 Hz, 1H, C<u>H</u>$_2$=CHCHOH), 5.13 (d, *J* = 6.0 Hz, 2H, OC<u>H</u>$_2$C$_6$H$_5$), 5.40 (dq, *J* = 15.2 Hz, 6.4 Hz, 1H, CH$_3$C<u>H</u>=CHCH$_2$Ar), 5.53 (dt, *J* = 15.2 Hz, 6.0 Hz, 1H, CH$_3$CH=C<u>H</u>CH$_2$Ar), 5.74 (ddt, *J* = 17.4 Hz, 10.4 Hz, 7.2 Hz, 1H, CH$_2$=C<u>H</u>CH$_2$CHOH), 6.65, 7.05 (each s, 1H, Ar<u>H</u>), 7.24-7.45 (m, 5H, OCH$_2$C$_6$<u>H</u>$_5$); ^{13}C-NMR ($CDCl_3$, 100 MHz) δ 17.80, 35.23, 42.98, 55.96, 68.91, 71.01, 111.87, 113.28, 117.81, 126.16, 127.73, 127.69, 128.39, 130.09, 130.15, 133.84, 134.79, 137.22, 146.60, 148.66; EI-MS (70 eV) *m/z* (rel. intensity, %) 338 (M^+, 4.15), 298 (19.97), 297 (100), 255 (5.90), 247 (5.49), 219 (10.16), 177 (7.86), 137 (5.14), 92 (7.41), 91 (80.11); *Anal. Calcd* for $C_{22}H_{26}O_3$: C, 78.07; H, 7.74. Found: C, 78.06; H, 7.76.

General procedure for the preparation of substituted 6,9-dihydro-5*H*-benzocyclohepten-5-ols (3a-h)

To compound **2a-h** (3 mmol) dissolved in anhydrous CH_2Cl_2 (60 mL), was added Grubbs catalyst (5% mol). The mixture was stirred for 8 h at ambient temperature under dry argon. Finally the solvent was removed under reduced pressure, and the residue was subjected to a silica gel column (3:1 hexane/MTBE) or distilled under vacuum to give **3a-h**, respectively.

6,9-Dihydro-1,2-dimethoxy-5*H*-benzocyclohepten-5-ol (3a)

Pure **3a** (0.54 g, 82%) was obtained as colorless crystals; mp 94-95 °C; R_f 0.18 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 400 MHz) δ 2.00 (d, *J* = 2.8 Hz, 1H, O<u>H</u>), 2.34, 2.66 (each m, 1H, H-6), 3.38 (dquint, *J* = 16.8 Hz, 3.2 Hz, 1H, H-9), 3.68 (dd, *J* = 16.8 Hz, 7.2 Hz, 1H, H-9), 3.83, 3.87 (each s, 3H, OC<u>H</u>$_3$), 5.30 (dt, *J* = 10.4 Hz, 3.6 Hz, 1H, H-5), 5.51, 5.78 (each m, 1H, H-7 and H-8), 6.79, 7.17 (each d, *J* = 8.4 Hz, 1H, ArH); ^{13}C-NMR ($CDCl_3$, 100 MHz) δ 23.64, 38.40, 55.71 60.98, 70.17, 109.47, 119.26, 125.80, 127.24, 132.56, 136.70, 145.29, 151.71; EI-MS (70 eV) *m/z* (rel. intensity, %): 220 (M^+, 100), 202 (28.50), 191 (48.65), 186 (42.76), 178 (52.41), 171 (43.46), 159 (29.92), 144 (27.56), 131 (22.26), 128 (24.26), 117 (29.80), 114 (72.79); HRMS calcd for

$C_{13}H_{16}O_3$: 220.1099. Found: 220.1096. *Anal. Calcd* for $C_{13}H_{16}O_3$: C, 70.89; H, 7.32. Found: 70.89; H, 7.31.

6,9-Dihydro-1-ethoxy-2-methoxy-5*H*-benzocyclohepten-5-ol (3b)

Pure **3b** (0.57 g, 81%) was obtained as colorless crystals; mp 98 °C; R_f 0.29 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 1.36 (t, *J* = 7.0 Hz, 3H, $OCH_2C\underline{H}_3$), 2.04 (br s, 1H, O<u>H</u>), 2.37, 2.66 (each m, 1H, H-6), 3.36 (dquint, *J* = 16.8 Hz, 3.2 Hz, 1H, H-9), 3.80 (dd, *J* = 16.8 Hz, 7.2 Hz, 1H, H-9), 3.83 (s, 3H, $OC\underline{H}_3$), 3.95 (q, *J* = 7.0 Hz, 2H, $OC\underline{H}_2CH_3$), 5.29 (dt, *J* = 10.4 Hz, 3.6 Hz, 1H, H-5), 5.51, 5.74 (each m, 1H, H-7 and H-8), 6.78, 7.16 (each d, *J* = 8.6 Hz, 1H, ArH); ^{13}C-NMR ($CDCl_3$, 75 MHz) δ 15.58, 23.90, 38.40, 55.73, 69.09, 70.15, 109.44, 118.98, 125.87, 127.23, 132.88, 136.62, 144.31, 151.80; EI-MS (70 eV) *m/z* 234 (M^+, 100), 216 (65.37), 205 (32.49), 187 (34.74), 173 (16.41), 115 (22.14); *Anal. Calcd* for $C_{14}H_{18}O_3$: C, 71.77; H, 7.74. Found: C, 71.74; H, 7.76.

6,9-Dihydro-1-isopropoxy-2-methoxy-5*H*-benzocyclohepten-5-ol (3c)

Pure **3c** (0.60 g, 81%) was obtained as colorless crystals; mp 101 °C; R_f 0.28 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 1.25 (d, *J* = 6.2 Hz, 3H, $OCH\underline{Me}_2$), 1.28 (d, *J* = 6.2 Hz, 3H, $OCH\underline{Me}_2$), 2.03 (br s, 1H, O<u>H</u>), 2.32, 2.66 (each m, 1H, H-6), 3.33 (dquint, *J* = 16.8 Hz, 3.2 Hz, 1H, H-9), 3.72 (dd, *J* = 16.8 Hz, 7.2 Hz, 1H, H-9), 3.82 (s, 3H, $OC\underline{H}_3$), 4.31 (hept, *J* = 6.2 Hz, 1H, $OC\underline{H}Me_2$), 5.30 (dt, *J* = 10.4 Hz, 3.6 Hz, 1H, H-5), 5.49, 5.72 (each m, 1H, H-7 and H-8), 6.77, 7.15 (each d, *J* = 8.5 Hz, 1H, ArH); ^{13}C-NMR ($CDCl_3$, 100 MHz) δ 22.52, 24.20, 38.42, 55.69, 70.07, 75.08, 109.42, 118.50, 125.96, 127.23, 133.40, 136.61, 143.17, 151.86; EI-MS (70 eV) *m/z* 248 (M^+, 100), 231 (21.61), 206 (36.68), 191 (15.00), 189 (18.66), 188 (76.42), 178 (11.46), 177 (37.03), 173 (39.41), 165 (32.79), 164 (15.61), 156 (19.68), 145 (14.35), 115 (10.56); HRMS calcd for $C_{15}H_{20}O_3$: 248.1412. Found: 248.1412. *Anal. Calcd* for $C_{15}H_{20}O_3$: C, 72.55; H, 8.12. Found: C, 72.55; H, 8.12.

1-Butoxy-6,9-dihydro-2-methoxy-5*H*-benzocyclohepten-5-ol (3d)

Pure **3d** (0.69 g, 88%) was obtained as colorless crystals; mp 67 °C; R_f 0.38 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 0.97 (t, *J* = 7.4 Hz, 3H, $OCH_2CH_2CH_2C\underline{H}_3$), 1.50 (sixt, *J* = 7.4 Hz, 2H, $OCH_2CH_2C\underline{H}_2CH_3$), 1.74 (quint, *J* = 7.4 Hz, 2H, $OCH_2C\underline{H}_2CH_2CH_3$), 2.03 (br s, 1H, O<u>H</u>), 2.33, 2.65 (each m, 1H, H-6), 2.48 (t, *J* = 7.4 Hz, 2H, $OC\underline{H}_2CH_2CH_2CH_3$), 3.35 (dquint, *J* = 16.8 Hz, 3.2 Hz, 1H, H-9), 3.70 (dd, *J* = 16.8 Hz, 7.2 Hz, 1H, H-9), 3.88 (s, 3H, $OC\underline{H}_3$), 5.29 (dt, *J* = 10.4 Hz, 3.6 Hz, 1H, H-5), 5.48, 5.76 (each m, 1H, H-7 and H-8), 6.78, 7.15 (each d, *J* = 8.5 Hz, 1H, ArH); ^{13}C-NMR ($CDCl_3$, 75 MHz) δ 13.89, 19.23, 23.79, 32.26, 38.40, 55.75, 70.15, 73.38, 109.54, 18.91, 125.88, 127.24, 132.73, 136.65, 144.56, 151.79; EI-MS (70 eV) *m/z* 262 (M^+, 98.91), 244 (78.36), 119 (28.71), 189 (23.41), 188 (80.99), 187 (42.73), 177 (48.94), 173 (100), 165 (33.09), 156 (43.08), 145 (28.44), 115 (29.24); *Anal. Calcd* for $C_{16}H_{22}O_3$: C, 73.25; H, 8.45. Found: 73.21; H, 8.44.

1-Benzyloxy-6,9-dihydro-2-methoxy-5*H*-benzocyclohepten-5-ol (3e)

Pure **3e** (0.76 g, 85%) was obtained as colorless crystals; mp 133 °C; R_f 0.26 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 1.94 (br s, 1H, O<u>H</u>), 2.32, 2.67 (each m, 1H, H-6), 3.28 (dquint, *J* = 16.8 Hz, 3.2 Hz, 1H, H-9), 3.65 (dd, *J* = 16.8 Hz, 7.2 Hz, 1H, H-9), 3.87 (s, 3H, $OC\underline{H}_3$), 4.91 (q, *J* = 11.0 Hz, 2H, $OC\underline{H}_2C_6H_5$), 5.28 (dt, *J* = 10.4 Hz, 3.6 Hz, 1H, H-5), 5.48, 5.61 (each m, 1H, H-7 and H-8), 6.82, 7.19 (each d, *J* = 8.4 Hz, 1H, ArH), 7.33 (d, *J* = 7.2 Hz, 2H, $OCH_2C_6\underline{H}_5$), 7.34 (t, *J* = 7.2 Hz, 2H, $OCH_2C_6\underline{H}_5$), 7.46 (d, *J* = 7.2 Hz, 1H, $OCH_2C_6\underline{H}_5$); ^{13}C-NMR ($CDCl_3$, 75 MHz), δ 23.92, 38.41, 55.81, 70.16, 75.27, 109.61, 119.26, 125.83, 127.06, 127.93, 128.34, 128.37, 132.88, 136.69, 137.69, 144.14, 151.77; EI-MS (70 eV) *m/z* 296 (M^+, 26.52), 279 (11.46), 278 (55.92), 205 (11.98), 188 (25.28), 187 (94.43), 173 (12.44), 172 (11.80), 159 (25.83), 144 (20.44), 115 (16.64), 91 (100); *Anal. Calcd* for $C_{19}H_{20}O_3$: C, 77.00; H, 6.80. Found: C, 77.01; H, 6.79.

6,9-Dihydro-2,3-dimethoxy-5*H*-benzocyclohepten-5-ol (3f)

Pure **3f** (0.37 g, 55%) was obtained as colorless liquid; R_f 0.26 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 400 MHz) δ 2.33, 2.61 (each m, 1H, H-6), 2.88 (br s, 1H, OH, D_2O exchangeable), 3.12 (dd, *J* = 16.8 Hz, 7.6 Hz, 1H, H-9), 3.55 (dt, *J* = 16.8 Hz, 3.6 Hz, 1H, H-9), 3.83, 3.84 (each s, 3H, OCH_3), 5.24 (dd, *J* = 10.4 Hz, 3.6 Hz, 1H, H-5), 5.49 (ddt, *J* = 11.6 Hz, 4.8 Hz, 2.4 Hz, 1H, H-7), 5.74 (m, 1H, H-8), 6.60, 7.06 (each s, 1H, H-1 and H-4); ^{13}C-NMR ($CDCl_3$, 100 MHz) δ 32.85, 37.93, 55.80, 55.83, 69.57, 107.95, 112.09, 126.08, 126.61, 130.35, 135.54, 146.82, 147.13; *m/z* (rel. intensity, %) 220 (M^+, 22.54), 203 (20.42), 202 (100), 191 (11.94), 187 (26.61), 179 (25.30), 171 (31.01), 159 (30.31), 151 (21.82), 144 (11.11), 131 (25.18), 129 (13.11), 128 (17.27), 116 (14.77), 115 (28.43); *Anal. Calcd* for $C_{13}H_{16}O_3$: C, 70.89; H, 7.32. Found: C, 70.90; H, 7.32.

3-Ethoxy-6,9-dihydro-2-methoxy-5*H*-benzocyclohepten-5-ol (3g)

Pure **3g** (0.42 g, 60%) was obtained as colorless liquid; R_f 0.30 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 400 MHz) δ 1.44 (t, *J* = 7.0 Hz, 3H, $OCH_2C\underline{H}_3$), 2.33, 2.61 (each m, 1H, H-6), 2.41 (br s, 1H, OH, D_2O exchangeable), 3.10 (dd, *J* = 16.8 Hz, 7.4 Hz, 1H, H-9), 3.55 (dt, *J* = 16.8 Hz, 3.2 Hz, 1H, H-9), 3.84 (s, 3H, OCH_3), 4.09 (q, *J* = 7.0 Hz, 2H, $OC\underline{H}_2CH_3$), 5.25 (dd, *J* = 10.4 Hz, 3.6 Hz, 1H, H-5), 5.50, 5.75 (each m, 1H, H-7 and H-8), 6.62, 7.06 (each s, 1H, H-1 and H-4); ^{13}C-NMR ($CDCl_3$, 100 MHz) δ 14.85, 33.03, 37.99, 56.00, 64.51, 69.88, 109.73, 112.52, 126.27, 126.65, 130.53, 135.45, 146.57, 147.39; *m/z* (rel. intensity, %) 234 (M^+, 47.29), 217 (19.24), 216 (97.47), 205 (22.31), 193 (40.77), 189 (19.76), 188 (100), 187 (26.83), 185 (20.78), 173 (48.44), 165 (36.79), 145 (51.59), 144 (17.95), 137 (26.44), 128 (19.08), 117 (19.45), 115 (35.84); *Anal. Calcd* for $C_{14}H_{18}O_3$: C, 71.77; H, 7.74. Found: C, 71.75; H, 7.75.

3-Benzyloxy-6,9-dihydro-2-methoxy-5*H*-benzocyclohepten-5-ol (3h)

Pure **3h** (0.61 g, 68%) was obtained as colorless crystals; mp 104-105 °C; R_f 0.32 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 400 MHz) δ 1.93 (d, *J* = 4.0Hz, 1H, OH, D_2O exchangeable), 2.24, 2.52 (each m, 1H, H-6), 3.18 (dd, *J* = 16.8 Hz, 7.4 Hz, 1H, H-9), 3.48 (dt, *J* = 16.8 Hz, 3.2 Hz, 1H, H-9), 3.86 (s, 3H, OCH_3), 5.14 (s, 2H, $OC\underline{H}_2C_6H_5$), 5.22 (dt, *J* = 10.4 Hz, 3.8 Hz, 1H, H-5), 5.51, 5.77 (each m, 1H, H-7 and H-8), 6.65, 7.10 (each s, 1H, H-1 and H-4); ^{13}C-NMR ($CDCl_3$, 100 MHz) δ 33.15, 38.00, 56.23, 70.02, 71.37, 111.13, 113.08, 126.28, 126.69, 127.45, 127.74, 128.45, 131.32, 135.52, 137.41, 151.23, 152.00; *m/z* (rel. intensity, %) 296 (M^+, 20.54), 278 (31.40), 205 (15.83), 188 (24.08), 187 (72.13), 159 (42.78), 145 (18.97), 144 (100), 131 (12.86), 128 (16.13), 116 (16.52), 115 (21.18); *Anal. Calcd* for $C_{19}H_{20}O_3$: C, 77.00; H, 6.80. Found: C, 76.98; H, 6.83.

General procedure for the preparation of substituted 5*H*-benzocycloheptenes (4a-h)

To compound **3a-h** (1 mmol) dissolved in anhydrous THF, was respectively added *conc*-H_2SO_4 (1.0 mL), and stirred at room temperature for 1 hr. Then the solution was quenched with 10% NH_4OH solution, and extracted with ethyl acetate (15 mL × 5). The extracted solution was washed with brine (10 mL × 2), and dried with anhydrous $MgSO_4$, and filtered. The filtrate was concentrated under vacuum, and the given residue was subjected to chromatographic column (silica gel, *n*-hexane/EA = 3/1) to give the pure **4a-h**.

3,4-Dimethoxy-5*H*-benzocycloheptene (4a)

Pure **4a** (0.19 g, 92%) was obtained as colorless liquid; R_f 0.71 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 400 MHz) δ 3.14 (d, *J* = 7.0 Hz, 2H, H-5), 3.83, 3.88 (each s, 3H, $OC\underline{H}_3$), 5.79 (dt, *J* = 9.7 Hz, 7.0 Hz, 1H, H-6), 6.10 (dd, *J* = 9.7 Hz, 5.4 Hz, 1H, H-7), 6.37 (dd, *J* = 11.5 Hz, 5.4 Hz, 1H, H-8), 6.81 (d, *J* = 8.5 Hz, 1H, H-2), 7.04 (d, *J* = 11.5 Hz, 1H, H-9), 7.05 (d, *J* = 8.5 Hz, 1H, H-1); ^{13}C-NMR ($CDCl_3$, 100 MHz) δ: 25.89, 55.90, 61.04, 109.53, 123.59, 126.43, 126.70, 126.74, 126.94, 130.67, 133.13, 144.67, 153.61; EI-MS (70 eV) *m/z* (rel. intensity, %) 202 (M^+, 100), 187 (52.19), 171 (44.93), 159 (23.70), 144 (19.76); HRMS: calcd. for $C_{13}H_{14}O_2$: 202.0994. Found: 202.0993.

4-Ethoxy-3-methoxy-5*H*-benzocycloheptene (4b)

Pure **4b** (0.20 g, 92%) was obtained as colorless liquid; R_f 0.72 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 400 MHz) δ 1.42 (t, *J* = 7.1 Hz, 3H, $OCH_2C\underline{H}_3$), 3.15 (d, *J* = 6.9 Hz, 2H, H-5), 3.86 (s, 3H, $OC\underline{H}_3$), 4.01 (q, *J* = 7.1 Hz, 2H, $OC\underline{H}_2CH_3$), 5.76 (dt, *J* = 9.7 Hz, 6.8 Hz, 1H, H-6), 6.09 (dd, *J* = 9.7 Hz, 5.4 Hz, 1H, H-7), 6.36 (dd, *J* = 11.4 Hz, 5.4 Hz, 1H, H-8), 6.79 (d, *J* = 8.5 Hz, 1H, H-2), 7.03 (d, *J* = 11.4 Hz, 1H, H-9), 7.04 (d, *J* = 8.5 Hz, 1H, H-1); ^{13}C-NMR ($CDCl_3$, 100 MHz) δ: 15.67, 26.10, 55.90, 69.13, 109.48, 123.40, 126.51, 126.67, 126.83, 130.72, 131.14, 133.17, 143.70, 153.74; *m/z* (rel. intensity, %) 216 (M^+, 69.55), 205 (43.05), 203 (75.70), 190 (57.69), 187 (44.07), 175 (68.08), 174 (47.44), 173 (51.39), 159 (91.36), 143 (95.61), 131 (74.82), 115 (100), 103 (60.91); HRMS: calcd. for $C_{14}H_{16}O_2$: 216.1150. Found: 216.1150.

4-Isopropoxy-3-methoxy-5*H*-benzocycloheptene (4c)

Pure **4c** (0.21 g, 89%) was obtained as colorless liquid; R_f 0.76 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 400 MHz) δ 1.36 (d, *J* = 6.1 Hz, 6H, $OCH\underline{Me}_2$), 3.14 (d, *J* = 7.0 Hz, 2H, H-5), 3.83 (s, 3H, $OC\underline{H}_3$), 4.42 (hept, *J* = 6.1 Hz, 1H, $OC\underline{H}Me_2$), 5.79 (dt, *J* = 9.7 Hz, 7.0 Hz, 1H, H-6), 6.10 (dd, *J* = 9.7 Hz, 5.4 Hz, 1H, H-7), 6.37 (dd, *J* = 11.5 Hz, 5.4 Hz, 1H, H-8), 6.81 (d, *J* = 8.5 Hz, 1H, H-2), 7.04 (d, *J* = 11.5 Hz, 1H, H-9), 7.05 (d, *J* = 8.5 Hz, 1H, H-1); ^{13}C-NMR ($CDCl_3$, 100 MHz) δ 22.54 ($OCH\underline{Me}_2$), 26.33 (C-5), 55.73 ($O\underline{C}H_3$), 74.91 ($O\underline{C}HMe_2$), 109.38, 123.08, 126.57, 126.62, 130.61, 131.76, 131.76, 133.13, 142.56, 153.77; EI-MS (70 eV) *m/z* (rel. intensity, %): 230 (M^+, 19.51), 188 (27.95), 173 (20.82), 167 (21.76), 149 (100), 145 (20.82), 128 (18.78), 115 (24.75), 104 (16.30); HRMS calcd for $C_{15}H_{18}O_2$: 230.1307. Found:

230.1305.

4-Butoxy-3-methoxy-5*H*-benzocycloheptene (4d)

Pure **4d** (0.21 g, 86%) was obtained as colorless liquid; R_f 0.83 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 400 MHz) δ 1.00 (t, *J* = 7.4 Hz, 3H, $OCH_2CH_2CH_2C\underline{H}_3$), 1.56 (sixt, *J* = 7.4 Hz, 2H, $OCH_2CH_2C\underline{H}_2CH_3$), 1.80 (quint, *J* = 7.4 Hz, 2H, $OCH_2C\underline{H}_2CH_2CH_3$), 3.15 (d, *J* = 7.0 Hz, 2H, H-5), 3.86 (s, 3H, $OC\underline{H}_3$), 3.95 (t, *J* = 7.0 Hz, 2H, $OC\underline{H}_2CH_2CH_2CH_3$), 5.76 (dt, *J* = 9.7 Hz, 7.0 Hz, 1H, H-6), 6.09 (dd, *J* = 9.7 Hz, 5.4 Hz, 1H, H-7), 6.36 (dd, *J* = 11.5 Hz, 5.4 Hz, 1H, H-8), 6.80 (d, *J* = 8.5 Hz, 1H, H-2), 7.03 (d, *J* = 11.5 Hz, 1H, H-9), 7.04 (d, *J* = 8.5 Hz, 1H, H-1); ^{13}C-NMR ($CDCl_3$, 100 MHz) δ 13.94, 19.30, 26.04, 32.36, 55.93, 73.44, 109.59, 123.34, 126.51, 126.69, 126.83, 130.78, 130.93, 133.21, 143.98, 153.73; EI-MS (70 eV) *m/z* (rel. intensity, %): 244 (M^+, 62.02), 188 (42.03), 187 (48.91), 173 (80.34), 156 (36.98), 145 (49.47), 143 (52.11), 128 (39.65), 116 (25.02), 115 (100); HRMS calcd for $C_{16}H_{20}O_2$: 244.1463. Found: 244.1460.

4-Benzyloxy-3-methoxy-5*H*-benzocycloheptene (4e)

Pure **4e** (0.26 g, 94%) was obtained as colorless liquid; R_f 0.87 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 400 MHz) δ 3.09 (d, *J* = 6.9 Hz, 2H, H-5), 3.90 (s, 3H, $OC\underline{H}_3$), 5.00 (s, 2H, $OC\underline{H}_2C_6H_5$), 5.54 (dt, *J* = 9.7 Hz, 6.9 Hz, 1H, H-6), 6.04 (dd, *J* = 9.7 Hz, 5.4 Hz, 1H, H-7), 6.36 (dd, *J* = 11.4 Hz, 5.4 Hz, 1H, H-8), 6.85 (d, *J* = 8.5 Hz, 1H, H-2), 7.03 (d, *J* = 11.4 Hz, 1H, H-9), 7.05 (d, *J* = 8.5 Hz, 1H, H-1), 7.33-7.50 (m, 5H, $OCH_2C_6\underline{H}_5$); ^{13}C-NMR ($CDCl_3$, 100 MHz) δ 29.69, 55.97, 75.33, 109.62, 123.68, 126.49, 126.50, 126.95, 127.98, 128.42, 128.44, 130.77, 131.12, 133.64, 137.75, 143.51, 153.65; *m/z* (rel. intensity, %) 278 (M^+, 45.34), 187 (63.06), 159 (68.69), 158 (27.40), 144 (59.82), 143 (24.40), 127 (19.09), 116 (26.46), 115 (63.98), 114 (31.63), 91 (100); HRMS: calcd. for $C_{19}H_{18}O_2$: 278.1307. Found: 278.1307.

2,3-Dimethoxy-5*H*-benzocycloheptene (4f)

Pure **4f** (0.19 g, 94%) was obtained as colorless crystals; mp 61-62 °C; R_f 0.58 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 400 MHz) δ 2.98 (d, *J* = 6.8 Hz, 2H, H-5), 3.87, 3.89 (each s, 3H, $OC\underline{H}_3$), 5.74 (dt, *J* = 9.6 Hz, 6.8 Hz, 1H, H-6), 6.06 (dd, *J* = 9.6 Hz, 5.6 Hz, 1H, H-7), 6.41 (dd, *J* = 11.6 Hz, 5.6 Hz, 1H, H-8), 6.67, 6.82 (each s, 1H, H-4 and H-1), 7.00 (d, *J* = 11.6 Hz, 1H, H-9); ^{13}C-NMR ($CDCl_3$, 100 MHz) δ: 34.03, 55.85, 55.93, 110.43, 110.62, 125.76, 126.08, 127.33, 128.91, 129.06, 132.96, 146.82, 150.04; *m/z* (rel. intensity, %) 202 (M^+, 100), 187 (26.30), 171 (57.05), 159 (47.98), 157 (18.41), 144 (18.12), 141 (19.32), 131 (35.78), 129 (21.34), 128 (27.73), 116 (20.16), 115 (22.64); HRMS: calcd. for $C_{13}H_{14}O_2$: 202.0994. Found: 202.0989. *Anal. Calcd* for $C_{13}H_{14}O_2$: C, 77.20; H, 6.98. Found: C, 77.20; H, 7.01.

2-Ethoxy-3-methoxy-5*H*-benzocycloheptene (4g)

Pure **4g** (0.20 g, 93%) was obtained as colorless crystals; mp 58-59 °C; R_f 0.68 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 400 MHz) δ 1.45 (t, *J* = 7.0 Hz, 3H, $OCH_2C\underline{H}_3$), 2.98 (d, *J* = 6.8 Hz, 2H, H-5), 3.88 (s, 3H, $OC\underline{H}_3$), 4.08 (q, *J* = 7.0 Hz, 2H, $OC\underline{H}_2CH_3$), 5.73 (dt, *J* = 9.8 Hz, 6.8 Hz, 1H, H-6), 6.05 (dd, *J* = 9.8 Hz, 5.4 Hz, 1H, H-7), 6.39 (dd, *J* = 11.4 Hz, 5.4 Hz, 1H, H-8), 6.66, 6.82 (each s, 1H, H-4 and H-1), 6.98 (d, *J* = 11.4 Hz, 1H, H-9); ^{13}C-NMR ($CDCl_3$, 100 MHz) δ: 14.80, 34.06, 55.88, 64.42, 110.64, 112.25, 125.77, 126.07, 127.19, 128.91, 129.14, 133.01, 146.10, 150.39, *m/z* (rel. intensity, %) 216 (M^+, 100), 188 (69.15), 187 (24.50), 173 (42.57), 145 (52.04), 144 (17.09), 128 (16.72), 115 (25.81); HRMS: calcd. for $C_{14}H_{16}O_2$: 216.1150. Found: 216.1148. *Anal. Calcd* for $C_{14}H_{16}O_2$: C, 77.75; H, 7.46. Found: C, 77.70; H, 7.45.

2-Benzyloxy-3-methoxy-5*H*-benzocycloheptene (4h)

Pure **4h** (0.23 g, 93%) was obtained as colorless crystals; mp 81-82 °C; R_f 0.71 (EA/*n*-Hexane = 1/3); ^{1}H-NMR ($CDCl_3$, 400 MHz) δ 2.98 (d, *J* = 6.8 Hz, 2H, H-5), 3.89 (s, 3H, $OC\underline{H}_3$), 5.12 (s, 2H, $OC\underline{H}_2C_6H_5$), 5.60 (dt, *J* = 9.7 Hz, 6.9 Hz, 1H, H-6), 6.05 (dd, *J* = 9.7 Hz, 5.4 Hz, 1H, H-7), 6.37 (dd, *J* = 11.4 Hz, 5.4 Hz, 1H, H-8), 6.69, 6.86 (each s, 1H, H-4 and H-1), 6.92 (d, *J* = 11.4 Hz, 1H, H-9), 7.32-7.46 (m, 5H, $OCH_2C_6\underline{H}_5$); ^{13}C-NMR ($CDCl_3$, 100 MHz) δ: 34.15, 56.03, 71.37, 111.05, 113.70, 125.86, 126.07, 127.25, 127.30, 127.77, 128.50, 129.00, 129.83, 130.00, 132.99, 137.28, 146.18; *m/z* (rel. intensity, %) 278 (M^+, 45.18), 188 (13.99), 187 (96.43), 159 (48.08), 145 (14.84), 145 (100), 141 (11.56), 131 (15.39), 115 (20.00); HRMS: calcd. for $C_{19}H_{18}O_2$: 278.1307. Found: 278.1305. *Anal. Calcd* for $C_{19}H_{18}O_2$: C, 81.99; H, 6.52. Found: C, 81.95; H, 6.53.

ACKNOWLEDGEMENTS

We are grateful to NSC, Taiwan, for financial support. We are also thankful to Prof. Yamazaki Takao, the preceding president of Toyama Medical and Pharmaceutical University, Japan, for encouragement.

Received September 9, 2003.

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