Available online at www.sciencedirect.com
ScienceDirect
Tetrahedron 63 (2007) 12616–12620
Tetrahedron

The first total synthesis of (±)-laurokamurene B

A. Srikrishna,* I. A. Khan, R. Ramesh Babu and A. Sajjanshetty

Department of Organic Chemistry, Indian Institute of Science, Bangalore, Karnataka 560012, India

Received 7 July 2007; revised 14 September 2007; accepted 4 October 2007
Available online 6 October 2007

Abstract—The first total synthesis of the rearranged aromatic sesquiterpene (±)-laurokamurene B, isolated from the Chinese red alga *Laurencia okamurai* Yamada, has been accomplished, confirming the structure of the natural product. A combination of Ireland–Claisen rearrangement and ring-closing metathesis was employed as key reactions.

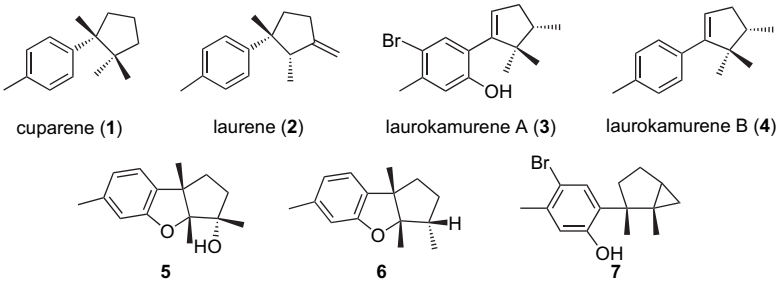
1. Introduction

Red algae of the genus *Laurencia* are found throughout the world. Over the four decades, a significant number of cuparene **1** and laurene **2** sesquiterpenoids have been isolated from the genus *Laurencia*, which are characteristic of the genus.[1] Recently, Mao and Guo in the course of their investigations on the isolation of biologically active compounds from Chinese marine organisms reported the isolation of two new aromatic sesquiterpenes laurokamurenes A and B, **3** and **4**, containing a new rearranged laurene skeleton, along with known laurene sesquiterpenes **5**–**7**.[2] The structures of laurokamurenes A and B, **3** and **4**, were established on the basis of 1 and 2D NMR spectra. A large number of brominated and nonbrominated sesquiterpenes, which can be classified into more than 20 sesquiterpenoid skeletons, are known from the red algae of the genus *Laurencia*. However, in most cases, three methyls in the aliphatic portion were located at either positions 1,2,3 (laurene type) or 1,2,2 (cuparene type).[3] Laurokamurenes **3** and **4** were the first members of a new class of sesquiterpenes with three methyls in the aliphatic ring arranged in a 2,2,3 fashion.

2. Results and discussion

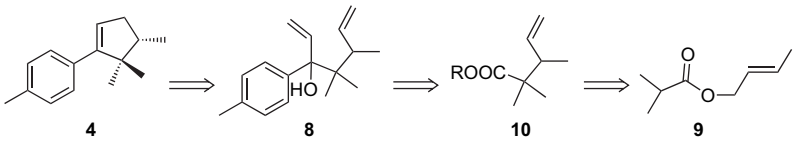
The presence of a new sesquiterpene carbon framework prompted us to investigate the total synthesis of laurokamurene B **4** to unambiguously establish the structure of the marine natural product. It was contemplated, Scheme 1, that a ring-closing metathesis (RCM) reaction[4] of the diene **8** would generate an allyl alcohol, which can be reductively deoxygenated to produce laurokamurene B **4**. An Ireland–Claisen rearrangement[5] of the isobutyrate **9** was conceived for the generation of the hydroxydiene **8** via the ester **10**.

The synthetic sequence starting from isobutyric acid is depicted in Scheme 2. Thus, reaction of isobutyric acid with potassium carbonate and *E*-crotyl chloride in refluxing acetone generated the ester **9** in 80% yield. Ireland–Claisen rearrangement of the ester **9** was explored via the corresponding trimethylsilyl (TMS) enol ether **11**. Thus, generation of the TMS enol ether **11** of the ester **9** with LDA, trimethylsilyl chloride and triethylamine in THF at −70 °C followed by heating the reaction mixture at reflux resulted in the Ireland–Claisen rearrangement. Hydrolysis of the

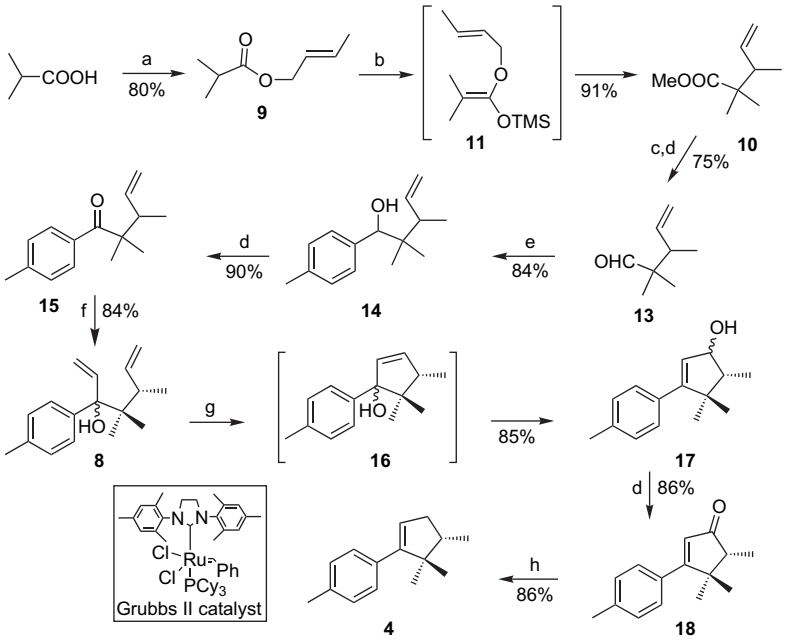


Keywords: Laurenes; Cuparenes; Laurokamurenes A and B; Ring-closing metathesis; Ireland–Claisen rearrangement.
* Corresponding author. Tel.: +91 80 22932215; fax: +91 80 23600529; e-mail: ask@orgchem.iisc.ernet.in

0040–4020/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.tet.2007.10.021



Scheme 1.



Scheme 2. Reagents and conditions: (a) K_2CO_3, acetone, MeCH═CHCH$_2$Cl reflux, 8 h; (b) (i) LDA, THF, TMSCl, NEt_3, −70 °C, 30 min, rt, 4 h, reflux, 4 h; (ii) dil HCl, 40 min; (iii) CH_2N_2, Et_2O, 0 °C, 30 min; (c) LAH, Et_2O, rt, 1 h; (d) PCC, silica gel, CH_2Cl_2, rt, 0.5 h; (e) Li, *p*-MeC_6H_4Br, THF,))), rt, 1 h; (f) CH_2═CHMgBr, THF, 0 °C→rt, 4 h; (g) (i) Grubbs' second generation catalyst (15 mol %), CH_2Cl_2, reflux, 4 h; (ii) moist CH_2Cl_2, silica gel, rt, 1 h; (h) $BF_3 \cdot Et_2O$, $NaCNBH_3$, THF, reflux, 1 h.

reaction mixture with dilute hydrochloric acid followed by esterification with ethereal diazomethane furnished the ester **10** in 91% yield. The ester **10** was then converted into the aldehyde[6] **13** by a two-step protocol, via reduction with lithium aluminium hydride (LAH), followed by oxidation of the resultant primary alcohol **12** with pyridinium chlorochromate (PCC) and silica gel in methylene chloride. Sonochemically accelerated Barbier reaction of the aldehyde **13** with lithium and 4-bromotoluene furnished the secondary alcohol **14** in 84% yield, which on oxidation with PCC and silica gel in methylene chloride at rt furnished the aryl ketone **15** in 90% yield. Grignard reaction with vinylmagnesium bromide in THF transformed the aryl ketone **15** into a 1:1 diastereomeric mixture of the hydroxydiene **8** in 84% yield. RCM reaction of the hydroxydiene **8** with 15 mol % Grubbs' second generation catalyst in methylene chloride at reflux for 4 h furnished the cyclopentenol **16**, which was found to be unstable. Hence, it was treated with silica gel in moist methylene chloride to furnish an ~2:1 epimeric mixture of the rearranged alcohol **17** in 85% yield. Oxidation of the allyl alcohol **17** with PCC and silica gel in methylene chloride at rt furnished the enone **18** in 86% yield, whose structure was established from its spectral data. An ionic hydrogenation reaction[7] was explored for the reductive deoxygenation of the enone **18**.[8] Thus, refluxing a THF solution of the enone **19** with boron trifluoride diethyl etherate and sodium cyanoborohydride for 1 h furnished laurokamurene B **4** in 86% yield. Synthetic (±)-laurokamurene B **4** exhibited spectral data (IR, ^{1}H and ^{13}C NMR) identical to that reported in the literature,[2] confirming the structure of the marine natural product.

In conclusion, we have accomplished the first total synthesis of the sesquiterpene laurokamurene (±)-**4**, confirming the structure of the natural product containing a new sesquiterpene carbon framework. A combination of an Ireland–Claisen rearrangement and a RCM was employed as the key reactions. Laurokamurene B **4** was obtained from isobutyric acid in 10 steps with an average yield of 86% in each step.

3. Experimental section

3.1. General

IR spectra were recorded on Jasco FTIR 410 spectrophotometer. ^{1}H (300 MHz) and ^{13}C (75 MHz) NMR spectra were recorded on JNM λ-300 spectrometer. The chemical shifts (δ ppm) and coupling constants (Hz) are reported in the standard fashion with reference to either internal tetramethylsilane (for ^{1}H) or the central line (77.0 ppm) of $CDCl_3$ (for ^{13}C). In the ^{13}C NMR spectra, the nature of the carbons (C, CH, CH_2 or CH_3) was determined by recording the DEPT-135 spectra, and is given in parentheses. High-resolution mass spectra were recorded using Micromass

Q-TOF micro mass spectrometer using electrospray ionisation.

3.2. *E*-But-2-enyl 2-methylpropionate 9

To a mixture of 2-methylpropanoic acid (1.27 g, 14.4 mmol) and *E*-crotyl chloride (1.0 g, 11.1 mmol) in dry acetone (8 mL) was added anhydrous K_2CO_3 (2.45 g, 17.77 mmol) and the mixture heated at reflux for 8 h. The reaction mixture was concentrated, poured onto crushed ice and extracted with ether (3×5 mL). The ether extract was washed with brine (6 mL) and dried (Na_2SO_4). The solvent was evaporated and the residue was purified on a silica gel column using hexane as eluent to furnish the isobutyrate **9** (1.26 g, 80%) as oil. R_f (5% CH_2Cl_2/hexane) 0.5; IR (neat): ν_{max}/cm^{-1} 1737; ^1H NMR (300 MHz, $CDCl_3$): δ 5.77 (1H, dq, *J* 15.3 and 6.0 Hz), 5.56 (1H, dt, *J* 15.3 and 6.9 Hz), 4.46 (2H, d, *J* 6.3 Hz, OCH_2), 2.52 (1H, septet, *J* 6.9 Hz, Me_2CH), 1.71 (3H, d, *J* 6.0 Hz, =CHCH_3), 1.15 (6H, d, *J* 6.9 Hz, CH(CH_3)$_2$); ^{13}C NMR (75 MHz, $CDCl_3$): δ 176.6 (C), 130.8 (CH), 125.3 (CH), 64.8 (CH_2), 33.9 (CH), 19.0 (2C, CH_3), 17.7 (CH_3); HRMS (ESI): *m*/*z* for $C_8H_{14}O_2Na$ $(M+Na)^+$ calcd: 165.0891; found: 165.0892.

3.3. Methyl 2,2,3-trimethylpent-4-enoate 10

To a pre-cooled (−70 °C), magnetically stirred solution of diisopropylamine (23.7 mmol) in anhydrous THF (10 mL) was added a solution of *n*-BuLi (2.3 M in hexane, 9.2 mL, 21.1 mmol) and stirred for 10 min. To LDA thus formed were added dropwise a solution of the ester **9** (1.2 g, 8.45 mmol) in anhydrous THF (10 mL), TMSCl (2.6 mL, 21.1 mmol) and Et_3N (1.3 mL) and the reaction mixture was stirred for 30 min at the same temperature. It was further stirred at rt for 4 h and then heated at reflux for 4 h. The reaction mixture was then cooled, diluted with ether (5 mL) and 3 N HCl (1 mL) was added and stirred for 40 min. The resulting biphasic mixture was separated, and the aqueous layer was extracted with ether (3×5 mL) and dried (Na_2SO_4). Evaporation of the solvent furnished the acid, which was dissolved in dry ether (5 mL), added dropwise to a cold (0 °C) solution of diazomethane (excess, prepared from 1.4 g of *N*-nitroso-*N*-methylurea and 10 mL 60% aq KOH solution and 10 mL of ether) and the reaction mixture was stirred at rt for 30 min. Evaporation of the solvent on a hot water bath and purification of the residue over a silica gel column using CH_2Cl_2/hexane (1:9) as eluent furnished the ester **10** (1.1 g, 91%) as oil. R_f (10% CH_2Cl_2/hexane) 0.6; IR (neat): ν_{max}/cm^{-1} 1733, 917; ^1H NMR (300 MHz, $CDCl_3$): δ 5.80–5.60 (1H, m, H-4), 5.05–4.95 (2H, m, H-5), 3.64 (3H, s, OCH_3), 2.46 (1H, quintet, *J* 6.9 Hz, H-3), 1.10 (3H, s) and 1.08 (3H, s) [2×*tert*-CH_3], 0.93 (3H, d, *J* 6.9 Hz, *sec*-CH_3); ^{13}C NMR (75 MHz, $CDCl_3$): δ 177.8 (C, OC=O), 139.6 (CH, C-4), 115.6 (CH_2, C-5), 51.4 (CH_3, OMe), 45.4 (C, C-2), 45.1 (CH, C-3), 22.9 (CH_3), 21.0 (CH_3), 15.2 (CH_3); HRMS (ESI): *m*/*z* for $C_9H_{17}O_2$ $(M+H)^+$ calcd: 157.1228; found: 157.1221.

3.4. 2,2,3-Trimethylpent-4-enal 13

To a cold (0 °C) magnetically stirred solution of the pentenoate **10** (200 mg, 1.40 mmol) in dry ether (3 mL) was added LAH (107 mg, 2.82 mmol) and the mixture stirred for 1 h at rt. Ethyl acetate (0.5 mL) was added to the reaction mixture to consume the excess reagent. The reaction was then quenched with water (5 mL) and extracted with ether (3×5 mL). The combined ether extract was washed with brine (5 mL) and dried (Na_2SO_4). Evaporation of the solvent and purification of the residue on a silica gel column using ethyl acetate/hexane (1:3) as eluent furnished the alcohol **12** (168 mg, 92%). To a magnetically stirred suspension of PCC (539 mg, 2.5 mmol) and silica gel (539 mg) in CH_2Cl_2 (1 mL) was added a solution of the alcohol **12** (160 mg, 1.25 mmol) in CH_2Cl_2 (1 mL) and stirred vigorously at rt for 30 min. The reaction mixture was then filtered through a silica gel column using CH_2Cl_2. Evaporation of the solvent furnished the aldehyde **13** (130 mg, 82%) as oil, which was found to decompose slowly on standing.[6] R_f (10% CH_2Cl_2/hexane) 0.8; IR (neat): ν_{max}/cm^{-1} 2704, 1732, 1639, 918; ^1H NMR (300 MHz, $CDCl_3$): δ 9.37 (1H, s, H-1), 5.60 (1H, ddd, *J* 18.3, 9.0 and 7.2 Hz, C*H*=CH_2), 5.02–4.90 (2H, m, CH=CH_2), 2.31 (1H, quintet, *J* 7.2 Hz, C*H*CH=CH_2), 0.91 (6H, s, 2×*tert*-CH_3), 0.88 (3H, d, *J* 7.2 Hz, *sec*-CH_3); ^{13}C NMR (75 MHz, $CDCl_3$): δ 205.6 (CH), 138.9 (CH), 116.2 (CH_2), 48.3 (C), 42.8 (CH_3), 19.7 (CH_3), 17.9 (CH_3), 14.9 (CH_3).

3.5. 2,2,3-Trimethyl-1-(4-methylphenyl)pent-4-en-1-ol 14

To sonochemically activated lithium (22 mg, 3.2 mmol) in dry THF (1 mL) in a round bottom flask was added slowly a solution of the aldehyde **13** (80 mg, 0.63 mmol) and 4-bromotoluene (325 mg, 1.90 mmol) in THF (1 mL) over a period of 5 min and the reaction irradiated sonochemically for 1 h. The reaction mixture was decanted from excess lithium, quenched with aq NH_4Cl (5 mL) and extracted with ether (3×5 mL). The ether extract was washed with brine (5 mL) and dried (Na_2SO_4). Evaporation of the solvent and purification of the residue over a silica gel column using CH_2Cl_2/hexane (1:5) as eluent furnished the alcohol **14** (115 mg, 84%) as oil. R_f (5% EtOAc/hexane) 0.5; IR (neat): ν_{max}/cm^{-1} 3569, 3559, 1514, 913; ^1H NMR (300 MHz, $CDCl_3$): (mixture of two isomers) δ 7.20–6.95 (4H, m, Ar–H), 5.90–5.55 (1H, m, *H*C=CH_2), 5.00–4.85 (2H, m, HC=CH_2), 4.44 and 4.42 (1H, s, C*H*OH), 2.40–2.20 (1H, m), 2.21 (3H, s, Ar–CH_3), 1.68 (1H, br s), 0.92 and 0.89 (3H, d, *J* 7.2 Hz, *sec*-CH_3), 0.73 and 0.72 (3H, s, *tert*-CH_3), 0.52 and 0.51 (3H, s, *tert*-CH_3); ^{13}C NMR (75 MHz, $CDCl_3$): δ 142.1 and 142.0 (CH), 139.3 (C), 136.7 (C), 128.2 (2C, CH), 128.0 (2C, CH), 114.9 and 114.7 (CH_2), 78.7 and 78.6 (CH), 44.0 and 43.9 (CH), 40.6 and 40.2 (C), 21.2 (CH_3), 19.9 and 19.7 (CH_3), 19.3 and 19.0 (CH_3), 15.4 and 15.2 (CH_3); HRMS (ESI): *m*/*z* for $C_{15}H_{22}ONa$ $(M+Na)^+$ calcd: 241.1568; found: 241.1558.

3.6. 2,2,3-Trimethyl-1-(4-methylphenyl)pent-4-en-1-one 15

To a magnetically stirred suspension of PCC (317 mg, 1.48 mmol) and silica gel (317 mg) in CH_2Cl_2 (1 mL) was added a solution of the alcohol **14** (80 mg, 0.37 mmol) in CH_2Cl_2 (0.5 mL). The reaction mixture was stirred at rt for 30 min and then filtered through a small bed of silica gel. Evaporation of the solvent and purification of the residue on a silica gel column using CH_2Cl_2/hexane (1:9) as eluent

furnished the ketone **15** (71 mg, 90%) as oil. R_f (5% EtOAc/hexane) 0.6; IR (neat): ν_{max}/cm^{-1} 1671, 1608, 915; ^1H NMR (300 MHz, $CDCl_3$): δ 7.61 (2H, d, *J* 8.4 Hz) and 7.18 (2H, d, *J* 8.4 Hz) [Ar–H], 5.73 (1H, ddd, *J* 17.4, 10.8 and 8.1 Hz, C*H*=CH_2), 5.02 (1H, d, *J* 10.2 Hz) and 4.99 (1H, d, *J* 17.4 Hz) [CH=CH_2], 2.89 (1H, quintet, *J* 7.2 Hz, C*H*–CH=), 2.39 (3H, s, Ar–CH_3), 1.26 (3H, s) and 1.21 (3H, s) [2×*tert*-CH_3], 0.95 (3H, d, *J* 7.2 Hz, *sec*-CH_3); ^{13}C NMR (75 MHz, $CDCl_3$): δ 207.8 (C), 141.1 (C), 139.7 (CH), 136.4 (C), 128.7 (2C, CH), 128.2 (2C, CH), 115.9 (CH_2), 50.6 (C), 44.4 (CH), 24.2 (CH_3), 21.6 (CH_3), 21.5 (CH_3), 15.3 (CH_3); HRMS (ESI): *m/z* for $C_{15}H_{21}O$ $(M+H)^+$ calcd: 217.1592; found: 217.1586.

3.7. 4,4,5-Trimethyl-3-(4-methylphenyl)hepta-1,6-dien-3-ol 8

To a cold (0 °C) magnetically stirred solution of the ketone **15** (280 mg, 1.30 mmol) in THF (1 mL) was added dropwise a solution of vinylmagnesium bromide [freshly prepared from Mg (127 mg, 5.21 mmol) and vinyl bromide (0.55 mL, 7.82 mmol) in THF (3 mL)] and stirred at rt for 4 h. The reaction was quenched with cold saturated aq NH_4Cl (10 mL) and extracted with ether (3×5 mL). The organic layer was washed with water and brine, and dried (Na_2SO_4). Evaporation of the solvent and purification of the residue on a silica gel column using ethyl acetate/hexane (1:19) as eluent furnished a ~1:1 diastereomeric mixture of the hydroxydiene **8** (267 mg, 84%) as oil. R_f (5% EtOAc/hexane) 0.55; IR (neat): ν_{max}/cm^{-1} 3542, 1513, 918; ^1H NMR (300 MHz, $CDCl_3$): (mixture of two isomers) δ 7.31 and 7.27 (2H, d, *J* 8.4 Hz), 7.06 and 7.03 (2H, d, *J* 8.4 Hz), 6.80 and 6.66 (1H, dd, *J* 16.8 and 10.5 Hz), 6.10–5.80 (1H, m), 5.40–4.90 (4H, m), 2.68 (1H, s, OH), 2.55–2.45 (1H, m), 2.32 and 2.30 (3H, s), 0.95 and 0.93 (3H, d, *J* 6.9 Hz), 0.90 and 0.88 (3H, s), 0.86 and 0.85 (3H, s); ^{13}C NMR (75 MHz, $CDCl_3$): (mixture of two isomers) δ 145.0 and 144.0 (CH), 142.6 and 142.0 (CH), 142.2 and 141.4 (C), 135.9 and 135.6 (C), 128.0 and 127.9 (2C, CH), 127.6 and 127.4 (2C, CH), 115.0 and 113.9 (CH_2), 113.6 and 113.3 (CH_2), 82.4 and 82.2 (C), 43.8 and 43.4 (C), 43.8 and 43.4 (CH), 23.3 and 21.4 (CH_3), 21.0 (CH_3), 18.1 (CH_3), 17.7 and 17.0 (CH_3); HRMS (ESI): *m/z* for $C_{17}H_{24}ONa$ $(M+Na)^+$ calcd: 267.1725; found: 267.1722.

3.8. 4,4,5-Trimethyl-3-(4-methylphenyl)cyclopent-2-en-1-ol 17

To a diastereomeric mixture of the hydroxydiene **8** (50 mg, 0.21 mmol) in anhydrous CH_2Cl_2 (10 mL, 0.02 M) was added Grubbs' second generation catalyst (26 mg, 15 mol %) and the mixture heated at reflux for 4 h. The solvent was then removed under reduced pressure. The residue was then taken in moist CH_2Cl_2 (2 mL), silica gel added (~1 g) and the mixture magnetically stirred at rt for 1 h. The reaction mixture was then filtered through a small pad of silica gel using CH_2Cl_2 as eluent. Evaporation of the solvent and purification of the residue on a silica gel column using ethyl acetate/hexane (1:19) as eluent furnished 1:3 epimeric mixture of the cyclopentenol **17** (35 mg, 85%) as oil. R_f (5% EtOAc/hexane) 0.4; IR (neat): ν_{max}/cm^{-1} 3376, 1510; ^1H NMR (300 MHz, $CDCl_3$): (peaks due to the major isomer) δ 7.19 (2H, d, *J* 8.1 Hz) and 7.08 (2H, d, *J* 8.1 Hz) [Ar–H], 5.85 (1H, d, *J* 2.4 Hz, C=C*H*CHOH), 4.48 (1H, dd, *J* 6.3 and 3.0 Hz, C*H*OH), 2.34 (3H, s, Ar–CH_3), 2.05–1.70 (3H, m), 1.14 (3H, s, *tert*-CH_3), 1.06 (3H, d, *J* 6.9 Hz, *sec*-CH_3), 1.05 (3H, s, *tert*-CH_3); ^{13}C NMR (75 MHz, $CDCl_3$): (peaks due to the major isomer) δ 158.5 (C), 136.8 (C), 134.4 (C), 128.7 (2C, CH), 128.1 (CH, C-2), 127.7 (2C, CH), 76.4 (CH), 49.2 (CH), 47.9 (C), 26.1 (CH_3), 25.6 (CH_3), 21.3 (CH_3), 8.9 (CH_3); HRMS (ESI): *m/z* for $C_{15}H_{20}ONa$ $(M+Na)^+$ calcd: 239.1412; found: 239.1423.

3.9. 4,4,5-Trimethyl-3-(4-methylphenyl)cyclopent-2-en-1-one 18

To a magnetically stirred suspension of PCC (139 mg, 0.65 mmol) and silica gel (139 mg) in CH_2Cl_2 (1 mL) was added a solution of the alcohol **17** (35 mg, 0.16 mmol) in CH_2Cl_2 (0.5 mL). The reaction mixture was stirred at rt for 30 min and filtered through a small bed of silica gel column using CH_2Cl_2. Evaporation of the solvent furnished the cyclopentenone **18** (30 mg, 86%) as oil. R_f (5% EtOAc/hexane) 0.45; IR (neat): ν_{max}/cm^{-1} 1705, 1611, 1587, 1509; ^1H NMR (300 MHz, $CDCl_3$): δ 7.36 (2H, d, *J* 8.1 Hz) and 7.20 (2H, d, *J* 8.1 Hz) [Ar–H], 6.13 (1H, s, C=C*H*C=O), 2.40 (3H, s, Ar–CH_3), 2.35 (1H, q, *J* 7.5 Hz, C*H*Me), 1.35 (3H, s) and 1.23 (3H, s) [2×*tert*-CH_3], 1.14 (3H, d, *J* 7.5 Hz, *sec*-CH_3); ^{13}C NMR (75 MHz, $CDCl_3$): δ 209.1 (C, C=O), 182.1 (C, C-3), 139.5 (C), 132.2 (C), 129.2 (2C, CH), 127.9 (CH, C-2), 127.8 (2C, CH), 54.6 (CH, C-5), 46.6 (C, C-4), 26.5 (CH_3), 24.7 (CH_3), 21.4 (CH_3), 9.8 (CH_3); HRMS (ESI): *m/z* for $C_{15}H_{19}O$ $(M+H)^+$ calcd: 215.1436; found: 215.1436.

3.10. 4,5,5-Trimethyl-1-(4-methylphenyl)cyclopentene (4, laurokamurene B)

Sodium cyanoborohydride (16 mg, 0.25 mmol) was added to a magnetically stirred solution of the enone **18** (15 mg, 0.07 mmol) and boron trifluoride etherate (0.1 mL, 0.9 mmol) in 1 mL of dry THF and the reaction mixture was heated at reflux for 1 h. After completion of the reaction (monitored by TLC), saturated aq $NaHCO_3$ (2 mL) was added to the reaction mixture and extracted with ether (3×5 mL). The ether extract was washed with brine (5 mL) and dried (Na_2SO_4). The solvent was evaporated and the residue was purified on a silica gel column using hexane as eluent to furnish laurokamurene B **4** (12 mg, 86%) as oil. R_f (hexane) 0.8; IR (neat): ν_{max}/cm^{-1} 1510, 828, 721; ^1H NMR (300 MHz, $CDCl_3$): δ 7.18 (2H, d, *J* 8.0 Hz) and 7.07 (2H, d, *J* 8.0 Hz) [Ar–H], 5.67 (1H, br s, *H*C=C), 2.50–2.30 (1H, m), 2.33 (3H, s, Ar–CH_3), 2.10–1.90 (2H, m), 1.09 (3H, s, *tert*-CH_3), 1.00 (3H, d, *J* 6.6 Hz, *sec*-CH_3), 0.97 (3H, s, *tert*-CH_3); ^{13}C NMR (75 MHz, $CDCl_3$): δ 152.9 (C, C-1), 136.0 (C), 135.5 (C), 128.6 (2C, CH), 127.5 (2C, CH), 126.1 (CH, C-2), 47.8 (C, C-5), 45.8 (CH, C-4), 37.9 (CH_2, C-3), 26.3 (CH_3), 21.2 (CH_3), 20.8 (CH_3), 14.2 (CH_3); HRMS (ESI): *m/z* for $C_{15}H_{19}$ $(M-H)^+$ calcd: 199.1482; found: 199.1478.

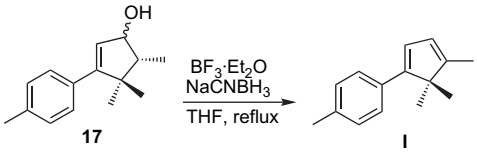
Acknowledgements

We thank the Indian Academy of Sciences and Indian National Science Academy for providing summer fellowships

to I.A.K. and A.S., and University Grants Commission, New Delhi for the award of a research fellowship to R.R.B.

References and notes

1. Martin, J. D.; Darias, J. *Marine Natural Products*; Scheuer, P. J., Ed.; Academic: New York, NY, 1978; Vol. 1, pp 151–161.
2. Mao, S.-C.; Guo, Y.-W. *J. Nat. Prod.* **2006**, *69*, 1209–1211.
3. Mao, S.-C.; Guo, Y.-W. *Chin. Tradit. Herb. Drugs* **2004**, *35*, 8–17.
4. (a) Grubbs, R. H.; Chang, S. *Tetrahedron* **1998**, *54*, 4413–4450; (b) Fürstner, A. *Angew. Chem., Int. Ed.* **2000**, *39*, 3013–3043; (c) Trnka, T. M.; Grubbs, R. H. *Acc. Chem. Res.* **2001**, *34*, 18–29; (d) Grubbs, R. H. *Tetrahedron* **2004**, *60*, 7117–7140.
5. (a) Ireland, R. E.; Mueller, R. H. *J. Am. Chem. Soc.* **1972**, *94*, 5897–5898; (b) Ireland, R. E.; Wipf, P.; Armstrong, J. D. *J. Org. Chem.* **1991**, *56*, 650–657; (c) Gilbert, J. C.; Yin, J.; Fakhreddine, F. H.; Karpinski, M. L. *Tetrahedron* **2004**, *60*, 51–60.
6. Bailey, P. D.; Harrison, M. J. *Tetrahedron Lett.* **1989**, *30*, 5341–5344.
7. Srikrishna, A.; Viswajanani, R.; Sattigeri, J. A.; Yelamaggad, C. V. *Tetrahedron Lett.* **1995**, *36*, 2347–2350.
8. Initially, reductive deoxygenation of the allyl alcohol **17** was attempted via ionoic hydrogenation to generate directly laurokamurene B **4**. However, treatment of the allyl alcohol **17** with boron trifluoride diethyl etherate and sodium cyanoborohydride in refluxing THF furnished laurokamuradiene **I** by rapid dehydration, whose structure was established from its IR and NMR spectral data. IR (neat): ν_{max}/cm^{-1} 1508; ^1H NMR (300 MHz, $CDCl_3$): δ 7.38 (2H, d, J 8.1 Hz) and 7.11 (2H, d, J 8.1 Hz) [Ar–H], 6.55 (1H, br s), 5.98 (1H, br s), 2.34 (3H, s, Ar–CH_3), 1.92 (3H, s), 1.20 (6H, s, 2×*tert*-CH_3); ^{13}C NMR (100 MHz, $CDCl_3$): δ 155.5 (C), 153.6 (C), 135.6 (C), 133.7 (C), 129.0 (2C, CH), 126.0 (2C, CH), 125.3 (CH), 123.4 (CH), 53.0 (C), 29.8 (CH_3), 22.6 (2C, CH_3), 21.3 (CH_3), 12.6 (CH_3).



17 I