LIST OF PUBLICATIONS

1. Tris(Pentafluorophenyl)borane: a mild and efficient catalyst for the chemoselectiv tritylation of alcohols. Ch. Raji Reddy*, G. Rajesh, **S.V. Balaji**, N. Chethan *(Tetrahedron letters*, **2008**, *6*, 970-973)

2. First total synthesis of achaetolide: S.Chandrasekhar*, **S.V.Balaji**, G. Rajesh. (*Tetrahedron letters*, **2010**, *51*, 5164-5166)

3. Total synthesis of Pectinolide A and Pectinolide H
   S.Chandrasekhar*, **S.V.Balaji** (To be communicated)

4. Carbohydrate-pyrrolidine based organocatalyst for enantioselective Michael addition of carbonyls to nitroolefins.
   S.Chandrasekhar*, **S.V.Balaji** (To be communicated)

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irst total synthesis of achaetolide

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ABSTRACT

The first total synthesis of achaetolide, a 10-membered macrolactone was achieved using Mitsunobu reaction and Grubbs ring-closing metathesis reaction as the key steps for ring construction. The desired stereo centres were generated by Jacobsen hydrolytic kinetic resolution, dihydroxylation and Sharpless asymmetric epoxidation reactions.

In 1983, Bodo et al. reported the isolation of achaetolide Fig. 1) from the culture broth of *Achaetomium crisalliferum*.[1] wever, the stereochemistry of **1** was unknown until recently. 2009, Takada and co-workers established the stereochemistry **1** after isolating it from a different species, *Ophiobolus* sp.[2] achaeide is a 10-membered macrolide having four stereo centres, ee hydroxyl groups and a trans-olefin functionality. The biolog-l activity of **1** was also unknown. The structural features of aetolide combined with our interest on synthesis of macroes[3] prompted us for the synthesis of achaetolide. Further, its emical synthesis would allow to evaluate the biological activity. Our retrosynthetic plan was to construct the complete skeleton ough the assembly of the fragments: secondary alcohol **2** and d **3** through a Mitsunobu esterification followed by ring closing tathesis (RCM) reaction. The fragment **2** was envisioned from ichlorohydrin (**6**) using Jacobsen hydrolytic kinetic resolution d dihydroxylation for the generation of stereo centres and the d fragment **3** can be obtained from the known epoxy alcohol ich in turn is prepared from 1,3-propane diol (Scheme 1).

The synthesis of alcohol **2** began from the commercially availe epichlorohydrin (**6**), regioselective ring opening of the epoxide g by *n*-hexylmagnesium bromide in the presence of CuCN folved by intramolecular substitution using NaOH to give nonene ide **8** in 70% (for two steps). The epoxide was enantioselectively olved using (*S,S*)-Jacobsen's catalyst (**I**) by hydrolytic kinetic resition to give **9** in 43% yield.[4] Next, ring opening of the epoxide th lithium salt of ethyl propiolate gave the homopropargylic ohol **10** (80%).[5] To make a six-membered unsaturated lactone, wo-step sequence was followed; partial hydrogenation of the yne using Lindlar's catalyst (palladium on $CaCO_3$, poisoned with quinoline) followed by lactonisation using catalytic *p*-TSA afford the lactone **12** in 82% yield (for two steps). Dihydroxylation of using catalytic OsO_4 and NMO was highly diasteroselective. The diol **13** was obtained as a sole product in 58% yield, which was protected as its acetonide using 2,2-DMP and cat. PPTS to afford the lactone **14** in 72% yield.[6] The lactone was then reduced to lactol **15** (78%) using DIBAL-H which on homologation using $PPh_3^+ CH_3Br^-$ gave the alcohol **2** in 77% yield (Scheme 2).

The synthesis of acid **3** (Scheme 3) began with 1,3-propane diol **7** which was transformed to epoxy alcohol **5** using a known sequence.[7] The epoxy alcohol **5** was then iodinated using TPP, iodine and imidazole, which on refluxing in ethanol in the presence of zinc transforms to secondary allylic alcohol followed by the

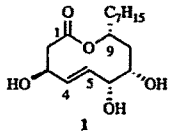
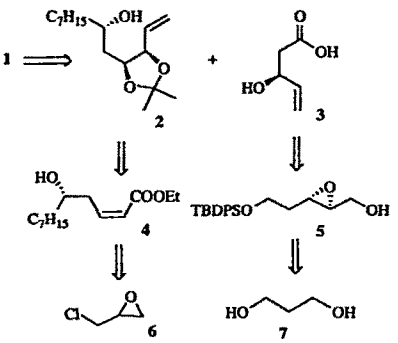


Figure 1. Structure of achaetolide.



Scheme 1. Retrosynthetic analysis.

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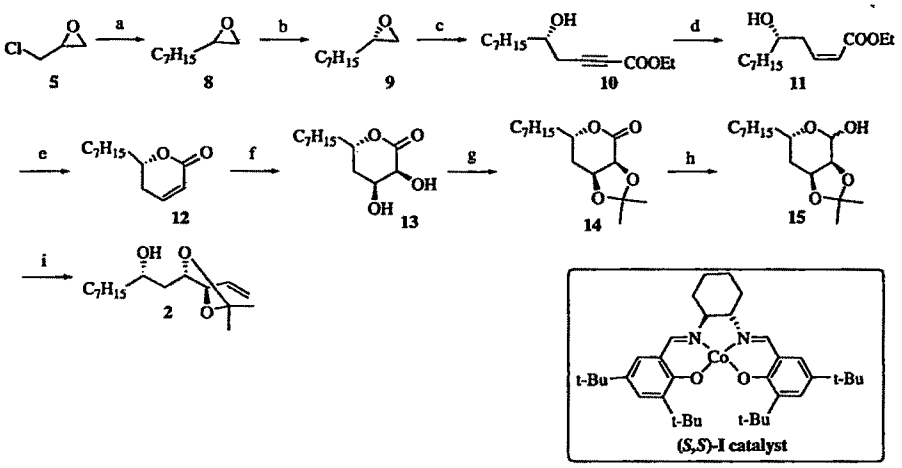
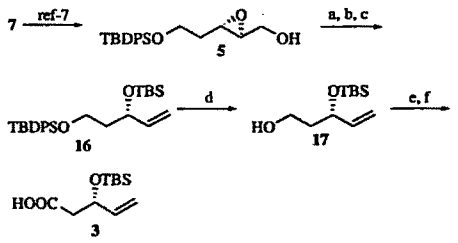
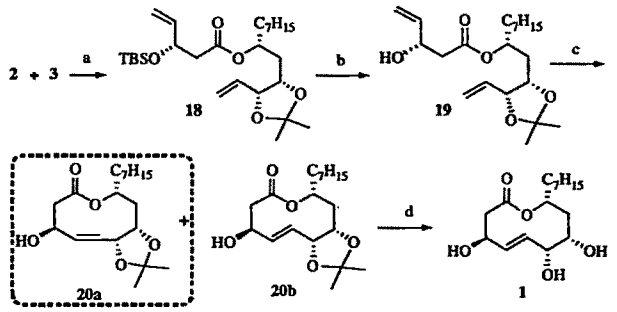


Scheme 2. Reagents and conditions: (a) (i) n-$C_6H_{13}MgBr$, CuCN, THF, −78 °C, 3 h; (ii) NaOH, THF, 0 °C to rt, 70% (for two steps), (b) (*S,S*)-*I*, H_2O AcOH, toluene. 0 °C to rt, 10 h, 43%; (c) ethyl propiolate, n-BuLi, BF_3·OEt_2, THF, −78 °C, 80%; (d) Lindlar's catalyst, quinoline (cat), H_2, benzene, 1 h; (e) p-TSA (cat), benzene 82% (for two steps); (f) OsO_4, NMO, acetone/H_2O (7:3), rt, 58%, 12 h; (g) 2,2-DMP, PPTS (cat), CH_2Cl_2, 72%, 2 h; (h) DIBAL-H, CH_2Cl_2, −78 °C, 30 min, 78%; (i) $PPh_3{}^+CH_3Br^-$, n-BuLi, THF, 0 °C to rt, 4 h, 77%.



Scheme 3. Reagents and conditions: (a) TPP, I_2, imidiazole, Et_2O/CH_3CN (3:1), 0 °C to rt 30 min, 88%; (b) Zn, ethanol, reflux, 2 h, 85%; (c) TBSCl, imidiazole, CH_2Cl_2, 0 °C to rt, 95%; (d) $NH_4{}^+F^-$, CH_3OH, 10 h, 80%; (e) IBX, DMSO, THF, rt, 1 h; (f) $NaClO_2$, NaH_2PO_4, 2-methyl-2-butene, t-BuOH/H_2O (7:3), 6 h, 76%.



Scheme 4. Reagents and conditions: (a) DIAD, PPh_3, benzene, 6 h, 0 °C to rt, 62%; (b) TBAF, 1 M solution, THF, 0 °C to rt, 1 h, 87%; (c) Grubbs' catalyst II, 3 h, 40 °C, 70% (mixture of cis and trans); (d) TFA, CH_2Cl_2, 0 °C to rt, 1 h, 65%.

protection as TBS ether **16** in 88% (for three steps). Selective deprotection of the TBDPS ether using $NH_4{}^+F^-$ gave the alcohol **17** in 80% yield. The alcohol on oxidation with IBX afforded the aldehyde, which on further oxidation using $NaClO_2$ and NaH_2PO_4 in the presence of 2-methyl-2-butene gave the acid **3** in 76% yield (two steps).

The alcohol **2** and the acid **3** were coupled under Mitsunobu conditions to afford the diene **18** in 62% yield, with the inversion of configuration at the hydroxyl carbon.[8] Having the diene in hand, the stage is set for the RCM reaction. Though RCM reaction is an efficient method for the construction of macrolide core, it is well documented that the outcome of an RCM reaction depends upon the stereochemistry near the alkene, protecting group, catalyst etc.[9] The diene **18** on RCM reaction condition did not afford the expected product, therefore the TBS group was deprotected using 1 M solution of TBAF to afford the allylic alcohol **19** in 87% yield. This allylic alcohol underwent RCM reaction neatly under refluxing CH_2Cl_2 in 2 h. Though the reaction was successful, a mixture of *Z* (**20a**, 23%) and *E* alkenes (**20b**, 47%) was formed in 4:6 ratio, which was easily separated by column chromatography. Acetonide deprotection of **20b** using TFA gave achaetolide **1** (Scheme 4). The spectroscopic data of **1** were compared with that of the natural product data and were found to exist as a mixture of conformers as reported by Takada.[2,10]

In conclusion, for the first time, we have accomplished the total synthesis of achaetolide. The synthetic sequence demonstrates the application of Mitsunobu reaction and ring-closing metathesis for the construction of a macrolide as key steps.

Acknowledgement

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10. *Spectral data of representative compounds*: Compound **11**: colourless liquid: $[\alpha]_D^{32}$ 4.7 (*c* 0.69, MeOH); ^{1}H NMR (300 MHz, $CDCl_3$): δ 6.3–6.4 (1H, m), 5.89 (1H, td, *J* = 11.3, 1.5 Hz); 4.16 (2H, q, *J* = 6.7 Hz), 3.66–3.79 (1H, m); 2.76 (2H, ddd, *J* = 8.3, 6.0, 1.5 Hz); 1.98 (1H, d, *J* = 4.5 Hz), 1.20–1.52 (15H, m), 0.85 (3H, t, *J* = 6.7 Hz); ^{13}C NMR (75 MHz, $CDCl_3$): 166.8, 146.2, 121.5, 71.1, 60.0, 37.4, 36.4, 31.7, 29.5, 29.1, 25.5, 22.5, 14.1, 13.9. IR ν_{max} (KBr): 3426, 2927, 2858, 1715, 1177 cm^{-1}; (ESI-MS): *m/z* 243 (M+H). Compound **12**: colourless liquid: $[\alpha]_D^{33}$ 88.5 (*c* 0.51, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$): δ 6.79–6.86 (1H, m), 5.99 (1H, td, *J* = 9.8, 1.5 Hz), 4.33–4.43 (1H, m), 2.28–2.34 (2H, m), 1.73–1.86 (1H, m), 1.22–1.68 (11 H, m); 0.89 (3H, t, *J* = 6.7 Hz); ^{13}C NMR (75 MHz, $CDCl_3$): δ 164.6, 145, 121.4, 78.0, 34.8, 31.7, 29.4, 29.3, 29.1, 24.8, 22.6, 14.0.; IR ν_{max} (KBr): 2926, 2857, 1718, 1638 cm^{-1}; (ESI-MS): *m/z* 197 (M+H) HRMS: calcd for $C_{12}H_{20}NaO_2$: 219.1356 (M+Na), found: 219.1354. Compound **13**: white solid; mp: 90–92 °C; $[\alpha]_D^{33}$ −32.0 (*c* 0.18, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$): δ 4.67–4.78 (1H, m), 4.27–4.31 (1H, m), 4.0 (1H, m), 3.43 (1H, br s), 2.7 (1H, br s) 2.2 (1H, td, *J* = 14.3, 3.7 Hz), 1.2–1.85 (13H, m), 0.89 (3H, t, *J* = 6.7 Hz); ^{13}C NMR (75 MHz, $CDCl_3$): δ 174.2, 78.3, 70.4, 65.9, 35.5, 33.8, 31.6, 29.2, 29.0, 24.7, 22.5, 14.0; IR ν_{max} (KBr): 3390, 2920, 2851, 1728, 1229, 1109 cm^{-1}; (ESI-MS): *m/z* 231 (M+H). Compound **15**: colourless liquid; $[\alpha]_D^{33}$ −45.3 (*c* 0.91, $CHCl_3$); 4.6 (1H, d, *J* = 5.8 Hz), 4.29–4.33 (1H, m), 3.67 (1H, t, *J* = 5.8 Hz), 3.57–3.64 (1H, m), 2.9 (1H, br s), 1.88–1.93 (1H, m), 1.64 (1H, ddd, *J* = 14.6, 10.9, 3.9 Hz), 1.1–1.5 (18H, m), 0.82 (3H, t, *J* = 6.8 Hz) 109.1, 96.4, 76.5, 70.5, 72.8, 35.4, 32.6, 31.7, 29.5, 29.1, 27.9 25.8, 25.4, 22.6, 14.0.; IR ν_{max} (KBr): 3422, 2926, 2856, 1051 cm^{-1}; (ESI-MS): *m/z* 295 (M+Na) HRMS: calcd for $C_{15}H_{28}NaO_4$: 295.1880 (M+Na) found: 295.1877. Compound **2**: colourless liquid; $[\alpha]_D^{32}$ −14.0 (*c* 0.2, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$): δ 5.76 (1H, ddd *J* = 17.3, 9.8, 7.5 Hz), 5.20–5.34 (2H, m), 4.52 (1H, td, *J* = 7.5, 0.8 Hz), 4.31 (1H, ddd, *J* = 9.8, 6.0, 3.7 Hz), 3.69–3.79 (1H, m), 3.0 (1H, br s), 1.23–1.53 (20H, m), 0.89 (3H, t, *J* = 6.7 Hz); ^{13}C NMR (75 MHz, $CDCl_3$): δ 133.8, 118.6, 108.2, 79.8, 78.4, 71.3, 37.5, 37.2, 31.7, 29.5, 29.2, 28.0, 25.5, 25.4, 22.6, 14.0; IR ν_{max} (KBr): 3468, 2926, 2857, 1045 cm^{-1}; (ESI-MS): *m/z* 293 (M+Na); HRMS: calcd for $C_{16}H_{30}NaO_3$: 293.2089 (M+Na), found: 293.2087. Compound **19**: colourless liquid; $[\alpha]_D^{32}$ −19.8 (*c* 0.53, $CHCl_3$); ^{1}H NMR (300 MHz, $CDCl_3$): δ 5.67–5.91 (2H, m), 5.31–5.35 (1H, m), 5.25–5.29 (1H, m), 5.19–5.25 (1H, m), 5.09–5.16 (1H, m), 5.01–5.09 (1H, m), 4.43–4.54 (2H, m), 4.15 (1H, dd, *J* = 6.2, 2.8 Hz), 3.0 (1H, br s), 2.54 (1H, dd, *J* = 15.8, 3.7 Hz), 2.44 (1H, dd, *J* = 15.8, 8.3 Hz), 1.46–1.70 (2H, m), 1.45 (3H, s), 1.24–1.34 (15H, m), 0.89 (3H, t, *J* = 6.9 Hz); ^{13}C NMR (75 MHz, $CDCl_3$): δ 171.8, 138.7, 134.0, 118.5, 115.3, 108.4, 79.4, 74.4, 72.5, 68.9, 41.4, 34.9, 34.6, 31.7, 29.6, 29.3, 29.1, 28.1, 25.6, 22.6, 14.0; IR ν_{max} (KBr): 3449, 2926, 2856, 1731, 1375, 1217, 1044 cm^{-1}; (ESI-MS): *m/z* 391 (M+Na). Compound **20a**: colourless liquid; $[\alpha]_D^{32}$ 13.5 (*c* 0.25, $CHCl_3$); ^{1}H NMR (500 MHz, $CDCl_3/C_6D_6$, 1:1): δ 5.59–5.65 (1H, dd, *J* = 11.8, 10.5 Hz), 5.50–5.56 (2H, m), 5.05–5.12 (1H, m), 4.54–4.59 (1H, m), 4.20–4.25 (1H, m) 2.53 (1H, dd, *J* = 11.8, 5.2 Hz), 2.31–2.35 (1H, m), 2.29 (1H, br s), 1.88–1.96 (2H, m), 1.51–1.60 (1H, m), 1.46–1.49 (4H, m), 1.20–1.33 (13H, m), 0.88 (3H, t, *J* = 6.5 Hz); ^{13}C NMR (75 MHz, $CDCl_3$: C_6D_6, 1:1): δ 169.0, 131.5, 130.3, 106.8, 76.1, 73.6, 67.9, 71.4, 40.7, 35.1, 35.0, 31.0, 28.8, 28.6, 28.0, 25.2, 22.1, 24.8, 13.3; IR ν_{max} (KBr): 3458, 2926, 2858, 1728, 1253, 1166, 1044 cm^{-1}; (ESI-MS): *m/z* 363 (M+Na). Compound **1**: solid; mp: 122–124 °C; $[\alpha]_D^{30}$ −24 (*c* 0.23, MeOH); [lit.[1] mp 122 °C; $[\alpha]_D^{23}$ −27 (*c* 0.52, MeOH)]; ^{1}H NMR (500 MHz, $CDCl_3$): δ 6.02 (1H, dd, *J* = 15.6, 2.9 Hz), 5.68 (1H, d, *J* = 15.6 Hz), 4.82 (1H, dt, *J* = 7.8, 6.8 Hz), 4.76 (1H, m), 4.57 (1H, m), 3.6 (1H, d, *J* = 9.7 Hz), 2.62 (1H, dd, *J* = 11.7, 3.9 Hz), 2.58 (1H, dd, *J* = 11.7, 3.9 Hz), 2.34 (1H, m), 2.25 (1H, br s), 1.63 (2H, br s), 1.55 (2H, m), 1.48 (1H, d, *J* = 15.6 Hz), 1.26 (10H, m), 0.88 (3H, t, *J* = 7.8 Hz) (peaks corresponding to minor conformer are omitted); ^{13}C NMR (75 MHz, $CDCl_3$): δ 171.0, 130.8, 125.1, 75.3, 73.3, 67.2, 43.8, 36.9, 36.8, 31.7, 29.7, 29.4, 29.1, 25.03, 22.6, 14.1; IR ν_{max} (KBr): 3455, 2927, 2857, 1713, 1171 cm^{-1}; (ESI-MS): *m/z* 323 (M+Na); HRMS: calcd for $C_{16}H_{28}O_5Na$: 323.1834 (M+Na), found: 323.1830.

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Tris(pentafluorophenyl)borane: a mild and efficient catalyst for the chemoselective tritylation of alcohols

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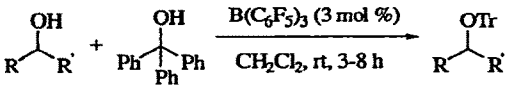
Abstract

An efficient acid-catalyzed protection of alcohols as trityl ethers is described using triphenylmethanol in the presence of tris(pentafluorophenyl)borane (3 mol %) in dichloromethane at room temperature. The chemoselectivity of this protocol is demonstrated by studying the tritylation of a primary alcohol in the presence of a secondary alcohol and also the mildness of this catalyst was studied with substrates containing acid labile protecting groups.

Keywords: Tris(pentafluorophenyl)borane; Chemoselective; Tritylation; Alcohol; Lewis acid

The development of efficient and practically useful Lewis acid catalysts for various organic transformations is of great importance. Tris(pentafluorophenyl)borane [$B(C_6F_5)_3$] is one such Lewis acid catalyst, which is being pursued as a mild and environmentally benign catalyst for various acid catalyzed transformations.[1–10] It is a non-conventional, air-stable, water-tolerant, and thermally stable Lewis acid. Recently, our research group was engaged in exploring the potential utility of $B(C_6F_5)_3$ for various organic transformations such as ring-opening of epoxides, and aza-Ferrier glycosylation,[11–13] and also as an efficient activator for polymethylhydrosiloxane in the reduction of different functional groups.[14,15] In continuation, we report the application of $B(C_6F_5)_3$ in the chemoselective protection of alcohols as trityl ethers in a mild acidic medium.

The triphenylmethyl (trityl) group is a commonly used protecting group for primary alcohols especially in carbohydrate and nucleoside chemistry.[16–18] The introduction of this group to a hydroxyl functionality is traditionally carried out with trityl chloride in the presence of a base.[19–21] Several other reagents such as AgOTf–TrCl,[22] TrODT–$TrATCl_5$,[23] tritylated pyridones,[24] BnOTr–DDQ,[25] TrOTMS–TMSOTf,[26] and *p*-methoxybenzyl trityl ether (*p*-MBTE) or prenyl trityl ether (PTE)–DDQ[27] are also available. Most of these tritylating reagents are not available commercially and have to be prepared from trityl chloride. To date, there are very limited examples known in the literature describing the protection of alcohols as trityl ethers with triphenylmethanol (as tritylating agent) in the presence of an acid catalyst.[28–31] The reaction conditions employed in some of these methods involve strong acidic conditions (H_2SO_4, $FeCl_3$, etc.). Furthermore, these catalysts were studied using only a few examples and no systematic study on chemoselectivity has been carried out. Thus, the development of a new Lewis acid for chemoselective protection of alcohols as trityl ethers under mild reaction conditions is interesting. Here we disclose our findings wherein $B(C_6F_5)_3$ has been identified as a mild and chemoselective Lewis acid catalyst for the said transformation (Scheme 1).



R=alkyl, aryl; R'=H, alkyl

Scheme 1. $B(C_6F_5)_3$-catalyzed tritylation of alcohols.

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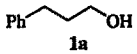
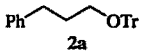
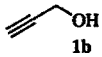
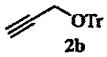
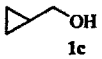
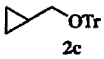
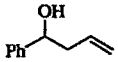
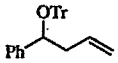
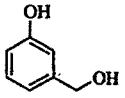
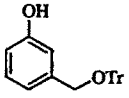
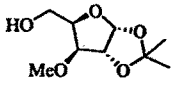
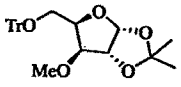
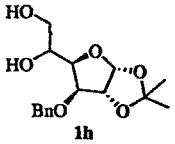
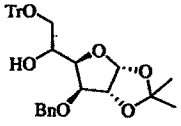
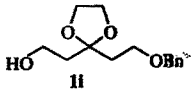
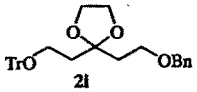
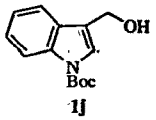
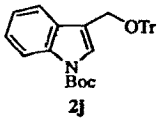
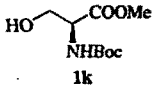
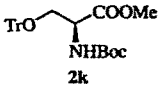
Initially, 3-phenyl-1-propanol **1a** was treated with triphenylmethanol in the presence of 3 mol % $B(C_6F_5)_3$ in dichloromethane at room temperature. The reaction proceeded smoothly in 3 h and afforded the corresponding trityl ether **2a** in 92% isolated yield (Table 1, entry 1). The scope of the reaction conditions was then tested for protection of various other alcohols and the results are summarized in Table 1. The primary alcohols **1b** and **1c** reacted well to yield the trityl ethers **2b** and **2c** in 87 and 93% yields, respectively (Table 1, entries 2 and 3). The secondary benzyl alcohols **1d** and **1e** reacted slowly at room temperature, however, they reacted under refluxing conditions to provide the corresponding trityl ethers **2d** and **2e** in 48 and 56% yields, respectively (Table 1, entries 4 and 5). Entry 6 (Table 1) demonstrates the chemoselective protection of a primary benzylic alcohol in the presence of a phenolic hydroxyl group. Substrates **1g** to **1i** were selectively converted to the trityl ethers **2g** to **2i**, without effecting the acid-labile acetonide, ketal, and benzyl protecting groups (Table 1, entries 7–9). Similarly, the reaction succeeded with alcohols **1j** and **1k**, keeping the acid-sensitive *tert*-butylcarbamate (NBoc) protecting group intact (Table 1, entries 10 and 11).

To check the compatibility and to confirm the mildness of the reagent system, we studied the protection of 1,3-propanediol monoether substrates **3a** to **3h** having a free-hydroxyl group at one end and a hydroxyl-protecting group at the other end. These substrates underwent tritylation at the free hydroxyl group without affecting the other protecting groups (Table 2, entries 1–8).

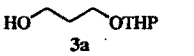
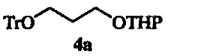
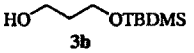
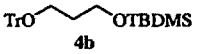
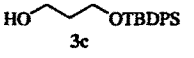
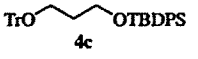
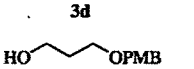
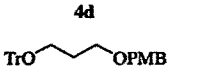
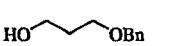
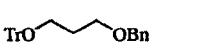
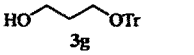
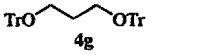
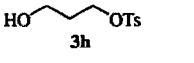
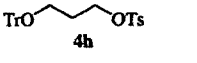
The efficiency of other Lewis acids was also investigated for this transformation using 3-phenylpropanol as a model substrate (Table 3). Treatment of 3-phenylpropanol with triphenylmethanol in the presence of 3 mol % of $BF_3{\cdot}Et_2O$ led to a complex mixture (Table 3, entry 1). The other acid catalysts, $ZnCl_2$, $AlCl_3$, *p*-TSA, and I_2 catalyzed the tritylation (Table 3, entries 2–5). Among these catalysts, $B(C_6F_5)_3$ was found to be more effective in terms of yield, reaction profile, and selectivity (Table 3, entry 6).

Table 1
$B(C_6F_5)_3$-catalyzed tritylation of alcohols

Entry	Substrate	Time (h)	Product	Yield[a] (%)
1	 **1a**	3	 **2a**	92
2	 **1b**	3.5	 **2b**	87
3	 **1c**	4	 **2c**	93
4	 **1d**	8	 **2d**	48[b]
5	 **1e**	8	 **2e**	56[b]
6	 **1f**	4.5	 **2f**	88
7	 **1g**	4	 **2g**	90
8	 **1h**	3.5	 **2h**	90
9	 **1i**	4	 **2i**	94
10	 **1j**	4	 **2j**	87
11	 **1k**	3.5	 **2k**	95

[a] Isolated yields after column chromatography.
[b] Yield from the reaction carried out at reflux.

Table 2
Tritylation of alcohols in the presence of other protecting groups

Entry	Substrate	Time (h)	Product	Yield[a] (%)
1	 **3a**	3	 **4a**	90
2	 **3b**	3.5	 **4b**	92
3	 **3c**	4	 **4c**	94
4	 **3d**	3.5	 **4d**	85
5	 **3e**	4	 **4e**	92
6	 **3f**	4	 **4f**	90
7	 **3g**	3.5	 **4g**	93
8	**3h**	4	**4h**	95

[a] Isolated yields after column chromatography.

Table 3
Tritylation of 3-phenylpropanol in the presence of different acid catalysts

Entry	Acid catalyst (3 mol %)	Time (h)	Yield[a] (%)
1	$BF_3{\cdot}Et_2O$	4	Complex mixture
2	$ZnCl_2$	5	86
3	$AlCl_3$	4	84
4	*p* TSA	4	88
5	I_2	4	74
6	$B(C_6F_5)_3$	3	92

[a] Isolated yield.

Deprotection of the trityl group, which is well known under acidic conditions,[16,32–34] was also attempted using the same catalyst [$B(C_6F_5)_3$] in methanol, but without success even at refluxing temperature.

In conclusion, we have demonstrated an extremely facile and efficient method for protection of alcohols as trityl ethers in the presence of 3 mol % of tris(pentafluorophenyl)borane. Using this procedure, primary alcohols were protected as trityl ethers in the presence of secondary alcohols under mild reaction conditions. The stability of acid-labile protecting groups is an added advantage of the method. In addition, the protocol offers the opportunity to install a trityl protecting group in the presence of base-sensitive functionalities such as esters.

General experimental procedure for the tritylation of alcohols: To a mixture of alcohol (1.0 mmol) and triphenylmethanol (1.5 mmol) in dichloromethane (5 mL), 3 mol % of $B(C_6F_5)_3$ was added and the reaction mixture stirred for the given time (see Tables 1 and 2). After completion of the reaction (monitored by TLC), the reaction mixture was diluted with dichloromethane (5 mL) and washed with water (1 × 5 mL) and brine (1 × 5 mL). The organic layer was dried over Na_2SO_4 and evaporated in vacuo. The crude compound was purified by column chromatography (hexanes and ethyl acetate) to afford the corresponding trityl ether.[35]

Acknowledgments

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Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.tetlet.2007.12.020.

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35. *Spectral data for representative products*: *(2S,3R,4S,5R)-2,3,4-Trimethoxy-5-(trityloxymethyl) tetrahydrofuran* (**2g**): ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.49–7.43 (m, 6H), 7.33–7.19 (m, 9H), 5.85 (d, J = 3.7 Hz, 1H), 4.54 (d, J = 3.7 Hz, 1H), 4.37–4.30 (m, 1H), 3.78 (d, J = 2.8 Hz, 1H), 3.46–3.40 (m, 1H), 3.32 (s, 3H), 3.29–3.25 (m, 1H), 1.53 (s, 3H), 1.33 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$): δ 144.1, 128.6, 127.6, 127.1, 111.6, 105.1, 86.5, 84.0, 82.1, 81.8, 79.4, 61.0, 58.1, 27.3; IR (KBr): ν 3418, 1636, 1215, 757 cm^{-1}; HRMS-ESI calcd for $C_{28}H_{30}O_5Na$: 469.1990; found, 469.1992. *2-(2-(Benzyloxy)ethyl)-2-(2-(trityloxy)ethyl)-1,3-dioxolane* (**2i**): ^{1}H NMR (300 MHz, $CDCl_3$):

δ 7.48–7.38 (m, 8H), 7.34–7.14 (m, 12H), 4.47 (s, 2H), 3.88–3.68 (m, 4H), 3.54 (t, $J = 6.7$ Hz, 2H), 3.20 (t, $J = 6.7$ Hz, 2H), 2.03–1.87 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$): δ 144.5, 138.6, 128.8, 128.5, 127.9, 127.8, 127.6, 127.0, 109.6, 87.0, 76.3, 66.3, 65.3, 60.0, 43.9, 37.9; IR (KBr): ν 2985, 1374, 1242, 1099, 1047 cm^{-1}; HRMS-ESI calcd for $C_{33}H_{34}O_4Na$: 517.2354; found, 517.2352. *tert-Butyldimethyl(3-(trityloxy)propoxy)-silane* (**4b**): ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.42 (d, $J = 6.2$ Hz, 6H), 7.24 (m, 9H), 3.70 (t, $J = 6.2$ Hz, 2H), 3.15 (t, $J = 6.2$ Hz, 2H), 1.89–1.61 (m, 2H), 0.92 (s, 9H), 0.06 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$): δ 144.6, 128.9, 127.8, 127, 86.6, 60.1, 59.9, 33.6, 26.1, 18.5, −5.12; IR (KBr): ν 3449, 2928, 1636, 1088, 836, 702 cm^{-1}; HRMS-ESI: calcd for $C_{28}H_{36}O_2NaSi$: 455.2376; found, 455.2386. *(3-(Methoxymethoxy)propoxy)triphenylmethane* (**4d**): ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.46–7.40 (m, 6H), 7.33–7.18 (m, 9H), 4.57 (s, 2H), 3.67 (t, $J = 6.7$ Hz, 2H), 3.29 (s, 3H), 3.17 (t, $J = 6.7$Hz, 2H), 1.96–1.84 (m, 2H); ^{13}C NMR (75 MHz, $CDCl_3$): δ 144.5, 128.9, 128.1, 127.9, 127.4, 127.0, 96.6, 86.6, 65.3, 60.7, 55.3, 30.6; IR (KBr): ν 3019, 1215, 762, 670 cm^{-1}; HRMS-ESI calcd for $C_{24}H_{26}O_3Na$: 385.1774; found, 385.1775. See Supplementary data for spectral data of all the other new products.