Journal of Labelled Compounds and Radiopharmaceuticals—Vol. XLI, No. 3

Synthesis of Carbon-14 Labeled Anti-HIV Agent 6-*O*-Butyrylcastanospermine

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SUMMARY

The synthesis of the carbon-14 labeled anti-HIV agent 6-*O*-butyrylcastanospermine (**8**) (MDL 28574A[^{14}C]) from castanospermine [3-^{14}C] (**7**) is described. Castanospermine [3-^{14}C] (**7**), a key intermediate for synthesis of **8**, was synthesized in 7 steps from cyclohexyl acetate (acetyl-1-^{14}C) in 5% overall yield and radiochemical purity of 100%. **8** was synthesized from **7** in two steps and 40% overall yield. Two lots of **8** were synthesized with radiochemical purities of 99.98% and 99.7%, respectively.

Key Words: Anti-HIV agent, castanospermine [3-^{14}C], 6-*O*-butyrylcastanospermine [3-^{14}C], cyclohexyl acetate (acetyl-1-^{14}C).

INTRODUCTION

Human immunodeficiency virus (HIV), a retrovirus, is the causative agent of acquired immunodeficiency syndrome (AIDS) in humans. Viral glycoproteins and host receptors play an important role in virus adsorption, penetration, syncytium formation, and spread of the virus to the adjacent cells. An attractive target of chemotherapy against HIV infection is the interference in processing of these viral glycoproteins. 6-*O*-Butyrylcastanospermine has been found to be a potent inhibitor of glycoprotein processing enzyme, glucosidase I, and is under development as a treatment of HIV infection. High anti-HIV activity of 6-*O*-butyrylcastanospermine compared to the parent castanospermine {[1*S*-(1α,6β,7α,8β,8aβ)]-octahydro-1,6,7,8-indolizinetetrol} is believed to be due to increased lipophilicity of the former[1]. A carbon-14 labeled sample of 6-*O*-butyrylcastanospermine was needed for metabolism and pharmacokinectic studies.

CCC 0362–4803/98/030201–10$17.50

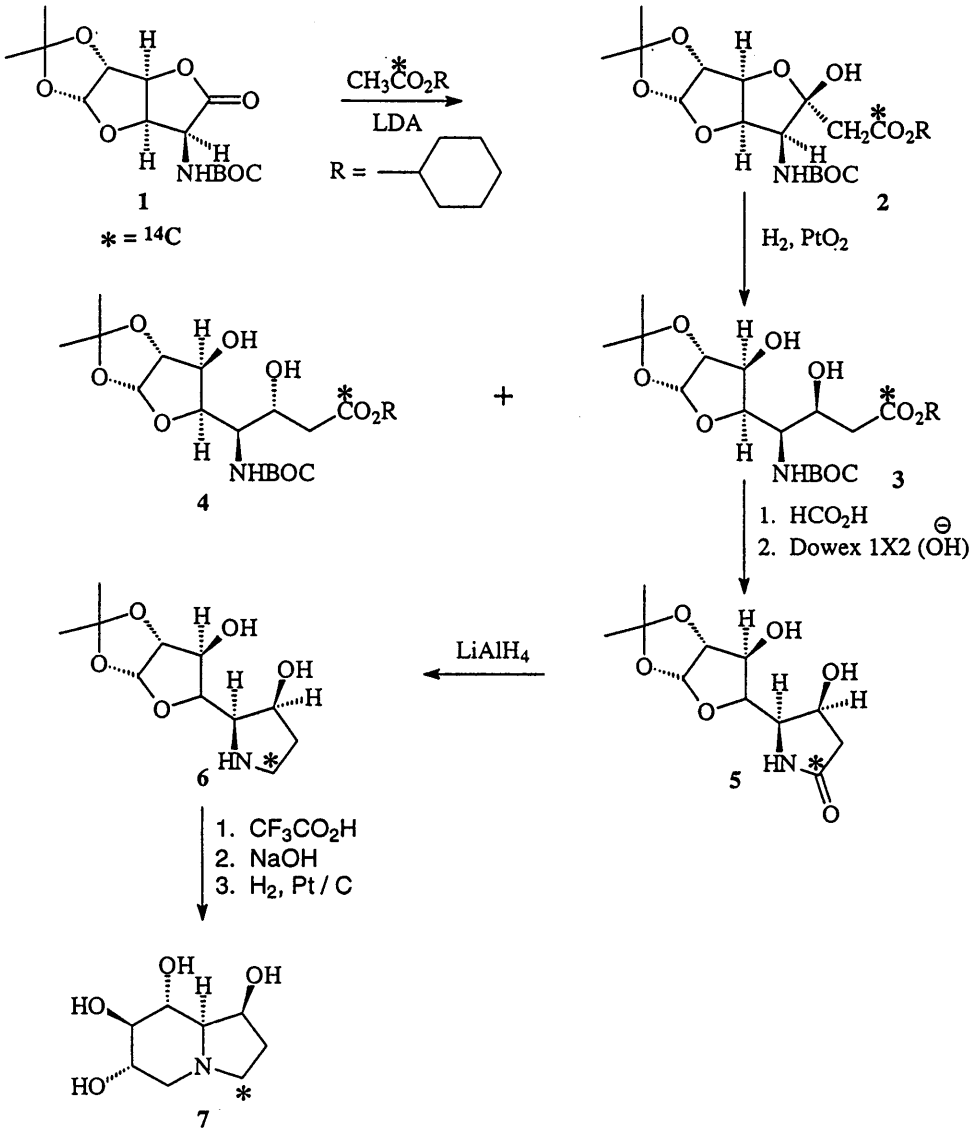
Received 2 September 1997
Revised 18 November 1997

RESULTS AND DISCUSSION

Unlabeled 6-*O*-butyrylcastanospermine has been prepared in 5 steps by acylation of suitably protected castanospermine in an overall yield of 41-45%[2]. For synthesis of carbon-14 labeled 6-*O*-butyrylcastanospermine (**8**), the low overall yield and large number of steps involved in the synthesis of castanospermine led to consideration of an approach different from the multiple-step protection-deprotection sequence used previously[2]. A one-step synthesis of 6-*O*-butyrylcastanospermine from castanospermine involving treatment with dibutyltin oxide and subsequent acylation of the dibutylstannyl derivative was reported to provide unlabeled **8** in 38% yield[3]. This approach was particularly attractive for synthesis of the C-14 labeled analogue as it will not only minimize production of radioactive waste but also the major by-product was castanospermine which could be recycled. Using the stannyl route, **8** was prepared in 35-41% yield and radiochemical purity of 94-97%[4]. However, the serious problems of hydrolysis of the butyryl-ester product to castanospermine and formation of isomeric butyrylcastanospermines were encountered[3,4]. Recently, a two step conversion of castanospermine to 6-*O*-butyrylcastanospermine involving the use of bis (tributyltin) oxide was reported to provide the target compound in good yield[5]. The latter route was adapted for synthesis of carbon-14 labeled isotopomer **8**, details of which are described herein.

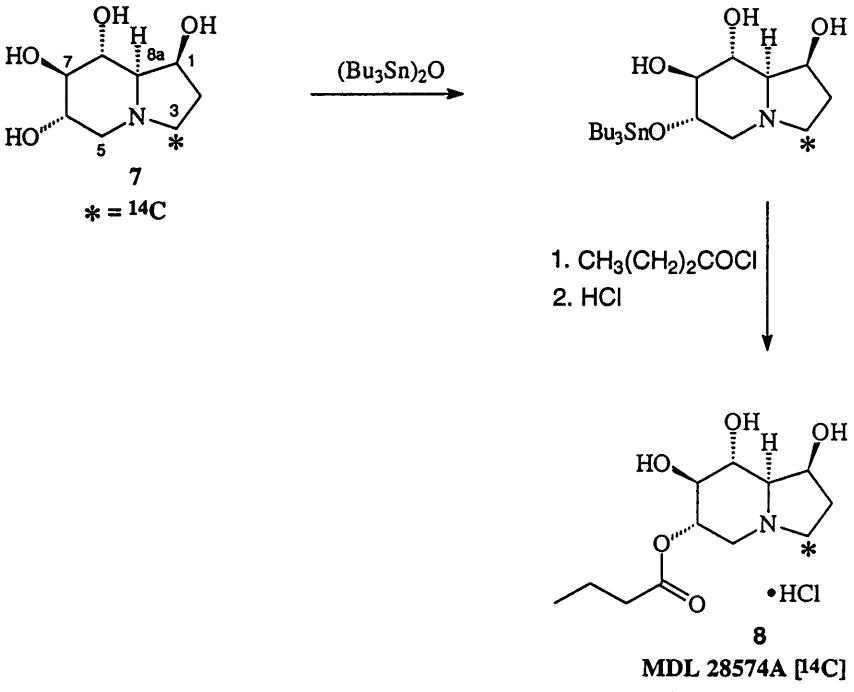
Syntheses of the key intermediate castanospermine in both the C-14 labeled and unlabeled forms have been reported, though no details are given in the former case[6,7]. The C-14 labeled synthesis employed lithium *tert*-butylacetate [1-^{14}C] to produce castanospermine [3-^{14}C] in a poor yield and was considered unsuitable for our purpose[6]. The major drawback of the unlabeled synthesis is the use of excess ethyl acetate which was going to be used for introduction of the C-14 label[7]. This problem was overcome by substituting ethyl acetate with cyclohexyl acetate which was easily recovered and recycled to produce more product. Thus treatment of Boc-amino-lactone[7] (**1**) with the anion generated by deprotonation of cyclohexyl acetate (acetyl-1-^{14}C) with lithium diisopropylamide resulted in formation of hemiketal (**2**) in 45% yield after recycling of cyclohexyl acetate (acetyl-1-^{14}C) twice (Scheme 1). Reduction of **2** with hydrogen (hydrogen balloon) in the presence of platinum (IV) oxide as catalyst gave diastereomeric Boc-amino-diols **3** and **4** in 94% yield as an approximately 1:1 ratio; this is in contrast to the reduction of unlabeled **2** at 45-50 psi which gave unlabeled **3** and **4** in 4:1 ratio[7]. Diastereomer **3**, separated by flash chromatography, was treated with formic acid to remove the carbamate function and the resulting amino ester was cyclized by treatment with Dowex 1X2-100 (OH^-) resin to provide **5**

SCHEME 1



(77% yield). Lactam **5** was reduced with lithium aluminum hydride to furanose pyrrolidine (6) (52% yield), which was treated with trifluoroacetic acid, followed by hydrogenation with Pt/C as catalyst, to afford castanospermine [3-^{14}C] (7) in 65% yield after purification on a Dowex 50WX-2-200 (H^+) resin.

Scheme 2



7

* = ^{14}C

8

MDL 28574A [^{14}C]

Castanospermine [3-^{14}C] (7) was treated with bis (tributyltin) oxide and the resulting tributyltin alkoxide was acylated with butyryl chloride to provide free base of 8 after purification by flash chromatography on silica gel and recovered 7 (16% yield) (Scheme 2). The free base of 8 was neutralized with anhydrous hydrogen chloride and crystallized after dilution with unlabeled material to provide 8 (19% yield). Purification of material from the mother liquor and other impure fractions provided an additional amount of 8 (21% yield) which afforded desired product in an overall yield of 40%. Compound 8 was found to be extremely labile as it hydrolyzed readily to parent castanospermine [3-^{14}C] (7) during purification by flash chromatography. For a successful synthesis of 8, it is critical that the purified free base of 8 be converted immediately into its hydrochloride salt under anhydrous conditions. This also avoids the formation of isomeric butyrylcastanospermines by migration of butyryl group to adjacent hydroxyl groups.

EXPERIMENTAL

General: All chemicals and reagents were used as received from the suppliers. Cyclohexyl acetate (acetyl-1-^{14}C) was purchased from NEN, Research Products, Boston, MA (USA). Analytical thin layer chromatography (TLC) was performed on E. Merck TLC plates with silica gel 60 F_{254} (0.25 mm). TLC

plates used in the analysis of radioactive samples were scanned on a Digital Diagnostic Vanguard Autoscanner using 1.3% isobutane in helium. In radio-TLC (RTLC) analysis, the product co-migrated with a standard sample of unlabeled analogue. Flash chromatography was performed using silica gel (particle size 40-63 μm, EM Science). Specific activity was determined on a Packard Tri-Carb Liquid Scintillation Analyser (Model 1600 TR) using Bio-Safe II as scintillation cocktail. Varian Gemini 300 NMR Spectrometer operating at 300 MHz was used for ^{1}H NMR.

Purification of **7** and **8** was monitored by HPLC performed on a Waters 600 Multisolvent Delivery System, Waters Lambda-Max Model 481 LC Spectrophotometer, Waters 740 Data Module and Beta-RAM Radioactive Flow-Through Monitor System, Model 2 (IN/US Systems Inc.). Radiochemical purity of **7** and **8** was assessed by HPLC performed on a Beckman 114M solvent delivery system, Beckman 421 Controller, Waters WISP 712B autosampler, Spectroflow 757 Variable Wavelength Spectrophotometer and Beta-RAM Radioactive Flow-Through Monitor System, Model 2 (IN/US Systems Inc.).

(6*R*)-5,7-Dideoxy-5-{[(1,1-dimethylethoxy)-carbonyl]amino}-1,2-*O*-(1-methylethylidene)-α-D-*gluco*-6-octulo-6,3-furanose-1,4-furanuronic-8-^{14}C acid, cyclohexyl ester, (2).

A solution of diisopropylamine (1.11 g, 10.97 mmol) in THF (20 mL) was cooled to -78 °C and n-butyllithium in hexane (6.86 mL, 10.97 mmol, 1.6 M in hexane) was added dropwise in 7 min. The mixture was stirred at -20 °C for 20 min, cooled to -78 °C and cyclohexyl acetate [acetyl-1-^{14}C] (565 mCi, 10.97 mmol) was added over a period of 25 min. After stirring for 30 min at -78 °C, a solution of Boc-amino-lactone[7], (**1**) (5-deoxy-5-{[(1,1-dimethylethoxy)-carbonyl]amino}-1,2-*O*-(1-methylethylidene)-α-D-glucofuranuronic acid, γ-lactone), (1.15 g, 3.65 mmol) in THF (15 mL) was added during 30 min and the mixture was stirred at -78 °C for 2 h. The reaction mixture was allowed to warm to -16 °C during a period of 1.5 h, kept at this temperature for 30 min and quenched by adding it to a mixture of 1N HCl (60 mL) and ice (60 g). The mixture was extracted with diethyl ether (60 mL) and organic extract was washed with sat. sodium bicarbonate (20 mL) and brine (30 mL). The aqueous layer from the sodium bicarbonate and brine wash was extracted with diethyl ether (60 mL). The combined organic extracts were dried (Na_2SO_4) and the solvent removed under reduced pressure. The residue was purified by flash chromatography on silica gel (hexane/diethyl ether, 9/1 (600 mL) to 8/2 (500 mL); CH_2Cl_2/acetone, 100/5 (400 mL) to provide **2** (1.55 g, 174.5 mCi, 31% yield) as a solid along with unreacted cyclohexyl acetate [acetyl-1-^{14}C] (304.27 mCi, 54 % yield).

As described above, recovered cyclohexyl acetate [acetyl-1-^{14}C] (304.27 mCi, 5.91 mmol) was treated with lithium diisopropylamide [generated from diisopropylamine (0.607 g, 6.0 mmol, n-butyllithium (3.75 mL, 6.0 mmol) and THF (15 mL)] and the anion formed was reacted with Boc-amino-lactone, (1) (0.63 g, 2.0 mmol) to provide **2** (0.60 g) and unreacted cyclohexyl acetate [acetyl-1-^{14}C] (161.1 mCi, 3.13 mmol). The recovered acetate was again treated with Boc-amino-lactone, (1) (0.35 g, 1.1 mmol) to provide **2** (0.23 g). The product (0.83 g) from the latter two runs was further purified by flash chromatography on silica gel (CH_2Cl_2/acetone, 100/2.5) and combined with the product from the first run to provide **2** (2.27 g, 255.5 mCi, 45 % yield). RTLC: CH_2Cl_2/acetone, 100/0.25, R_f = 0.30.

5,7-Dideoxy-5-[[(1,1-dimethylethoxy)carbonyl]-amino}-1,2-*O*-(1-methylethylidene)-L-*glycero*-α-D-*gluco*-octofuranuronic-8-^{14}C acid, cyclohexyl ester, (3).

To a solution of **2** (2.27 g, 255.5 mCi, 4.96 mmol) in ethyl acetate (50 mL) was added platinum (1V) oxide (1.25 g) as a slurry in ethyl acetate (5 mL) and the mixture was exposed to hydrogen (hydrogen balloon) after degassing. After 22 h, all of **2** was converted into product as indicated by TLC (silica gel, CH_2Cl_2/acetone, 100/0.5). The reaction mixture was filtered through celite (2.0 g). Celite was washed with acetone (30 mL), then methanol (40 mL) and the solvent was removed *in vacuo*. The residue was purified by flash chromatography on silica gel [CH_2Cl_2/acetone, (100/5 to 100/10)] to provide **3**, diasteromer **4** and a mixture of **3** and **4**. The mixture of **3** and **4** was separated again by flash chromatography on silica gel [CH_2Cl_2/acetone, (100/5 to 50/50)] and combined with the respective diasteromers from first separation to provide **3** (1.11 g, 124.4 mCi, 48.7% yield) and **4** (1.03 g, 115.4 mCi, 45.2% yield). RTLC: CH_2Cl_2/acetone, 100/0.5, R_f = 0.21, for **3**; R_f = 0.14, for **4**.

{3a*R*-[3aα,5α(4*S,5*R**),6α,6aα]}-4-Hydroxy-5-(tetrahydro-6-hydroxy-2,2-dimethylfuro[2,3-d]-1,3-dioxol-5-yl)-2-pyrrolidinone-2-^{14}C, (5).**

Boc-amino-diol, (3) (1.01 g, 113.2 mCi, 2.2 mmol) was dissolved in methylene chloride (9 mL), cooled to 0-5 °C and formic acid (27 mL, 98%) was added during 10 min. The mixture was stirred at 0-5 °C for 1 h then at room temperature for 6 h. TLC (silica gel, CH_2Cl_2/acetone, 100/0.5) of an aliquot showed complete conversion of compound **3** to amino-diol. Solvent was removed under reduced pressure. The white solid obtained was dried under vacuum (0.1 mm Hg) for 1 h, dissolved in water (50 mL) and applied to a column of Dowex 1X2-100 (OH, 100 g) resin. The Dowex 1X2-100 (OH) resin was prepared from Dowex 1X2-100 (Cl) by washing with 1N NaOH (325 mL) followed by washing with water till the eluent

was neutral. The column was eluted with water, fractions containing the product were combined and solvent was removed under reduced pressure (14 mm Hg, 50-55 °C) to afford **5** (0.44 g, 87.2 mCi, 77% yield) as a white solid. RTLC: CH_2Cl_2/MeOH, 9/1, R_f = 0.22.

{3a*R*-[3aα,5α(2*R,3*S**),6α,6aα]}-2-(Tetrahydro-6-hydroxy-2,2-dimethylfuro[2,3-d]-1,3-dioxol-5-yl)-3-pyrrolidinol-5-^{14}C, (6).**

A solution of lactam, (**5**) (0.44 g, 87.2 mCi, 1.70 mmol) in THF (40 mL) was cooled to 0-5 °C and lithium aluminum hydride (0.55 g, 14.5 mmol) was added in 4 min. The mixture was refluxed for 21 h and quenched by careful addition of water (0.6 mL), 1N NaOH (0.6 mL) and water (1.8 mL). THF (50 mL) was added to the mixture, stirred for 1 h at room temperature, filtered through celite and the solids were washed with THF/H_2O (9/1, 30 mL). The solids were stirred with THF/H_2O (9/1, 60 mL) for 1.5 h at room temperature. The mixture was filtered through celite and the solids were refluxed with THF/H_2O (9/1, 50 mL) for 1 h. The combined filtrate was evaporated to dryness under reduced pressure. To the residue was added hexane (40 mL) and the solvent was removed *in vacuo*. The residue was dried under vacuum (0.1 mm Hg) to provide **6** (0.242 g, 45.3 mCi, 52% yield). RTLC: CH_2Cl_2/MeOH/ NH_4OH (28%), 5/5/0.2, R_f = 0.28; EtOH/ NH_4OH (28%), 8/2, R_f = 0.59.

Castanospermine[3-^{14}C], (7) {[1*S*-(1α,6β,7α,8β,8aβ)]-Octahydro-1,6,7,8-indolizinetetrol-3-^{14}C}.

Furanose-pyrrolidine, (**6**) (0.242 g, 45.3 mCi, 0.99 mmol) was cooled to 0-5 °C and CF_3CO_2H/ H_2O (9/1, 40 mL) was added in 15 min. The solution was stirred for 17.5 h at room temperature, solvent was removed under reduced pressure and the residue was dried for 2 h under vacuum (0.1 mm Hg). The crude product was dissolved in water (25 mL) and the pH of the solution was adjusted to 9.75 by adding 1N NaOH (3.5 mL). After addition of Pt/C (5%, 300 mg), the mixture was degassed and exposed to hydrogen (hydrogen balloon) for 24 h. The reaction mixture was filtered through celite and celite was washed with water (18 mL). The combined filtrate was evaporated to dryness under reduced pressure and the residue was applied as a solution in water (20 mL) to a cation-exchange column prepared from Dowex 50WX2-200 (H^+) resin (60 g). The column was washed with water (450 mL) and the product was eluted with 1N NH_4OH. The fractions containing product were combined and the solvent was removed under reduced pressure to provide a solid (0.14 g) which on examination by RTLC on silica gel displayed a single peak (MeOH/ NH_4OH (28%), 10/1, R_f = 0.44). Radio-HPLC (Zorbex Rx, C8, 5 μm,

4.6 x 250 mm, mobile phase 0.025M sodium phosphate buffer (pH 6.9), flow rate 1 mL/min, uv detector at 210 nm) analysis of the solid showed mainly a single peak (RCP, >99%, R_t, 6.37 min). The solid (0.14 g) was diluted by adding a solution of unlabeled castanospermine (0.35 g, 1.85 mmol) in water (8 mL). After filtration, the solvent was removed *in vacuo* and the residue was dried under vacuum (0.1 mm Hg) for 1 h. The solid obtained was dissolved in refluxing methanol (25 mL), the solution was concentrated to 15 mL and ether (40 mL) was added to induce crystallization. After stirring for 1.5 h at -5 °C, the mixture was filtered, the solid washed with MeOH/ether (1/10, 8 mL) and dried under vacuum (0.1 mm Hg, 22 °C) for 18 h. The solid (0.41 g) was recrystallized from MeOH/ether (1/3) to provide **7** (0.36 g, 23.5 mCi, 52% yield). RTLC: MeOH/ NH_4OH (28%), 10/1, R_f = 0.50. Mother liquor provided an additional amount of **7** (5.87 mCi) after purification by flash chromatography on silica gel (MeOH/ NH_4OH (28%)/H_2O, 10/1/0.2). Thus the combined yield of **7** (449.89 mg, 29.37 mCi) was 65%. ^{1}HNMR (DMSO-d_6) δ 1.44-2.14 (5H, m, 2α-H, 2β-H, 3αH, 5αH, 8a-H), 2.87-3.02 (3H, m, 3β-H, 5β-H, 7-H), 3.26-3.41 (2H, m, 6-H, 8-H), 4.10 (1H, m, 1-H), 4.18 (1H, m, bs, OH), 4.44 (1H, m, bs, OH), 4.67 (2H, m, bs, OH); Radio-HPLC (Zorbex Rx, C8, 5 μm, 4.6 x 250 mm, mobile phase 0.05M sodium phosphate buffer (pH 6.9), flow rate 1 mL/min, uv detector at 210 nm), RCP 100%, R_t, 6.9 min.

6-*O*-Butyrylcastanospermine hydrochloride[3-^{14}C], (8) {[1*S*-(1α,6β,7α,8β,8aβ)]-Octahydro-1,7 8-trihydroxy-6-indolizinyl-3-^{14}C-butanoic acid ester, hydrochloride}.

To a suspension of castanospermine [3-^{14}C], (**7**) (0.23 g, 1.22 mmol, 15.02 mCi) in toluene (10 mL) was added bis(tributyltin) oxide (1.59 g, 2.66 mmol) and the mixture was refluxed for 7 h. A Dean-Stark trap was used to remove water. The solution was cooled to -15 °C and butyryl chloride (0.23 g, 2.17 mmol) was added in 4 min. The reaction mixture was allowed to warm to 10 °C during 15 h and solvent was removed under reduced pressure. Aqueous methanol (10%, 10 mL) and hexane (10 mL) were added to the oily residue and stirred for 30 min. The aqueous layer was separated and extracted with hexane two more times. The aqueous layer was concentrated under reduced pressure, ethanol (abs., 20 mL) was added to the residue and the solvent was removed *in vacuo*. Methanol (10 mL) was added to the residue and the solvent was removed under reduced pressure. The residue was dissolved in ethyl acetate (15 mL), the solvent was evaporated with nitrogen and the oily product was dried under vacuum (0.1 mm) for 16 h. Diethyl ether (10 mL) was added to the oil, the solution was concentrated to 5 mL and the solid (0.16 g) was collected on a filter. The filtrate was acidified with 1M HCl in ether (1.5 mL), the solvent removed under reduced pressure and the residue combined with material obtained

from mother liquor as described below. The solid (0.16 g) was dissolved in ethanol (abs., 2 mL), cooled to 0-5 °C and acidified with 1M HCl in ether (0.82 mL). After addition of ether (4 mL) and stirring for 30 min, the mixture was filtered, the solid was washed with ether (8 mL) and dried *in vacuo*. The crude product was purified by flash chromatography on silica gel (CH_2Cl_2/MeOH, 85/15) to provide an oil which was dissolved in 2-propanol (20 mL), cooled to 0-5 °C, acidified with 1M HCl in ether (2 mL) and solvent was removed under reduced pressure. The residue was dissolved in methanol (10 mL), concentrated to 3 mL, diluted with ether (16 mL) and the solid (95.14 mg) collected on a filter. The solid (95.15 mg) was diluted with unlabeled **8** (0.306 g) and crystallized three times from methanol/ether (1-1.25/2) to provide 6-*O*-butyrylcastanospermine hydrochloride [3-^{14}C], (**8**) (MDL 28574A-32 [^{14}C]) (0.25 g , 2.55 mCi, 19% yield) as a white solid. RTLC: CH_2Cl_2/MeOH, 8.5/1.5, R_f = 0.34. ^{1}HNMR (DMSO-d_6) δ 0.89 (3H, t, J=7.5 Hz, 12-H), 1.55 (2H, sextet, J=7.5 Hz, 11-H), 1.87 (1H, m, 2α-H), 2.25-2.41 (3H, m, 2β-H, 10-H), 2.94-3.72 (7H, m, 3-H, 5-H, 7-H, 8-H, 8a-H), 4.41 (1H, m, 1-H), 4.93 (1H, td, J=10.0, 4.5 Hz, 6-H), 5.61 (1H, bs, OH), 5.75 (2H, bs, OH). Radio-HPLC (Zorbex Rx, C8, 5 µm, 4.6 x 250 mm, mobile phase 15/85 (v/v) CH_3CN/0.025M sodium phosphate buffer (pH 7.0), flow rate 0.7 mL/min, uv detector at 210 nm), RCP 99.98%, R_t, 14.68 min.

Various fractions containing the impure product were combined with the material from mother liquor and purified by flash chromatography on silica gel (CH_2Cl_2/MeOH, 90/10-85/15). The oil obtained was converted into hydrochloride salt by treatment with 1M HCl in ether as described above to provide a white solid (0.16 g) which was crystallized from methanol/ether to afford MDL 28574A-35[^{14}C], (**8**) (0.13 g, 2.84 mCi, 21% yield). RTLC: CH_2Cl_2/MeOH, 8.5/1.5, R_f = 0.43. ^{1}HNMR (DMSO-d_6) of MDL 28574A-35[^{14}C], (**8**) was identical to MDL 28574A-32[^{14}C] (**8**). Radio-HPLC (Zorbex Rx, C8, 5 µm, 4.6 x 250 mm, mobile phase 15/85 (v/v) CH_3CN/0.025M sodium phosphate buffer (pH 7.0), flow rate 0.7 mL/min, uv detector at 210 nm), RCP 99.7%, R_t, 14.72 min. The combined overall yield of **8** was 40%. Unreacted **7** (1.56 mCi) was obtained by eluting the flash chromatography column with MeOH/ NH_4OH (28%), 10/1).

ACKNOWLEDGEMENT

The author wishes to thank F.J. Keeley, Edward Kulber and E.W. Huber of Analytical and Structural Sciences, Cincinnati, for the HPLC and ^{1}H NMR analyses.

REFERENCES

1. Sunkara, P.S.; Taylor, D.L.; Kang, M.S.; Bowlin, T.L.; Liu, P.S.; Tyms, A.S.; Sjoerdsma, A. - Lancet 1: 1206 (1989).
2. Liu, P.S.; Hoekstra, W.J.; King, C.R. - Tetrahedron Lett. 31: 2829 (1990).
3. Anderson, W.K.; Coburn, R.A.; Gopalsamy, A.; Howe, T.J. - Tetrahedron Lett. 31: 169 (1990); Gopalsamy, A.; Anderson, W.K. - Tetrahedron Lett.. 32: 4669 (1991).
4. Gill, H.S. - unpublished results.
5. Furneaux, R.H.; Gainsford, G.J.; Mason, J.M.; Tyler, P.C. - Tetrahedron Lett. 50: 2131 (1994).
6. Kepler, J.A.; Berrang, B.D.; Correa, I.D.; Lefevre, C.J.; Taylor, G.F.; Haugwitz, R.D. - Synthesis and Application of Isotopically Labeled Compounds, Elsevier, 599 (1989)
7. Anzeveno, P.B.; Angell, P.T.; Creemer, L.J.; Whalon, M.R. - Tetrahedron Lett. 31: 4321 (1990); Anzeveno, P.B.; Creemer, L.J. - Tetrahedron Lett. 31: 2085 (1990).

