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APPLICATION OF THE VICINAL OXYAMINATION REACTION WITH ASYMMETRIC INDUCTION TO THE HEMISYNTHESIS OF TAXOL AND ANALOGUES †

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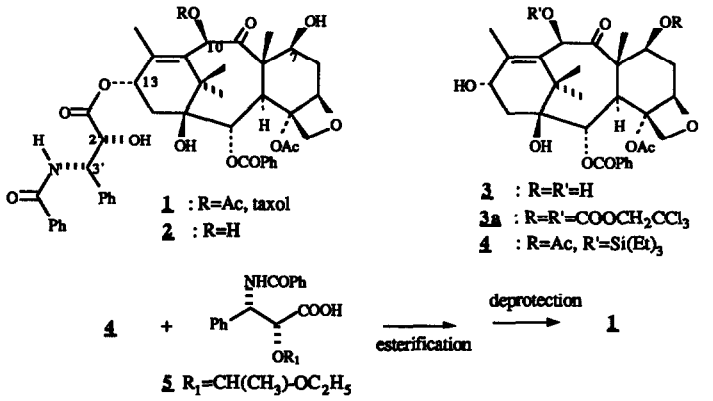
Abstract - Taxol, 10-deacetyl taxol and their related side chain analogues can be obtained via a "Sharpless" oxyamination reaction on 13-cinnamoyl baccatin III. Asymmetric induction has been studied using different bridgehead amines as chiral ligands. This procedure constitutes an alternative route to taxol derivatives for biological studies.

Taxol **1** [1], a complex diterpene isolated from the trunk bark of several species of yew (genus Taxus, family Taxaceae) [2], is the only natural product known to promote the assembly of tubulin into microtubules (the major component of the mitotic spindle) and to inhibit the microtubules disassembly process [3]. Therefore it appears to be the prototype of a new class of anti-cancer agents and has effectively been shown to possess a wide spectrum of anti-leukemic and tumor-inhibiting activity [3a,3c,4].Taxol is currently in phase II clinical trials in the United States[5]. The limited availability of taxol from natural sources, has initiated investigations directed towards its total synthesis [6]: recently Holton and coll. succeeded in the first synthesis of (-)taxusin (enantiomer of the natural taxane diterpene) [6].

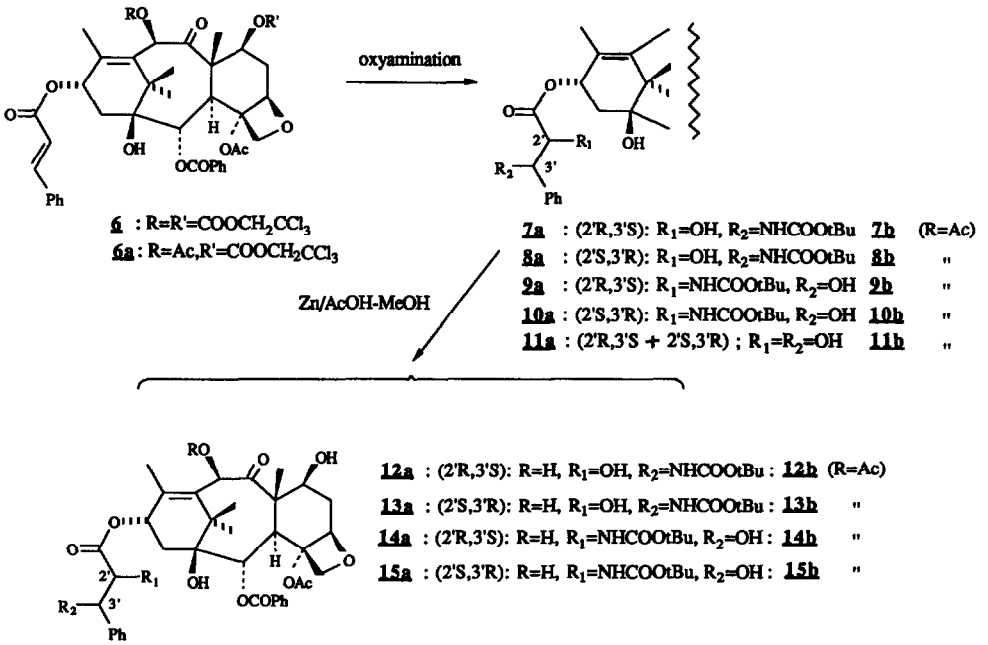
Our interest in this area has been mainly focused on a partial synthesis of taxol and structural analogues from a simpler and more easily accessible taxol congener. In a preceding paper [7] we proposed an hypothesis for the biogenesis of taxol and we reported two procedures for its hemisynthesis as well as that of 10-deacetyl taxol **2** which has similar anticancer properties [8]. The starting material was natural 10-deacetyl baccatin III **3** readily extracted with high yields from the leaves of *Taxus baccata L.*[9,10]. One of the hemisynthetic methods used the direct coupling of 7-triethylsilyl baccatin III **4** with the suitably protected (2R, 3S)-N-benzoyl-3-phenylisoserine **5** [11]. Removal of the protecting groups led to taxol **1** (Scheme 1).

† Dedicated to the memory of Professor Edgar Lederer.



Scheme 1

Before finding the best conditions for this direct hemisynthesis, we proposed another pathway which consists in applying the Sharpless vicinal oxyamination reaction to a cinnamate taxane derivative such as **6** [10] (scheme 2). Among the oxyaminated products so obtained, **7a** produced 10-deacetyl taxol **2** after deprotection of the t-butoxycarbonyl group, benzoylation and removal of the trichloroethyloxycarbonyl group[12] (Scheme 3). Each procedure can be applied to the preparation of both taxol **1** and 10-deacetyl taxol **2**.



Scheme 2

In this communication we would like to report the results we have obtained from this oxyamination procedure leading to taxol and new isomers under different experimental conditions (effects of solvents, temperatures, metallic salts and different tertiary bridgehead amines).

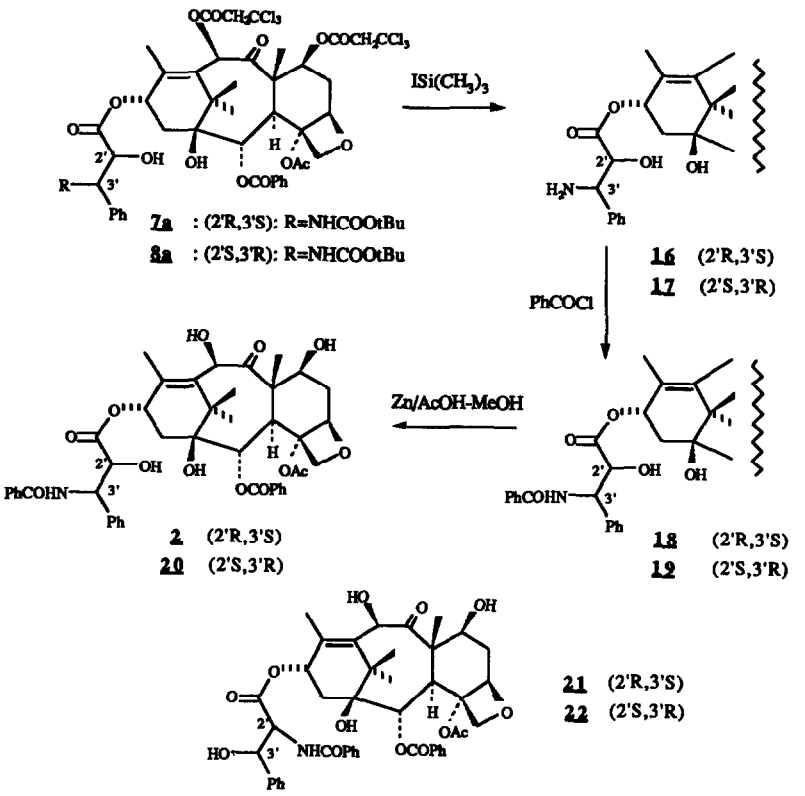
To obtain the 2'R,3'S configuration of taxol, a cis addition is required on the 2'-3' double bond of the trans cinnamate ester **6** [13,14]. In preliminary work, we found that cis vicinal oxyamination using Chloramine T and a catalytic amount of osmium tetroxide afforded a mixture of hydroxy p-toluenesulfonamide isomers [13]. Because of the sensitivity of taxol derivatives to both acid [15a] and base [1,2a,15] and the difficulty of removing the sulfonamide protecting groups without damage to the taxane skeleton, we applied the same reaction using t-butyl-N-chloro-N-argentocarbamate. Despite the bulky asymmetric taxane skeleton, a negligible induction took place using the classical catalytic procedure (tBuOCONNaCl (1.5eq), $AgNO_3$ (3eq), OsO_4 (1%), H_2O (4.5eq), CH_3CN)[16]. Two pairs of threo regioisomers **7a, 8a** and **9a, 10a** were obtained in ,respectively, 13%, 11%, 11% and 8% yield (Table I: entry 1B) and the cinnamate ester **6** was recovered in 50% yield; each of these diastereoisomers has a different R_F in thin layer chromatography and was easily isolated. The presence of **9a** and **10a** in the oxyamination reaction mixture (scheme 2) shows that no regioselectivity occured during the cis addition of the osmium complex to the cinnamate ester. Deprotection of the C-7 and C-10 protecting groups of the four oxyaminated products led, respectively, to compounds **12a, 13a** and **14a, 15a** (Scheme 2).

The assignment of the structure of the four isomers was based largely on ^1H NMR. Decoupling experiments were performed to assign the position of the hydroxyl and t-butoxycarbonylamino substituents. The ^1H NMR spectra of **12a** and **13a** (2'-OH, 3'-$NHCO_2tBu$) exhibited a broad doublet (J = 9 Hz) for the C-3' proton at 5.26 and 5.27 ppm respectively while the C-2' proton absorbed at higher field (4.60 and 4.49 ppm) and appeared as a broad singlet. Irradiation at the resonance frequency of the NH proton resulted in the disappearance of the coupling (J=9HZ) for the C-3' proton. The same decoupling experiments were performed for **14a** and **15a** (2'-$NHCO_2tBu$, 3'OH). The C-2' proton appeared as a doublet (J=9Hz) of doublets (J=2Hz) at 4.58 ppm for **14a** and **15a**. The proton at C-3' appeared as a doublet (J=2Hz) at 5.35 (compound **14a**) and 5.14 ppm (compound **15a**).

Compound **12a** was correlated to 10-deacetyl taxol **2** (Scheme 3). The t-butoxycarbonyl group of **7a** was easily removed with iodotrimethylsilane affording the desired cis-β-aminoalcohol **16**. Treatment of **16** with benzoyl chloride yielded **18**. Finally, the 2,2,2-trichloroethyloxycarbonyl groups at C-7 and C-10 were removed with zinc dust in methanolic acetic acid to give 10-deacetyl taxol **2**. The derivative isolated was identical in all respects to an authentic sample of natural 10-deacetyl taxol **2** (tlc, α_D, nmr, mass spectra, melting point). Moreover, X-ray analysis of compound **12a** gave the configuration of the 2' and 3' carbons and represented the first X-ray analysis of an intact taxol congener [17].

The configurations of 2' and 3' carbons of the regioisomers **14a** and**15a** were attributed after hydrolysis of the ester bond at C-13 and removal of the t-butoxycarbonyl group. The optical rotatory power of the amino acids so obtained was compared to those of (L) and (D) 3-phenylserine[18].Thus **9a** and **14a** (2'R, 3'S) were correlated to (D)3-phenylserine and compounds **10a** and **15a** (2'S, 3'R) to (L)3-phenylserine.

Treatment of the oxyaminated product **8a** with iodotrimethylsilane yielded the aminoalcohol **17**, and the latter was then treated with benzoyl chloride. Removal of the troc group from **19** yielded 2',3'-epi,10-deacetyl taxol **20** (Scheme 3).



Scheme 3

Compounds **9a** and **10a** were similarly modified leading to the regioisomers of 10-deacetyl taxol **21** and **22**.

In order to improve the yield of the oxyamination reaction, we used both the stoichiometric[19] (method A) and catalytic[16] (method B) procedures. The reaction mixtures were analysed using high-performance liquid chromatography after reduction of the reaction medium with sodium bisulfite followed by extraction.

As shown in Table I, the highest yields of vicinal hydroxycarbamates were obtained when the reaction was carried out in acetonitrile or toluene under stoichiometric and catalytic conditions (entries 1 and 2). Reaction carried out in pyridine gave poor yields of amino alcohols and diol **11a** [15b,14] was the major component isolated from the reaction mixture (entry 3). In our hands, a decrease of the reaction temperature or the use of mercury (II) salts did not enhance the yield of *cis* hydroxycarbamates as it does with simpler alkenes[20] (entries 4, 5, 6).

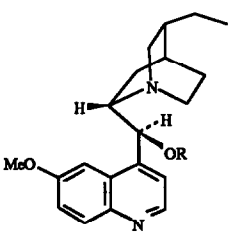
In all cases where catalytic conditions were used the oxyamination reaction did not proceed to completion and cinnamate ester **6** was recovered in about 50% yield.

entry	cond.[a]	solvent	temp.	6	7a	8a	9a	10a	11a	yield[b]
				(% yields of compounds)						
1	A	Acetonitrile	rt	2	25	22	21,5	16,5	2	85
	B	~	~	50	13	11	11	8	0	43
2	A	Toluene	rt	5	24	20	21	15	7	80
	B	~	~	50	15	13	12,5	9,5	0	50
3	A	Pyridine	rt	0					99	1
	B	~	~	50					50	1
4	A	Acetonitrile	4°	10	20	18	16	12	9	66
	B	~	~	57	12	11	11	8	0	42
5	A	Toluene	4°	5	20	17	18	14	12	70
	B	~	~	50	12	10	11	7	3	40
6	B	Toluene[c] or acetonitrile	rt	50	12	11	11	8	6	40

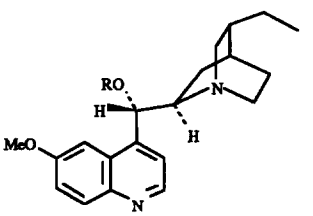
a) A : stoichiometric procedure , B : catalytic procedure
b) Overall yield in oxyaminated products
c) reaction was conducted with $Hg(NO_3)_2$ as metallic salt instead of $AgNO_3$

Table I

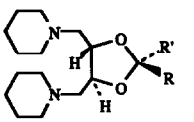
We then checked the influence of different tertiary bridgehead amines known to form stable adducts with OsO_4 [21] and consequently improve the oxyamination procedure [22]. Moreover, the addition of chiral tertiary amines could also induce chirality in the amino-alcohol products as it does in the asymmetric dihydroxylation of olefins with osmium tetroxide under both stoechiometric [23] and catalytic [24] conditions. It must be noted that chiral N-chloro N-argento carbamates have been used recently for the asymmetric synthesis of α-amino alcohols [25].



2.3 R=Ac
2.5 R=pClPhCO



2.4 R=Ac
2.6 R=pClPhCO



2.7 R=H, R'=Ph
2.8 R=R'=CH_3

In our case quinuclidine had no effect on the amino alcohol yields (Table II, compare entries 1 and 2), but some chiral tertiary amines had a beneficial effect on the formation of the desired compounds. The results are collected in Table II and can be summarized as follows : a) addition of dihydroquinine acetate **23** [26] or chlorobenzoate **25** [24] to the reaction mixture strongly enhanced the yields of hydroxycarbamates under catalytic conditions (Entry 3B, 85% and 5B, 92%). Moreover, amine **25** promoted the formation of hydroxycarbamates with the 2'R,3'S configurations (entry 5B);

b) On the contrary, addition of dihydroquinidine acetate **24** [26] using stoichiometric and catalytic conditions, decreased the yield in oxyaminated products (Entry 4). This effect can be related to the steric interactions occurring between the tertiary-amine-imidoosmium complex and the carbon-carbon double bond of the bulky cinnamate ester; however, the contradictory results obtained in entry 6A could be explained by the existence of two different conformations of the imidoosmium complex obtained with **24** and **26** [24]. c) Under stoichiometric conditions we found that chiral amines **23** and **24** were the most effective ligands for asymmetric induction (Entries 3A and 4A).

Other amines like **27** and **28** [23b], derived from L-tartaric acid, were also used for the asymmetric induction but these attempts were unsuccessfull.

Entry	Condition	Inducers	% chemic.yield oxyamination	% relative yields 2'R,3'S **7a+9a**	2'S,3'R **8a+10a**
1	A	0	80	56	44
	B	0	49	55	45
2	A	Quinuclidine	75	55	45
	B	--	40	55	45
3	A	**23**	85	80	20
	B		85	54	46
4	A	**24**	30	20	80
	B		30	48	52
5	A	**25**	88	62	38
	B		92	73	27
6	A	**26**	87	34	66
	B		54	54	46

Table II

The same reactions (Schemes 2 and 3) were applied to the cinnamate ester **6a**: the oxyamination reaction provided oxycarbamates **7b, 8b, 9b, 10b** and diol **11b** in about the same yields and ratios as those obtained with ester **6**. Deprotection at C-7 of the oxyaminated products led to compounds **12b, 13b, 14b** and **15b**. Finally **7b** was correlated with taxol **1** after deprotection of the t-butoxycarbonyl group, benzoylation and deprotection of the C-7 position.

In summary, application of the Sharpless oxyamination reaction to cinnamate esters **6** and **6a** easily led to 10-deacetyl taxol **2** and taxol **1** and the use of some chiral ligands highly improved the oxyamination process. This overall procedure allowed us to prepare new diastereoisomers and regioisomers of taxol in order to try to improve bio-availability and diminish toxicity of taxol and derivatives. The biological activities of most of the taxol analogues described in this paper were evaluated first *in vitro* (tubulin test), then *in vivo*. One of them possesses antimitotic activity superior to that of taxol; it is currently under pharmacological evaluation [27].

EXPERIMENTAL SECTION

General methods. The purity of the samples was checked by chromatographic methods (hplc and tlc) and careful analysis of NMR spectra. Tlc was performed on precoated silica gel plates (Merck 60F, 0.25 mm thick). Silica gel 7736 supplied by Merck was used for column chromatography under medium pressure (0.5 bars). Hplc was performed on a Waters liquid chromatography system equipped with a photodiode array detector model 990 and carried out on a Resolve 5μ spherical silica Waters column. The elution system was a gradient of isopropanol in heptane (3 to 5%) at a flow rate of 3ml/mn. Melting points were determined with a Kofler hot bench and are uncorrected. Optical rotations (c, g/100ml) were determined on a Perkin-Elmer 141MC polarimeter using a 10 cm path length cell. Infra red spectra (cm-1, $CHCl_3$) were recorded on a Perkin-Elmer 257 apparatus. Ultraviolet spectra (EtOH, max nm) were recorded on a Jobin-Yvon "Duospac 203" apparatus. ^1H and ^{13}C spectra were recorded at 200 MHz or at 400 MHz on a Brucker AM 200 or AM400, using Me_4Si as internal standard. NMR spectra were recorded in $CDCl_3$ or $CDCl_3/CD_3OD$ solution and chemical shifts are expressed in parts per million (ppm). Coupling constants (J) are given in Hertz; s, d, t, dd and m indicate singlet, doublet, triplet, doublet of doublet and multiplet. Mass spectra were measured on an AEI MS9 (CI) or on a Kratos MS80 (FAB).

Solvents were distilled before use. tert-Butyl-N-Chloro-N-sodiocarbamate[16], dihydroquinine acetate[26] and chlorobenzoate[24], dihydroquinidine acetate[26] and chlorobenzoate[24], were prepared following literature procedures. Commercially available compounds were used without purification.

-7,10-di(2,2,2-Trichloroethyloxycarbonyl)-13-cinnamoyl-10-deacetyl baccatin III **6**:

Cinnamic acid (330 mg, 2.24 mmol), dicyclohexylcarbodiimide (460 mg, 2.24 mmol), 7,10-di(2,2,2-trichloroethyloxycarbonyl)-10-deacetyl baccatin III **3a** (500 mg, 0.56 mmol) and 4-dimethylaminopyridine (68 mg, 0.56 mmol) were stirred under argon at 70°C. After 15h , the mixture was cooled and filtered. The solid was washed with toluene and the filtrate was concentrated under vacuum. To the residue methylene chloride was added and the solution washed with 2% aqueous hydrochloric acid. The organic layer was separated, dried ($MgSO_4$) and the solvent removed under vacuum. The residue (1g) was purified by column chromatography using a mixture of hexane/ethyl acetate 7:3 as eluent to give cinnamate ester **6** (540mg, 94%). Spectral data are given in ref.14.

Cinnamate ester **6a** was obtained in the same way from 7(2,2,2-trichloroethyloxycarbonyl) baccatin III [14,28] and cinnamic acid in 95% yield:

-7(2,2,2-trichloroethyloxycarbonyl)-13-cinnamoyl baccatin III **6a**: U.V. : 210 (26040), 218 (33330), 223 (34460), 232 (22910), 281 (33120); I.R. (CHCl3): 3500, 2900, 1740, 1710 cm-1; 1H NMR (CDCl3): 1.15 (3H,s,C-17H3), 1.21 (3H,s,C-16H3), 1.83 (3H,s,C-19H3), 2.09 (3H,s,C-18H3), 2.15 (3H,s,OAc at C-10), 2.28 (3H,s,OAc at C-4), 2.22 (2H,m,C-14H2), 2.42 (1H,m,C-6H), 2.65(1H,m,C-6H), 4.0 (1H,d,J=7,C-3H), 4.18 and 4.31 (2H,2d,J=9,C-20H2), 4.68 and 5.09 (2H,2d,J=12,CH2 of the 7-protect. group), 5.03 (1H, d,J=9,C-5H), 5.65 (1H,dd,J=12 and 7,C-7H), 5.72 (1H,d,J=7,C-2H), 6.22 (1H,t,J=8,C-13H), 6.46 (1H,s,C-10H), 6.58 (1H,d,J=16,C-2'H), 7.49 (5H,Ph), 7.52, 7.65, 8.12 (5H,OBz), 7.92 (1H,d,J=16,C-3'H); MS (CI) m/z: 891(MH+), 699, 551, 533, 491, 429, 369, 351, 309, 149, 131.

-Procedure for the stoichiometric hydroxyamination of cinnamate ester (Procedure A):

In a flask, a mixture of N-chloro-N-sodio-tertbutylcarbamate (47mg,0.27mmol) and silver nitrate (91.4mg,0.54mmol) or other metallic salts in acetonitrile, toluene or pyridine (2ml) was stirred for 10mn. To this suspension cinnamate ester **6** (50mg,0.049mmol), and 0.537ml of a solution of osmium tetroxide in tertbutyl alcohol (0.1mmol/1ml) was added. The mixture was stirred at room temperature or 4°C in the dark. After 24hrs, the reaction mixture was filtered. To the filtrate, 0.22mmol.of sodium bisulfite (2.5% aq.) was added and stirred for 3hrs. The reaction mixture was extracted with methylene chloride. The organic phase was dried and concentrated. Separation by preparative tlc using ether/hexane 7/3 as an eluant yielded hydroxycarbamates **7a**, **8a**, **9a**, **10a**, diol **11a**, and cinnamate **6** (Yields shown in Table I).

Improved procedures were studied by adding 5 equivalents of various amines to the reaction mixture, using the literature procedure (Results shown in Table II).

-Procedure for the catalytic hydroxyamination of cinnamate ester 6 (Procedure B):

In a flask, a mixture of N-chloro-N-sodio-tert-butylcarbamate (50mg, 0.29 mmol) and silver nitrate (100mg, 0.59 mmol) or other metallic salts in acetonitrile, toluene or pyridine (2ml) was stirred for 10 min. To this suspension, cinnamate ester **6** (200mg, 0.2 mmol), water (0.016 ml) and 0.02 ml of a solution of osmium tetroxide in tert-butyl alcohol (O.1 mmol/ml) was added. The mixture was stirred at room temperature in the dark. After 48 h, a saturated sodium chloride solution was added, and the mixture was filtered and then extracted with methylene chloride. The organic phase was dried and concentrated to yield the crude hydroxycarbamates **7a**, **8a**, **9a** and **10a** and cinnamate ester **6a** . Isomers were separated by silica gel column chromatography using ether/hexane 1:1 as an eluant or thick layer chromatography using ether/hexane 7/3 (Yields shown in Table I).

Improved procedures were studied by adding 0.1 equivalent of various amines to the reaction mixture using literature procedures (Yields shown in Table II).

-Compound **7a** (2'R,3'S): IR ($CHCl_3$): 3580, 3440, 2960, 1770, 1730 cm-1; ^1H NMR ($CDCl_3$) : 1.21 (3H, s, C-17H_3), 1.27 (3H, s, C-16H_3), 1.36 (9H, s, t-Bu), 1.86 (3H, s, C-19H_3), 1.96 (3H, s, C-18H_3), 2.39 (3H, s, OAc), 2.62 (1H, m, C-6H), 3.90 (1H, d, J=7, C-3H), 4.17 and 4.32 (2H, 2d, J=9, C-20H_2), 4.63 (1H, d, J=3, C-2'H), 4.59 and 4.90 (2H, 2d, J=12, CH_2 of the 7-protect. group), 4.77 (2H, s, CH2 of the 10-protect. group), 4.96 (1H, d, J=9, C-5H), 5.27 (1H, dd, J=9 and 3, C-3H), 5.42 (1H, d, J=9, NH), 5.55 (1H, m, C-7H), 5.69 (1H, d, J=7, C-2H), 6.21 (1H, t, J=9, C-13H), 6.23 (1H, s, C-10H), 7.39 (5H, m, Ph), 7.51, 7.62, 8.09 (5H, OBz).

-Compound **8a** (2'S,3'R): IR ($CHCl_3$): 3400, 3000, 1770, 1730 cm-1; 1H NMR ($CDCl_3$): 1.18 (3H, s, C-17H_3), 1.23 (3H, s, C-16H_3), 1.40 (9H, s, t-Bu), 1.86 (3H, s, C-19H_3), 2.08 (3H, s, C-18H_3), 2.24 (3H, s, OAc), 2.64 (1H, m, C-6H), 3.98 (1H, d, J=7, C-3H), 4.17 and 4.32 (2H, 2d, J=9, C-20H_2), 4.48 (1H, d, J=3, C-2'H), 4.60 and 4.92 (2H, 2d, J=12, CH_2 of the 7-protect. group), 4.78 (2H, s, CH2 of the 10-protect. group), 4.97 (1H, d, J=9, C-5H), 5.22 (1H, dd, J=9 and 3, C-3'H), 5.32 (1H, d, J=9, NH), 5.58 (1H, m, C-7H), 5.70 (1H, d, J=7, C-2H), 6.07 (1H, t, J=9, C-13H), 6.27 (1H, s, C-10H), 7.33, 7.45 (5H, Ph), 7.48, 7.61, 8.04 (5H, OBz).

-Compound **9a** (2'R,3'S): IR (CHCl3): 3590, 3440, 3000, 1770, 1730 cm-1; 1H NMR (CDCl3) : 1.20 (3H, s, C17H3), 1.27 (3H, s, C16H3), 1.37 (9H, s, t-Bu), 1.87 (3H, s, C19H3), 2.02 (3H, s, C18H3), 2.42 (3H, s, OAc), 2.64 (1H, m, C6H), 3.96 (1H, d, J=7, C3H), 4.19 and 4.32 (2H, 2d, J=9, C20H2), 4.59 (2H, br d, CH of the 7-troc group (J=12) + C2'H (J=9)), 4.78 (2H, s, CH2 of the 10-troc group), 4.91 (1H, d, J=12, CH of the 7-troc group), 5.OO (1H, d, J=9, C5H), 5.40 (1H, br s, C3'H), 5.51 (1H, d, J=9, NH), 5.58 (1H, m, C7H), 5.69 (1H, d, J=7, C2H), 6.25 (1H, s, C10H), 6.31 (1H, t, J=9, C13H), 7.36, 7.40, 7.46 (5H, Ph), 7.48, 7.68, 8.06 (5H, OBz).

-Compound **10a** (2'S,3'R): IR ($CHCl_3$): 3600, 3440, 3000, 1770, 1730 cm-1; 1H NMR ($CDCl_3$) : 1.18 (3H, s, C-17H_3), 1.27 (3H, s, C-16H_3), 1.38 (9H, s, t-Bu), 1.89 (3H, s, C-19H_3), 2.O2 (3H, s, C-18H_3), 2.32 (3H, s, OAc), 2.62 (1H, m, C-6H), 3.87 (1H, d, J=7, C-3H), 4.15 and 4.32 (2H, 2d, J=9, C-20H_2), 4.60 (2H, br d, CH of the 7-protect. group (J=12) + C2'H (J=9)), 4.77 (2H, s, CH_2 of the 10-protect. group), 4.91 (1H, d, J=12, CH of the 7-protect. group), 4.96 (1H, d, J=9, C-5H), 5.16 (1H, br s, C-3'H), 5.34 (1H, d, J=9, NH), 5.57 (1H, m, C-7H), 5.67 (1H, d, J=7, C-2H), 6.16 (1H, t, J=9, C-13H), 6.23 (1H, s, C-10H), 7.39 (5H, Ph), 7.53, 7.66, 8.07 (5H, OBz).

-Compound **11a** : Spectral data are given in ref.[14].

The same oxyamination procedures were applied to the cinnamate ester **6a** to give:

-Compound **7b** (2'R,3'S): UV: 204 (15790), 232 (6270), 278 (2170), 283 (2170); IR ($CHCl_3$): 3660, 3440, 3400, 1760, 1740, 1710 cm^{-1}; ^1H NMR ($CDCl_3$): 1.18 (3H, s, C-17H_3), 1.25 (3H, s, C-16H_3), 1.35 (9H, s, tBu), 1.83 (3H, s, C-19H_3), 1.9 (3H, s, C-18H_3), 2.05 (2H, m, C-14H_2), 2.18 (3H, s, OAc at C-10), 2.38 (3H, s, OAc at C-4), 2.61 (2H, m, C-6H_2), 3.93 (1H, d, J=7, C-3H), 4.18 and 4.32 (2H, 2d, J=9, C20H_2), 4.61 (1H, br s, C-2'H), 4.61 and 5.02 (2H, 2d, J=12, CH_2 of the troc group), 4.95 (1H, d, J=9, C-5H), 5.26 (1H,br d, J=9, C-3'H), 5.4 (1H, br d, J=9, NH), 5.53 (1H, dd, J=12 and 7, C-7H), 5.67(1H, d, J=7, C-2H), 6.19 (1H, t, J=8, C-13H), 6.35 (1H, s, C-10H), 7.4 (5H, Ph), 7.5, 7.6 and 8.1 (5H, OBz).

-Compound **8b** (2'S,3'R): UV: 207 (17210), 229 (13370), 278 (1280), 282 (1160); IR ($CHCl_3$): 3700, 3600, 3450, 1760, 1745, 1730, 1710 cm^{-1}; ^1H NMR ($CDCl_3$): 1.15 (3H, s, C-17H_3), 1.2 (3H, s, C-16H_3), 1.38 (9H, s, tBu), 1.82 (3H, s C-19H_3), 2.00 (3H, s, C-18H_3), 2.1 (2H, m, C-14H_2), 2.18 (3H, s, OAc at C-10), 2.3 (3H, s, OAc at C-4), 2.4 (1H, m, C-6H), 2.62 (1H, m, C-6H), 392 (1H, d, J=7, C-3H), 4.12 and 4.28 (2H, 2d, J=9, C-20H_2), 4.45 (1H, br s, C2'H), 4.6 and 5.00 (2H, 2d, J=12, CH_2 of the troc group), 4.95 (1H, d, J=9, C-5H), 5.2 (1H, br d, C-3'H), 5.3 (1H, d, NH), 5.58 (1H, dd, J=12 and 7, C-7H), 5.64 (1H, d, J=7, C-2H), 6.00 (1H, t, J=8, C-13H), 6.35 (1H, s, C-10H), 7.38 (5H, Ph), 7.45, 7.58 and 8.00 (5H, OBz).

-Compound **9b** (2'R,3'S): UV: 204 (14050), 230 (11940), 278 (4440), 282 (4550); IR ($CHCl_3$): 3680, 3600, 3440, 1750, 1730, 1710 cm^{-1}; ^1H NMR ($CDCl_3$): 1.16 (3H, s, C-17H_3), 1.23 (3H, s, C-16H_3), 1.36 (3H, s, tBu), 1.85 (3H, s, C-19H_3), 2.00 (3H, s, C-18H_3), 2.06 (2H, m, C-17H_2); 2.15 (3H, s, OAc at C-10), 2.3 (1H, m, C-6H), 2.4 (3H, s, OAc at C-4), 2.64 (1H, m, C-6H), 3.98 (1H, d, J=7, C-3H), 4.18 and 4.22 (2H, 2d, J=9, C-20H_2), 4.6 (1H, dd, J=9 and J=2, C-2'H), 4.63 and 5.04 (2H, 2d, J=12, CH_2 of the troc group), 5.00 (1H, d, J=9, C-5H), 5.4 (1H, d, J=2, C-3'H), 5.50 (1H, d, J=9, NH), 5.59 (1H, dd, J=12 and 7, C-7H), 5.68 (1H, d, J=7, C-2H), 6.3 (1H,t,J=8, C-13H), 6.37, (1H, s, C-10H), 7.35 and 7.4 (5H, Ph), 7.48, 7.6 and 8.05 (5H, OBz).

-Compound **10b** (2'S,3'R): U.V.: 207 (18158), 232 (14578), 278 (1598), 282 (1534); IR ($CHCl_3$) : 3700, 3600, 3450, 1760, 1750, 1730, 1710; ^1H NMR ($CDCl_3$): 1.15 (3H, s, C-17H_3), 1.25 (3H, s, C-16H_3), 1.4 (9H, s, tBu), 1.82 (3H, s, C-19H_3), 2.00 (3H, s, C-18H_3), 2.08 (2H, m, C-14H_2), 2.18 (3H, s, OAc at C-10), 2.32 (3H, s, OAc at C-4), 2.65 (1H, m, C-6H), 2.9 (1H, br s, OH), 3.92 (1H, d, J=7, C-3H), 4.25 and 4.32 (2H, 2d, J=9, C-20H_2), 4.6 (1H, br d, J=9, C-2'H), 4.67 and 5.3 (2H, 2d, J=12, CH_2 of the troc group), 4.97 (1H, d, J=9, C-5H), 5.19 (1H, br s, C-3'H), 5.38 (1H, br d, J=9, NH), 5.6 (1H, dd, J=12 and 7, C-7H), 5.68 (1H, d, J=7, C-2H), 6.16 (1H, t, J=8, C-13H), 6.38 (1H, s, C-10H), 7.4 (5H, Ph), 7.55, 7.68 and 8.1 (5H, 0Bz).

-Compound **11b** (2'R,3'S) + (2'S,3'R): U.V.: 203 (23330), 220 (19330), 230 (20670), 276 (1000), 284 (833); IR ($CHCl_3$): 3580, 2990, 1760, 1750, 1730; ^1H NMR ($CDCl_3$): 1.00 (3H, s, C-17H_3), 1.07 (3H, s, C-16H_3), 1.65 (3H, s, C-19H_3), 1.8 (3H, s, C-18H_3), 1.9 (3H, s, OAc at C-10), 2.1 (3H, OAc at C-4), 2.3 (1H, m, C-6H), 2.45 (1H, m, C-6H), 3.6 (1H, d, J=7, C-3H), 3.8 and 3.9 (2H, 2d, J=9, C-20H_2), 4.45 and 4.52 (1H, br d, C-2'H), 4.2 and 4.6 (2H, 2d, J=12, CH2of the troc group), 4.52 (1H, d, J=9, C-5H), 5.09 and 5.21 (1H, br d, C-3'H), 5.1 (1H, dd, J=12 and 7, C-7H), 5.2 (1H, d, J=7, C-2H), 5.5 (1H, t, J=8, C-13H), 5.8 (1H, s, C-10H), 6.7 (5H, Ph), 6.8, 6.9 and 7.3 (5H, OBz).

-General procedure for the deprotection of C-7 and/or C-10 troc group: Compounds **7a**, **8a**, **9a**, **10a** and **7b**, **8b**, **9b**, **10b** (0.13mmol) were independently treated with Zn dust (150mg) in 5ml methanol-acetic acid (1:1) at 60°C for 2 h. Filtration, concentration and extraction with ethyl acetate gave after purification by thick layer chromatography (methylene chloride/methanol 7:3):

-N-debenzoyl-N-tert-butoxycarbonyl-10-deacetyl taxol (2'R,3'S) **12a** (90% from **7a**): mp=232°C (MeOH); $[\alpha]_D$=-36° (c=0.74, EtOH); UV: 230 (14800), 275 (1730), 283 (1670); IR ($CHCl_3$): 3400, 2900, 1710 cm-1, ^1H NMR ($CDCl_3$) : 1.12 (3H, s, C-17H_3), 1.24 (3H, s, C-16H_3), 1.35 (9H, s, t-Bu), 1.77 (3H, s, C-19H_3), 1.87 (3H, s, C-18H_3), 2.28 (2H, m, C-14H_2), 2.37 (3H, s, OAc), 2.58 (1H, m, C-6H), 3.91 (1H, d, J=7, C-3H), 4.19 and 4.32 (2H, 2d, J=9, C-20H_2), 4.26 (1H, m, C-7H), 4.62 (1H, br s, C-2'H), 4.94 (1H, d, J=9, C-5H), 5.22 (1H, s, C-10H), 5.26 (1H, br d, J=9, C-3'H), 5.46 (1H, d, J=9, NH), 5.68 (1H, d, J=7, C-2H), 6.22 (1H, t, J=9, C-13H), 7.38 (5H, Ph), 7.50, 7.60, 8.12 (5H, OBz); ^{13}C NMR ($CDCl_3$) : 9.90 (C19), 14.29 (C18), 20.74 (C17), 22.54 (CH_3-acetate), 26.52 (C16), 28.23 (CH_3-tBu), 35.76 (C14), 36.71 (C6), 43.11 (C15), 46.57 (C3), 56.57 (C3'), 57.73 (C8), 71.85 (C7), 72.20 (C13), 73.87 (C2'), 74.54 (C10), 75.10 (C2), 77.32 (C20), 78.81 (C1), 80.17 (C-tBu), 81.16 (C4), 84.36 (C5), 126.81, 127.38, 127.93, 128.71, 130.16, 133.03 (o-Bz, m-Bz, p-Bz, o-Ph, m-Ph, p-Ph), 129.33 (C1-Bz), 136.03 and 138.48 and 138.5O (C11, C12 and C1-Ph), 155.55 (C=O of carbamate), 166.98 (C=O of Bz), 170.35 (C=O of Ac), 172.68 (C1'), 211.13 (C9); MS (FAB) m/z: 808 (MH^+), 790, 752, 734, 708, 690, 527, 509, 449, 405, 387, 345, 327, 282, 226.

-2'-epi 3'-epi N-debenzoyl N-tert-butoxycarbonyl-10-deacetyltaxol (2'S,3'R) **13a** (88% from **8a**); $[\alpha]_D$=-29° (c=O.69, EtOH); UV: 229 (14680), 275 (2350), 282 (2280); IR ($CHCl_3$): 3400, 2900, 1710 cm-1; 1H NMR ($CDCl_3$) : 1.11 (3H, s, C-17H_3), 1.20 (3H, s, C-16H_3), 1.38 (9H, s, t-Bu), 1.76 (3H, s, C-19H_3), 1.98 (3H,

s, C-18H_3), 2.23 (3H, s, OAc), 2.60 (1H, m, C-6H), 3.96 (1H, d, J=7, C-3H), 4.18 and 4.31 (2H,2d, J=9, C-20 H_2), 4.26 (1H, m, C-7H), 4.49 (1H, d, J=1, C-2'H), 4.49 (1H, d, J=9, C-5H)), 5.27 (2H, s, C-10H bd, J=9, C3'H), 5.49 (1H, d, J=9, NH), 5.67 (1H, d, J=7, C-2H), 6.19 (1H, t, J=9, C-13H), 7.30, 7.45 (5H, Ph), 7.48, 7.62, 8.07 (5H, OBz); MS (FAB) m/z: 808 (MH^+), 790, 752, 734, 708, 690, 527, 509, 449, 405, 387, 345, 327, 226.

-Compound **14a** (2'R, 3'S) (86.5% from **9a**) : mp=195-198°C; $[\alpha]_D$=-29° (c=0.47, EtOH); UV: 229 (16300), 274 (2570), 282 (2380); IR ($CHCl_3$): 3590, 3440, 2920, 1725 cm-1; 1H NMR ($CDCl_3$) : 1.12 (3H, s, C-17H_3), 1.22 (3H, s, C-16H_3), 1.35 (9H, s, t-Bu), 1.77 (3H, s, C-19H_3), 1.91 (3H, s, C-18H_3), 2.27 (2H, m, C-14H_2), 2.38 (3H, s, OAc), 2.59 (1H, m, C-6H), 3.96 (1H, d, J=7, C-3H), 4.19 and 4.31 (2H, 2d, J=9, C-20H_2), 4.27 (1H, m, C-7H), 4.58 (1H, dd, J=9 and J=2, C-2'H), 4.97 (1H, d, J=9, C-5H), 5.22 (1H, s, C-10H), 5.35 (1H, d, J=2, C-3'H), 5.48 (1H, d, J=9, NH), 5.67 (1H, d, J=7, C2H), 6.26 (1H, t, J=9, C-13H), 7.46, 7.40, 7.35 (5H, Ph), 7.49, 7.62, 8.07 (5H, OBz); MS (FAB) m/z: 808 (MH^+), 790, 752, 734, 708, 527, 509, 449, 405, 387, 345, 327, 299, 282, 277, 226.

- Compound **15a** (2'S, 3'R) (86% from **10a**) : mp= 210-212°C; $[\alpha]_D$=-33° (c=0.8, EtOH); UV: 230 (14240), 275 (1380), 282 (1270); IR ($CHCl_3$): 3580, 3440, 2900, 1740 cm-1; 1H NMR ($CDCl_3$) : 1.12 (3H, s, C-17H_3), 1.22 (3H, s, C-16H_3), 1.36 (9H,s,t-Bu), 1.72 (3H, s, C-19H_3), 1.94 (3H, s, C18H_3), 2.32 (3H, s, OAc), 2.51 (m, C6H), 3.85 (1H, d, J=7, C3H), 4.20 and 4.29 (2H, 2d, J=9, C20H_2), 4.22 (1H,m, C7H), 4.58 (1H, dd, J=2 and 9, C2'H), 4.97 (1H, d, J=9, C5H), 5.14 (1H, d, J=2, C3'H), 5.22 (1H, s, C10H), 5.65 (1H, d, J=7, C2H), 5.81 (1H, d, J=9, NH), 6.17 (1H, t, J=9, C13H), 7.37 (5H, C3'-Ph), 7.50, 7.63, 8.07 (5H, 0Bz); MS (FAB) m/z: 808 (MH+), 752, 740, 708, 690, 549, 527, 509, 449, 405, 387, 345, 327, 299, 226, 185.

- N-debenzoyl N-tert-butoxycarbonyl taxol **12b** (2'R, 3'S) (86% from **7b**): mp=201-203°C (MeOH); $[\alpha]_D$=-60° (c=0.77, $CHCl_3$); U.V.: 216 (12916), 229 (13670), 276 (1830), 284 (1604); IR ($CHCl_3$): 3680, 3580, 3500, 3440, 1750, 1730, 1710; ^1H NMR ($CDCl_3$): 1.15 (3H, s, C-17H_3), 1.25 (3H, s, C-16H_3), 1.3 (9H, s, tBu), 1.67 (3H, s, C-19H_3), 1.85 (3H, s, C-18H_3), 2.25 (3H, s, OAc at C-10), 2.38 (3H, s, OAc at C-4), 2.55 (2H, m, C-6H_2), 3.8 (1H, d, J=7, C-3H), 4.17 and 4.3 (2H, 2d, J=9, C-20H_2), 4.4 (1H, dd, J=12 and 7, C-7H), 4.6 (1H, br s, C-2'H), 4.95 (1H, d, J=9, C-5H), 5.25 (1H, d, J=9, C-3'H), 5.4 (1H, d, J=9, NH), 5.65 (1H, d, J=7, C-2H), 6.2 (1H, t, J=8, C-13H), 6.28 (1H, s, C-10H), 7.35 (5H, Ph), 7.45, 7.58 and 8.07 (5H, OBz); ^{13}C NMR ($CDCl_3$): 9.68 (C-19), 14.9 (C-18), 20.9 (C-17), 21.9 (CH_3-acetate), 22.7 (CH_3-acetate), 26.9 (C-16), 28.3 (CH_3-tBu), 35.6 (C-14), 35.7 (C-6), 43.4 (C-15), 45.7 (C-3), 58.7 (C-3'), 59.6 (C-8), 72.3 (C-7), 72.5 (C-13), 73.8 (C-2'), 75.1 (C-10), 75.7 (C-2), 77.14 (C-20), 77.7 (C-1), 79.2 (C-tBu), 81.3 (C-4), 84.36 (C-5), 126.9, 128.2, 128.8, 128.9, 130.2, 133.8 (o-Bz, m-Bz, p-Bz, o-Ph, m-Ph, p-Ph), 129.2 (C1-Bz), 133.2, 139 and 143 (C-11, C-12, C1-Ph), 155.5 (C=O of carbamate), 165 (C=O of Bz), 170.3 (2x C=O of acetate), 171 (C-1'), 201 (C-9); MS (CI) m/z: 850 (MH^+), 750, 690, 628, 569, 509, 551, 449, 447, 387, 327, 224, 206.

- 2'epi, 3'epi N-debenzoyl-N-tert-butoxycarbonyl-taxol **13b** (2'S, 3'R) (84% from **8b**): mp=191-193°C (MeOH); $[\alpha]_D$=-68° (c=0.71, $CHCl_3$); U.V.: 215 (10770), 230 (14285), 275 (923), 282 (846); IR ($CHCl_3$): 3680, 3580, 3500, 3450, 1780, 1730, 1710; ^1H NMR ($CDCl_3$): 1.15 (3H, s, C-17H_3), 1.24 (3H, s, C-16H_3), 1.36 (9H, s, tBu), 1.65 (3H,s, C-19H_3), 1.95 (3H, s, C-18H_3), 2.2 (3H, s, OAc at C-10), 2.25 (3H, s, OAc at C-4), 2.38 (1H m, C-6H), 2.53 (1H, m, C-6H), 3.85 (1H, d, J=7, C-3H), 4.15 and 4.28 (2H, 2d, J=9, C-20H_2), 4.45 (2H, m, C-7H and C-2'H), 4.95 (1H, d, J=9, C-5H), 5.22 (1H, d, J=9, C-3'H), 5.35 (1H, d, J=9, NH), 5.65 (1H, d, J=7, C-2H), 6.1 (1H, t, J=8, C-13H), 6.3 (1H, s, C-10H), 7.35 (5H, Ph), 7.44, 7.6 and 8.03 (5H, OBz); ^{13}C NMR ($CDCl_3$): 9.66 (C-19), 15.17 (C-18), 20.95 (C-17), 21.66 (CH_3-acetate), 22.71 (CH_3-acetate), 26.95 (C-16), 28.35 (CH_3-tBu), 35.82 (C-14), 36.33 (C-6), 43.26 (C-15), 45.98 (C-3), 58.87 (C-3'), 72.35 (C-7), 72.49 (C-13), 74.11 (C-2'), 75.15 (C-10), 75.80 (C-2), 77.13 (C-20), 77.76 (C-1), 80.47 (C-tBu), 81.38 (C-4), 84.59 (C-5), 126.60, 128.30, 128.80, 129.00, 130.20, 133.9 (à-Bz, m-Bz, p-Bz, o-Ph, m-Ph, p-Ph), 129.4 (C1-Bz), 133.10, 139.2 and 142.5 (C-11, C-12 and C1-Ph), 155.40 (C=O of carbamate), 167.10 (C=O of Bz), 169.70 (C=O of acetate), 171.20 (C=O of acetate), 172.50 (C-1'), 203.80 (C-9); MS (CI) m/z: 850 (MH^+), 774, 750, 690, 628, 569, 551, 509, 447, 387, 327, 206.

- Compound **14b** (2'R, 3'S) (85% from **9b**): mp=227-229°C (MeOH); $[\alpha]_D$=-35° (c=0.73, $CHCl_3$); U.V.: 215 (12500), 232 (15930), 275 (1250), 283 (1080); IR ($CHCl_3$): 3660, 3560, 3500, 3430, 1735, 1720,

1715, 1710; ^{1}H NMR ($CDCl_3$): 1.12 (3H, s, C-17H_3), 1.25 (3H, s, C-16H_3), 1.35 (9H, s, tBu), 1.69 (3H, s, C-19H_3), 1.88 (3H, s, C-18H_3), 2.25 (3H, s, OAc at C-10), 2.30 (2H, m, C-14H_2), 2.38 (3H, s, OAc at C-4), 2.56 (2H, m, C-6H_2), 3.86 (1H, d, J=7, C-3H), 4.2 and 4.31 (2H, 2d, J=9, C-20H_2), 4.45 (1H,dd, J=12 and 7, C-7H), 4.61 (1H, dd, J=9 and 2, C-2'H), 5.01 (1H,d, J=7, C-5H), 5.38 (1H, d, J=2, C-3'H), 5.5 (1H, d, J=9, NH), 5.69 (1H, d, J=7, C-2H), 6.31 (2H, m, C-10H and C-13H), 7.4 (5H, Ph), 7.45, 7.62 and 8.10 (5H, OBz); ^{13}C NMR ($CDCl_3$): 9.7 (C-19), 15.0 (C-18), 20.8 (C-17), 21.6 (CH_3-acetate), 22.9 (CH_3-acetate), 26.9 (C-16), 28.3 (CH_3-tBu), 35.9 (C-14), 36.2 (C-6), 43.2 (C-15), 46.0 (C-3), 58.8 (C-3'), 59.6 (C-8), 71.2 (C-7), 72.3 (C-13), 73.9 (C-2'), 75.2 (C-10), 75.8 (C-2), 77.1 (C-20), 77.7 (C-1), 79.3 (C-tBu), 81.3 (C-4), 84.6 (C-5), 126.4, 128.2, 128.8, 130.2, 133.8 (o-Bz, m-Bz, p-Bz, o-Ph, m-Ph, p-Ph), 129.8 (C1-Bz), 133.2, 139.8 and 143 (C-11, C-12, C1-Ph), 155.6 (C=O of carbamate), 167.1 (C=O of Bz), 170.2 (C =O of acetate), 170.5 (C=O of acetate), 171.2(C-1'), 203.8 (C-9); MS (CI) m/z: 744, 569, 551, 509, 491, 449, 447, 387, 327.

- Compound **15b** (2'S, 3'R) (82% from **10b**): mp=217-219°C (MeOH); $[\alpha]_D$=-40° (c=1.27, $CHCl_3$); U.V.: 220 (16920), 230 (17770), 276 (1154), 283 (1135); IR ($CHCl_3$): 3680, 3600, 3440, 1745, 1735, 1720, 1710; ^{1}H NMR ($CDCl_3$): 1.12 (3H, s, C-17H_3), 1.24 (3H, s, C-16H_3), 1.35 (9H, s, tBu), 1.62 (3H, s, C-19H_3), 1.88 (3H, s, C-18H_3), 2.05 (2H, m, C-14H_2), 2.2 (3H, s, OAc at C-10), 2.29 (3H, s, OAc at C-4), 2.53 b(2H, m, C-6H_2), 3.17 (1H, br s, OH), 3.72 (1H, s, C-3H), 4.12 and 4.25 (2H, 2d, J=9, C-20H_2), 4.4 (1H, m, C-7H), 4.53 (1H, br d, C-2'H), 4.9 (1H, d, J=9, C-5H), 5.12 (1H, br s, C-3'H), 5.4 (1H, d, J=9, NH), 5.6 (1H, d, J=7, C-2H), 6.12 (1H, t, J=8, C-13H), 6.22 (1H, s, C-10H), 7.33 (5H, Ph), 7.48, 7.59 and 8.05 (5H, OBz); ^{13}C NMR ($CDCl_3$): 9.7 (C-9), 14.8 (C-18), 20.9 (C-17), 22.2 (CH_3-acetate), 22.4 (CH_3-acetate), 26.9 (C-16), 28.3 (CH_3-tBu), 35.5 (C-14 and C-6), 43.3 (C-15), 45.6 (C-3), 58.6 (C-3' and C-8), 71.6 (C-7), 72.1 (C-13), 74.5 (C-2'), 75.3 C-10), 75.7 (C-2), 77.1 (C-20), 77.7 (C-1), 79.5 (C-tBu), 81.0 (C-4), 84.6 (C-5), 126.3, 128.7, 130.2, 133.9 (o-Bz, m-Bz, p-Bz, o-Ph, m-Ph, p-Ph), 129.4 (C1-Bz), 132.8, 139.4 and 142.9 (C-11, C-12, C1-Ph), 159 (C=O of carbamate), 167.1 (C=O of Bz), 170.0 (C-1'), 171.4 and 171.5 (C=O of acetate), 203.9 (C-9); MS (CI) m/z: 744, 732, 569, 551, 509, 447, 387, 327, 206.

-General procedure for the cleavage of C-2' or C-3' BOC group:

Hydroxycarbamates **7a**, **8a** (0.13 mmol.) in 5ml dry acetonitrile were independently treated with iodotrimethylsilane (0.025ml) at 0°C under argon for 30mn. Methanol was then added and the reaction was worked up by standard methods. β aminoalcohols **16** and **17** were obtained in 75% yield after purification by preparative tlc (CH_2Cl_2/MeOH: 95/5).

-Compound **16** (2'R,3'S): IR ($CHCl_3$): 3670, 3500, 3400, 2950, 1765, 1735 cm^{-1}; ^{1}H NMR (CDCl3): 1.18 (3H, s, C-17H_3), 1.25 (3H,s, C-16H_3), 1.85 (3H, s, C-19H_3), 2.01 (3H, s, C-18H_3), 2.31 (3H, s, OAc), 2.56 (m, C-6H), 3.89 (1H, d, J=7, C-3H),4.16 and 4.34 (2H, 2d, J=9, C-20H_2), 4.41 (2H, br s, C-2'H and C-3'H, 4.63 and 4.94 (2H, 2d, J=12, CH_2 of the 7-protect.group), 4.81 (2H, s, CH_2 of the 10-protect.group), 4.96 (1H, d, J=9, C-5H), 5.58 (1H, m, C-7H), 5.69 (1H, d, J=7, C-2H), 6.19 (1H, t, J=9, C-13H), 6.28 (1H, s, C-10H), 7.47 (5H, C-3'Ph), 7.57, 7.69 and 8.12 (5H, OBz).

-Compound **17** (2'S,3'R): IR ($CHCl_3$): 3550, 3400, 2900, 1765, 1740 cm^{-1}, ^{1}H NMR (CDCl3): 1.18 (3H, s, C-17H_3), 1.24 (3H, s, C-16H_3), 1.87 (3H, s, C-19H_3), 1.97 (3H, s, C-18H_3), 2.30 (3H, s, OAc), 2.65 (m, C-6H), 3.95 (1H, d, J=7, C-3H), 4.20 and 4.35 (2H, 2d, J=8, C-20H_2), 4.40 (2H, br s, C-2'H and C-3'H), 4.63 and 4.95 (2H, d, J=12, CH_2 of the 7-protect.group), 4.81 (2H, s, CH_2 of the 10-proct.group), 5.01 (1H, d, J=9, C-5H), 5.61 (1H, m, C-7H), 5.71 (1H, d, J=7, C-2H), 6.26 (1H, t, J=9, C-13H), 6.27 (1H, s, C-10H), 7.47 (5H, C-3'Ph), 7.52, 7.64 and 8.08 (5H, OBz).

General procedure for the benzoylation of β-aminoalcohols:

To a solution of β-amino alcohols **16** or **17** (30mg) in dry pyridine (2ml), 1.5 equivalents of benzoyl chloride were added. The reaction mixture was stirred at room temperature for about 3hrs and, then, worked up by standard methods to give quantitative yields of compounds **18** or **19**.

- Compound **18** (2'R,3'S): IR ($CHCl_3$): 3560, 3440, 2950, 1765, 1740, 1730, 1665 cm^{-1}; ^1H NMR ($CDCl_3$): 1.19 (3H, s, C-17H_3), 1.26 (3H, s, C-16H_3), 1.88 (3H, s, C-19H_3), 1.90 (3H, s, C-18H_3), 2.42 (3H, s, OAc), 3.93 (1H, d, J=7, C-3H), 4.23 and 4.27 (2H, 2d, J=9, C-20H_2), 4.63 and 4.94 (2H, 2d, J=12, CH2 of the 7-protect.group), 4.80 (2H, s, CH2 of the 10-protect.group), 4.83 (1H, d, J=2, C-2'H), 4.99 (1H, d, J=9, C-5H), 5.58 (1H, m, C-7H), 5.75 (1H, d, J=7, C-2H), 5.84 (1H, dd, J=9 and J=2, C-3'H), 6.28 (2H, s+t, J=9, C-10H and C-13H), 7.09 (1H, d, J=9, NH), 7.41-8.17 (15H, C-3'Ph, OBz and NBz).

- Compound **19** (2'S,3'R): IR ($CHCl_3$): 3550, 3430, 2950, 1770, 1745, 1730, 1670 cm^{-1}; ^1H NMR ($CDCl_3$): 1.16(3H,s,C-17H_3), 1.20(3H,s,C-16H_3), 1.85(3H,s,C-19H_3), 2.16(3H,s,C-18H_3), 2.22 (3H,s, OAc), 2.66(m,C-6H), 3.96(1H,d,J=7,C-3H), 4.12 and 4.32(2H,2d,J=8,C-20H_2), 4.60 and 4.93(2H, 2d,J=12, CH_2 of the prot. group), 4.63 (1H,bs,C-2'H), 4.78 (2H,s, CH_2 of the prot. group), 4.98 (1H, d,J=9,C-3'H), 5.61 (1H,m,C-7H), 5.69 (1H,d,J=7,C-2H), 5.75 (1H,d,J=9,C-3'H), 6.12(1H,t, J=9C-13H), 6.28 (1H,s,C-10H), 6.96 (1H,d,J=9,NH), 7.39-8.06 (15H, OBz, C-3'Ph and N-Bz).

- 10-deacetyl taxol **2** (2'R,3'S) and compound **20** (2'S,3'R) were obtained in 90% yield from respectively **18** and **19** (see general procedure for the removal of the troc groups):

- 2' epi, 3'epi 10-deacetyl taxol **20** (2'S,3'R): $[\alpha]_D$=-29° (MeOH, c=0.76); UV: 229 (24300), 274 (1950), 282 (1450); IR ($CHCl_3$): 3600, 3440, 2920, 1740, 1730, 1670, 1600 cm^{-1}; ^1H NMR ($CDCl_3$): 1.12 (3H,s,C-17H_3), 1.19 (3H,s,C-16H_3), 1.75 (3H,s,C-19H_3), 1.95 (3H,s,C-18H_3), 2.24 (3H,s,OAc), 3.96 (1H,d,J=7,C-3H), 4.19 and 4.32 (2H,2d, J=8,C-20H_2), 4.29 (1H,m,C-7H), 4.68 (1H,d,J=2,C-2'H), 4.98 (1H,d,J=9,C-5H), 5.26 (1H,s,C-10H), 5.68 (1H,d,J=7,C-2H), 5.74 (1H,dd,J=9 and 2,C-3'H), 6.22 (1H,t,J=9,C-13H), 7.19 (1H,d,J=9,NH), 7.34-8.10 (15H, OBz, NHBz and C-3'Ph); ^{13}C NMR ($CDCl_3$): 10.02 (C19), 14.81 (C18), 20.51 (C17), 22.63 (CH_3-acetate, 26.66 (C16), 36.43 (C14), 37.15 (C6), 43.18 (C15), 46.89 (C3), 55.77 (C3'), 57.98 (C8), 72.01 (C7), 72.75 (C13), 73.96 (C2'), 74.75 (C10), 75.12 (C2), 76.50 (C20), 79.15 (C1), 81.42 (C4), 84.42 (C5), 127.30, 127.58, 128.56, 128.85, 129.23, 130.21, 132.06, 133.85 (o-OBz, m-OBz, p-OBz, o-NBz, m-NBz, p-NBz, o-Ph, m-Ph, p-Ph), 129.81 (C1-OBz), 134.06, 136.25, 138.46, 138.97 (C1-NBz, C11, C12 and C1-Ph), 167.10, 167.34, 169.74, 172.74 (C=O of OBz, NBz, OAc and C1'), 211.43 (C9). MS (FAB) m/z:812(MH^+), (CI) m/z: 776, 654, 509, 268, 240, 224.

-Compound **21** (2'R,3'S) and **22** were obtained in about 70% overall yield from respectively **9a** and **10a** after removal of the boc group, benzoylation and removal of the troc groups:

Compound **21**: $[\alpha]_D$=-37° (MeOH, c=0.43), UV: 230 (32000), 276 (2800), 282 (2500); IR ($CHCl_3$): 3580, 3470, 3000, 1730, 1670 cm^{-1}; ^1H NMR ($CDCl_3$): 1.10 (3H,s,C-17H_3), 1.19 (3H,s,C-16H_3), 1.75 (3H,s,C-19H_3), 1.98 (3H,s,C-18H_3), 2.44 (3H,s,OAc), 3.94 (1H,d,J=7,C-3H), 4.17 and 4.29 (2H,2d,J=8,C-20H_2), 4.26 (1H,m,C-7H), 4.96 (1H,d,J=9,C-5H), 5.12 (1H,br d,J=9,C-2'H), 5.29 (1H,s,C-10H), 5.54 (1H,s,C-3'H), 5.56 (1H,d,J=7,C-2H), 6.28 (1H,t,J=8,C-9H), 7.16 (1H,d,J=9,NH), 7.29-8.10 (15H,OBz,NHBz and C-3'Ph). ^{13}C NMR ($CDCl_3$): 9.99 (C19), 14.75 (C18), 20.52 (C17), 23.10 (CH_3-acetate), 26.63 (C16), 36.57 (C14), 37.26 (C6), 43.21 (C15), 46.91 (C3), 58.08 (C8), 58.49 (C3'), 71.68 (C7), 72.25 (C13), 73.84 (C2'), 74.80 (C10), 75.08 (C2), 76.89 (C20), 79.05 (C1), 81.36 (C4), 84.35 (C5), 126.17, 127.26, 128.88, 129.00, 130.27, 132.06, 133.85 (o-OBz, m-OBz, p-OBz, o-NBz, m-NBz, p-NBz, o-Ph, m-Ph, p-Ph), 129.50 (C1-OBz), 136.44, 138.57, 139.67 (C11, C12 and C1-Ph), 167.15, 167.85, 170.28, 170.41 (C=O of OBz, NBz, OAc and C1'), 211.49 (C9); MS (FAB) m/z: 812(MH^+), 527, 509, 286, 268, 240.

-Compound **22** (2'S,3'R) : $[\alpha]_D$=-20° (MeOH, c=0.6), UV: 231 (21000), 275 (1850), 283 (1380); IR ($CHCl_3$): 3600, 3450, 2900, 1740, 1670 cm^{-1}; ^1H NMR ($CDCl_3$): 1.08 (3H,s,C17-H_3), 1.20 (3H,s,C-16H_3), 1.69 (3H,s,C-19H_3), 1.89 (3H,s,C-18H_3), 2.25 (3H,s,OAc), 3.84 (1H,d,J=7,C-3H), 4.12 and 4.28 (2H,2d,J=8,C-20H_2), 4.19 (1H, m,C-7H), 4.91 (1H,d,J=8.5,C-5H), 5.09 (1H,dd,J=8 and 5,C-2'H), 5.20 (1H,s,C-10H), 5.28 (1H,d,J=5,C-3'H), 5.63 (1H,d,J=7,C-2H), 6.12 (1H,t,J=9,C-13H),7.05 (1H,d,J=8,NH), 7.31-8.06 (15H,OBz,NBz and C-3'Ph); ^{13}C NMR ($CDCl_3$):10.07 (C19), 14.34 (C18), 21.01 (C17), 22.44 (CH_3-acetate), 26.69 (C16), 35.88 (C14), 37.04 (C6), 43.28 (C15), 46.54 (C3), 57.80 (C8), 59.30 (C3'), 71.98 (C7), 72.24 (C13), 74.64, 74.73 and 75.29 (C2', C10 and C2), 79.30 (C1), 81.09 (C4), 84.36 (C5), 126.27, 127.30, 128.82, 130.25, 133.21, 133.89 (o-OBz, m-OBz, p-OBz, o-NBz, m-NBz, p-NBz, o-Ph, m-Ph, p-Ph), 129.60 (C1-OBz), 133.35 (C1-NBz), 136.10, 138.85, 139.43 (C11, C12 and C1-Ph), 167.17, 167.91, 169.99, 171.20 (C=O of OBz, NBz, OAc, C1'), 211.62 (C9); MS (FAB) m/z: 812 (MH^+), 527, 509, 286, 268, 240.

- Taxol **1** was obtained from compound **7b** in 60% overall yield after deprotection of the boc group, benzoylation and removal of the troc group at C-7 (See general procedures).

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