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ALKALOIDS OF *ERYTHROXYLUM ZAMBESIACUM* ROOT-BARK*

YAHIA M. A. EL-IMAN, WILLIAM C. EVANS, RAYMOND J. GROUT and K. P. ANNE RAMSEY

Department of Pharmacy, The University, Nottingham NG7 2RD, U.K.

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Key Word Index—*Erythroxylum zambesiacum*; Erythroxylaceae; root-bark; tropane alkaloids; esterifying acids; chemotaxonomy

Abstract—Six new alkaloids characterized from the root-bark of *Erythroxylum zambesiacum* were: 3α-(3,4,5-trimethoxybenzoyloxy)nortropane, 3α-(3,4,5-trimethoxybenzoyloxy)tropan-6β-ol, 3α-(3,4,5-trimethoxybenzoyloxy)-nortropan-6β-ol, 6β-benzoyloxytropan-3α,7β-diol, 6β-benzoyloxy-3α-(3,4,5-trimethoxycinnamoyloxy)tropan-7β-ol, and 7β-acetoxy-6β-benzoyloxy-3α-(3,4,5-trimethoxycinnamoyloxy)tropane. Other bases identified included 3α-(3,4,5-trimethoxybenzoyloxy)tropane, 3α-(3,4,5-trimethoxycinnamoyloxy)tropane, 3α-phenylacetoxytropan-6β-ol, 3α-(3,4,5-trimethoxybenzoyloxy)tropan-6β,7β-diol, 6β-benzoyloxytropan-3α-ol, and 6β-benzoyloxy-3α-(3,4,5-trimethoxycinnamoyloxy)tropane; other bases could not be fully characterized. The chemotaxonomic implications of the esterifying acids are discussed.

INTRODUCTION

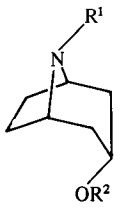
Erythroxylum zambesiacum N. Robson, first described in 1962 [1], is included in *Flora Zambesiaca* (1963) [2] and *Flora of Tropical East Africa* (1984) in which it is listed incorrectly as *E. zambesianum* [3]. It is a shrub or small tree mainly confined to the Zambesi valley from Kariba to above the Victoria Falls and is related to the West African *E. mannii* Oliv. [1]. No mention of local uses or reports concerning the phytochemistry of *E. zambesiacum* are to be found in the literature. As part of a wider investigation of the genus for tropane and related alkaloids having pharmacological and chemotaxonomic interest, we record here our findings on the basic constituents of the root-bark of this species.

RESULTS AND DISCUSSION

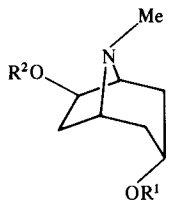
Preliminary thin-layer chromatography (TLC) examination of the extracts of small quantities of root- and stem-bark showed an apparent similarity in the alkaloid spectrum of both sources; the root-bark was studied in detail and five principal bases and several minor ones were apparent, representing 0.28% of the dried plant material. In typical experiments 100–200 g of root-bark were exhaustively extracted with ether and the alkaloid extract fractionated by column partition chromatography at pH 6.8 with petrol (bp 60–80°), ether and chloroform in succession as eluants. Preparative TLC and the fractional crystallization of picrates gave further separations. Thirteen basic fractions were recognised and identified 1–13 in order of their ascending R_f values on TLC. For the characterization of the isolated tropane alkaloids the spectroscopic criteria previously outlined [4] and standard chemical procedures were employed. Fraction 1, the slowest running by TLC, was eluted from the partition column by chloroform and contained one principal and seven minor bases. Preparative TLC gave the major alkaloid which by IR and mass spectroscopy was shown to be an ester of a nortropanol and trimethoxybenzoic acid. The structure of the new alkaloid was confirmed as 3α-(3,4,5-trimethoxybenzoyloxy)nortropane (**1a**) by comparison of the natural alkaloid picrate with that of the picrate of a synthetic sample of the base.

Fraction 2 (R_f 0.34, System B see Experimental) was not isolated in sufficient quantity for further investigation; fraction 3 was identified as 3α-(3,4,5-trimethoxybenzoyloxy)tropane (**1b**), a base previously isolated [5] from *E. monogynum*, and fraction 4 as the analogous 3,4,5-trimethoxycinnamate (**1c**), a constituent of both *E. monogynum* root-bark [5] and *E. ellipticum* leaves [6]. A dextrorotatory base from fraction 5 had R_f 0.41 (System C see Experimental) and possessed ester and hydroxyl functions. The molecular formula, $C_{18}H_{25}NO_6$, and mass fragmentation pattern, $[M]^+$ and $[M-44]^+$ $[M-(CHOH-CH_2)]^+$, corresponded to tropane-3,6-diol esterified at C-3 with an acid, $C_{10}H_{12}O_5$, shown after hydrolysis and isolation to be 3,4,5-trimethoxybenzoic acid. Further support for the C-3 ester linkage was given by the mass spectrum of this base, as its 6β-phenylacetyl derivative, ($[M]^+$ and $[M-(PhCH_2OCOCH-CH_2)]^+$). ^{1}H NMR spectroscopy indicated 3β- and 6α-protons. The structure of the new alkaloid is therefore (+)-3α-(3,4,5-trimethoxybenzoyloxy)tropan-6β-ol (**2a**); the picrate has mp 214°. From the picrate mother-liquors of **2a**, fraction 6 was deposited as a gummy picrate from which a laevorotatory base was released; this base was characterized as 3α-phenylacetoxytropan-6β-ol (**2b**), a known constituent of *E. hypericifolium* root-bark [4]. A comparison of the 6β-phenylacetyl derivative of this base with semi-synthetic compounds prepared from the (+)-, (−)- and (±)- tropanediols indicated the isolated alkaloid in this instance was an unequal mixture of the (+)- and (−)-esters; in contrast the alkaloid isolated from *E. hyper-*

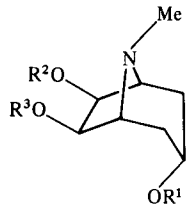
* Part 7 in the series 'Alkaloids of the Genus *Erythroxylum*'. For part 6 see ref. [10].



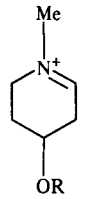
1a R^1 = H, R^2 = $(MeO)_3C_6H_2CO$ (Tmb)
1b R^1 = Me, R^2 = Tmb
1c R^1 = Me, R^2 = $(MeO)_3C_6H_2CH{:}CHCO$ (Tmc)



2a R^1 = Tmb, R^2 = H
2b R^1 = $PhCH_2CO$, R^2 = H
2c R^1 = H, R^2 = PhCO (Bz)
2d R^1 = Tmc, R^2 = Bz
2e R^1 = R^2 = $PhCH_2CO$



3a R^1 = Tmb, R^2 = R^3 = H
3b R^1 = R^3 = H, R^2 = Bz
3c R^1 = Tmc, R^2 = Bz, R^3 = H
3d R^1 = Tmc, R^2 = Bz, R^3 = MeCO



	R	*m/z*
4a	Tmb	307
4b	H	113
4c	Bz	217
4d	Tmc	333
4e	$PhCH_2CO$	231

icifolium appeared to be derived exclusively from the (+)-diol.

Fraction 7 contained the principal alkaloid of the chloroform eluate and it was identified as 3α-(3,4,5-trimethoxybenzoyloxy)tropan-6β,7β-diol (**3a**) a known constituent of *E. monogynum* root bark [5]. Fraction 8, closely associated with fraction 7 in the chromatographic separations, had R_f 0.62 (System A see Experimental) and readily formed a picrate. Elemental analysis and spectroscopy indicated a molecular formula of $C_{15}H_{19}NO_4$ for the base. The mass spectrum of the picrate was characteristic of a tropanol esterified with benzoic acid and the presence of a prominent ion **4b** and the absence of an ion (**4c**) $[M-60]^+$ indicated esterification at C-6 and a free hydroxyl at C-3.^{1}H NMR spectroscopy demonstrated 3β-, 6α- and 7α-protons together with aromatic, *N*-methyl and hydroxyl functions. The above data established the structure of the new alkaloid as 6β-benzoyloxytropan-3α,7β-diol (**3b**). The isomeric 3α-benzoyl ester was reported [7] as a constituent of *E. australe* roots.

Fraction 9 constituted the later portion of the ether eluate of the partition column and contained a base having the spectroscopic characters of a synthetic sample of (±)-6β-benzoyloxytropan-3α-ol (**2c**). The natural alkaloid was dextrorotatory and appears to be identical with the (+)-alkaloid isolated by Lounasmaa *et al.* [8] from *Knightia strobilina*, (Proteaceae). From fraction 10, the main ether eluate of the column, a base of R_f 0.25 (System B see Experimental) was isolated, and purified by picrate formation. Elemental analysis and spectroscopy indicated that the base had the molecular formula $C_{17}H_{23}NO_6$, with ester and hydroxyl functions. Mass

spectrometry suggested a substituted nortropane-3,6-diol associated with a trimethoxybenzoic acid moiety; the 3,4,5-substitution pattern for the methoxy groups was established by ^{1}H NMR spectroscopy (singlet at δ7.28), other isomers have dissimilar signals [9]. The distorted multiplet at δ5.0, assigned to the 3β-proton, is similar in multiplicity and chemical shift to the 3β-proton of noratropine. Although *m/z* 293 $[M-(C(6)HOH-C(7)H_2)]^+$ was absent in the mass spectrum, the occurrence of the 6α-proton as a doublet of doublets at δ4.56 confirms this substituent as the free alcohol rather than as an ester. Thus, this fraction was identified as 3α-(3,4,5-trimethoxybenzoyloxy)nortropan-6β-ol. Similar bases esterified at C-3 and involving benzoic or phenylacetic acid have been characterized [10, 11] from the leaves of *E. macrocarpum* and *E. sideroxyloides* and from the roots of *E. cumanense*.

The initial elution of the partition column with petrol gave three distinct fractions. Fraction 11 had R_f 0.70 (System B see Experimental) and was purified by picrate formation. Mass spectrometry gave M_r of 497 with a characteristic tropane-diol or -triol fragmentation. Esterification involving two different acids was indicated by the IR spectrum and by the $[M]^+$ ions of benzoic and trimethoxycinnamic acids and their acylium ions in the mass spectrum; attachment of the latter acid at C-3 was established by a low intensity ion at *m/z* 333 (**4d**). A free hydroxyl group was apparent in the IR spectrum. The ^{1}H NMR spectrum supported the mass spectral findings and, by the established criteria, showed the 3α-configuration of the ester group, the 3,4,5-substitution of the aromatic ring and the 6β,7β-orientation of the remaining groups. The new alkaloid is therefore 6β-benzoyloxy-3α-(3,4,5-trimethoxy-cinnamoyloxy)tropan-7β-ol (**3c**); it had previously been suspected, but not confirmed, as a component of *E. monogynum* root-bark [12].

Fraction 12 consisted principally of a base R_f 0.70 (System D) which was purified by picrate formation. Elemental analysis and mass spectroscopy gave the molecular formula of the base as $C_{29}H_{33}NO_9$ and the IR spectrum showed three different carbonyl functions. In the mass spectrum a trisubstituted tropane was indicated and benzoic and trimethoxycinnamic acids and their acylium ions were detected. The trimethoxycinnamic acid formed an ester function at C-3 of the tropanol [*m/z* 333 (**4d**)], with confirmation following from the absence of ions *m/z* 217 [3-benzoate (**4c**)] and 155 (3-acetate). The acetate moiety was supported by the ion *m/z* 43 and confirmed by the ^{1}H NMR signal at δ1.87, a three-proton singlet ascribable to the acetoxy group. The 3,4,5-trimethoxy substitution of the acid moiety and the 3α,6β,7β-orientation of the tropane substituents followed from the chemical shifts for the aromatic singlet and the C<u>H</u>-OH protons at δ6.88, 5.77 and 5.92, respectively. The remaining signals were consistent with the structure 7β-acetoxy-6β-benzoyloxy-3α-(3,4,5-trimethoxycinnamoyloxy)-tropane (**3d**) for this alkaloid.

Fraction 13 was obtained from residues of fraction 12; the constituent alkaloid was identified as 6β-benzoyloxy-3α-(3,4,5-trimethoxycinnamoyloxy)tropane (**2d**), a known alkaloid of *E. monogynum* root-bark [5].

Of the roots of the *Erythroxylum* spp. so far studied in detail, those of *E. zambesiacum* have yielded the largest number of alkaloids. In general the alkaloid mixture resembles that of *E. monogynum* [5], but the range is extended by the presence of nortropanes and the involvement of acetic and phenylacetic acids. It was previously suggested [4] that the esterifying acids might provide a basis for chemotaxonomic groupings within this genus of some 120 species, a large proportion of which probably contain tropane esters (28 species examined in these laboratories have, without exception, contained such bases). The acid components of the alkaloids of the roots of species so far examined are given in the Table 1. The examples represent seven of Schulz's sections of the genus and cover the principal geographic areas of distribution. Distinctive patterns of acids are particularly evident for the four sections originating from the S.E. Africa area of diversification of the genus. Further studies are required to validate such chemotaxonomic implications. Table 1 relates only to the root-barks; other acids also occur as components of the alkaloids of the aerial parts of particular species [7, unpublished results]. The isolation of **2c** is of interest as it appears to be the first reported tropane alkaloid common to *Erythroxylum* and the Proteaceae.

EXPERIMENTAL

Instrumentation and the chemical methods for the synthesis and hydrolysis of esters were as recorded in ref. [4]. The prep. TLC systems employed all involved 0.5 mm layers and were A, Al_2O_3 with Et_2O–EtOH (1:1); B, silica gel with $CHCl_3$–Et_2NH (9:1); C, silica gel with Me_2CO–H_2O–concNH_3 (80:15:2).

Plant material. Collected and authenticated by Mr D. B. Fanshawe, Division of Forest Research, Kitewe, Zambia, 1972. Collection area, Katombosa Forest Reserve. Material supplied via the Tropical Development and Research Institute, London.

Extraction and isolation of alkaloids. In typical procedures powdered root-bark (100 g) was mixed with $Ca(OH)_2$ (20 g) and H_2O (40 ml), allowed to stand for some hrs, and exhaustively extd with Et_2O. The solvent was removed and the residue redissolved in a minimum vol. of Et_2O and submitted to chromatography [kieselguhr (15 g), 0.5 M Pi buffer soln, pH 6.8. (7.5 ml)] with petrol (bp 40–60°), Et_2O and $CHCl_3$ as successive solvents. Further resolution of the alkaloid mixt. giving in all 13 fractions, was achieved by prep. TLC (System B and C above). Fractions 1–8 were principally associated with the $CHCl_3$ eluate above, fraction 9 with the later Et_2O eluate, fraction 10 with the main Et_2O eluate and fractions 11–13 with the petrol eluate.

3α-(3,4,5-*Trimethoxybenzoyloxy)nortropane* (**1a**). Fraction 1 contained one major alkaloid, R_f 0.25 (System C), and was purified as its picrate (serrated plates from EtOH–H_2O), mp 235° decomp. (softens 225°); EIMS (probe) 70 eV, *m/z* (rel. int.): 321.1595 $[M]^+$ ($C_{17}H_{23}NO_5$ requires M_r 321.1576 (1), 212.0692 $[TmbA]^+$ (calc. for $C_{10}H_{12}O_5$: 212.0685) (100), 197.0456 $[TmbA-Me]^+$ (calc. for $C_9H_9O_5$: 197.0450) (24), 195.0652 $[Tmb]^+$ (calc. for $C_{10}H_{11}O_4$: 195.0657) (8), 110.1018 (calc. for $C_7H_{12}N$; 110.0970) (44), 82, 80. The R_f value (System C) and the IR spectrum of the base were identical to those of the authentic semi-synthetic base (see below); mmp of the two picrates 235° decomp.

Preparation of synthetic **1a** *picrate.* An authentic sample of **1a** prepared by demethylation of the corresponding *N*-methyl compound gave a picrate (plates from EtOH–H_2O), mp 244° decomp. (Found: C, 50.0; H, 4.9; N, 10.5. $C_{17}H_{23}NO_5 \cdot C_6H_3N_3O_7$ requires C, 50.2; H, 4.8; N, 10.2%).

Fractions 2–4. The base contained in fraction 2 was not identified; that contained in fraction 3 had R_f 0.39 (System C) and was characterized as 3α-(3,4,5-trimethoxybenzoyloxy)tropane (**1b**) by comparison of its R_f values, mp of picrate, high resolution MS data and IR spectrum with those of the authentic compound.

Table 1. Acids recorded as ester-components of tropanols in *Erythroxylum* root-barks

	E. zambesiacum [this paper]	*E. dekindtii* [13]	*E. hypericifolium* [4]	*E. macrocarpum* [10]
Section (Schulz)	Melanocladus	Lagynocarpus	Venelia	Pachylobus
Source	Zambesi valley	Angola	Mauritius	Mauritius
	TmbA (5)	Isovaleric (2)	Phenylacetic (5)	Benzoic (1)
	Benzoic (5)	α-Methyl-butyric (1)	3-Hydroxy-phenylacetic (1)	
	TmcA (4)	Phenylacetic (1)	Acetic (1)	
	Phenylacetic (1)	Furoic (1)		
	Acetic (1)			

E. sideroxyloides [10]	*E. monogynum* [5]	*E. cumanense* [11]	*E. coca*	*E. australe*
Pachylobus	Sethia	Archerythroxylum	Archerythroxylum	Coelocarpus
Mauritius	S. India	Venezuala	Peru, etc	N. Queensland Australia
Benzoic (1)	TmbA (2)	Benzoic (2)	No esters reported	Benzoic (1) [7]
Butyric (1)	TmcA (2)	Phenylacetic (2)	in root-bark	Cinnamic(1) [unpublished]
	Benzoic (1)	TmbA (1)		
		Acetic (1)		

Figure in parenthesis indicates the number of alkaloids involving this acid. TmbA = 3,4,5-trimethoxybenzoic acid, TmcA = 3,4,5-trimethoxycinnamic acid.

Fraction 4, associated with fraction 3, had R_f 0.35 (System C) and was identified as 3α-(3,4,5-trimethoxycinnamoyloxy)tropane by comparison of R_f values and the CIMS with those of the authentic compound.

(+)-3α-(3,4,5-*Trimethoxybenzoyloxy*)*tropan-6β-ol* (**2a**). The principal base of fraction 5 had R_f 0.41 (System C) and was purified by recrystallization of the picrate (rods from EtOH–H_2O), mp 214° (Found: C, 49.7; H, 5.1; N, 9.8. $C_{18}H_{25}NO_6 \cdot C_6H_3N_3O_7$ requires C, 49.6; H, 4.9; N, 9.7%). For the free base $[\alpha]_D^{20}$ + 3.5° (EtOH; *c*1.5); IR ν_{max}^{KBr} cm^{-1}; 3500 (OH), 1710 (ester C=O); EIMS (probe) 70 eV, *m/z* (rel. int.): 351.1678 $[M]^+$ ($C_{18}H_{25}NO_6$ requires M_r 351.1682) (1), 307.1411 [**4a**]$^+$ (calc. for $C_{16}H_{21}NO_5$: 307.1420) (1), 212.0677 $[TmbA]^+$ (5), 195.0653 $[Tmb]^+$ (8), 140.1072 (calc. for $C_8H_{14}NO$: 140.1075) (35), 122, 110, 94 (100); ^1H NMR (250 MHz, $CDCl_3$): δ1.61, 1.67, 1.75 and 1.81 (4H, 4 × *dd*, H_2-2, H_2-4), 2.29 (2H, *m*, H_2-7), 2.56 (1H, *s*, exchangeable with D_2O, OH-6), 2.63 (3H, *s*, NMe), 3.16 (1H, *br s*, H-1), 3.40 (1H, *br s*, H-5), 3.92 (9H, *s*, 3 × OMe), 4.67 (1H, *dd*, H-6), 5.23 (1H, *t*, *J* = 5.0 Hz, H-3), 7.28 (2H, *s*, *o*-Tmc-H_2). Alkaline hydrolysis of the base gave tropane-3α,6β-diol (TLC) and 3,4,5-trimethoxybenzoic acid (mp, mmp); EIMS, *m/z* 212.0672 $[M]^+$, (calc. for $C_{10}H_{12}O_5$; M_r 212.0685). The 6-phenylacetate derivative of the alkaloid, purified by TLC, gave MS *m/z* 469.2077 $[M]^+$ ($C_{26}H_{31}NO_7$ requires M_r 469.2101), 307.1370 [**4a**]$^+$.

(−)-3α-*Phenylacetoxytropan-6β-ol* (**2b**). Fraction 6 was deposited as a semi-solid from the picrate mother-liquors of **2a**; the liberated base gave $[\alpha]_D^{20}$ − 13.5° (EtOH; *c*1.1) and had the spectroscopic properties (MS, NMR) of authentic **2b**. The 6β-phenylacetate of natural **2b** prepared by standard means gave a picrate (flat needles/from EtOH–H_2O, 1:1), mp 134° (Found: C, 57.6; H, 4.8; N, 8.8. Calc. for $C_{24}H_{27}NO_4 \cdot C_6H_3N_3O_7$C, 57.9; H, 4.9; N, 9.0); mmp with picrate (mp 130°) of diester prepared from (±)-diol 130–135°; mmp with picrate (mp 151°) of (−)-diester prepared from the (+)-diol 135–146°.

3α-(3,4,5-*Trimethoxybenzoyloxy*)*tropan-6β,7β-diol* (**3a**). Fraction 7 contained **3a** as a principal component of the alkaloid mixture of the bark. The properties of the base (IR, MS, NMR, picrate characters and hydrolytic products) were as recorded [5] for the characterization of **3a** from *E.* monogynum.

6β-*Benzoyloxytropan*-3α,7β-*diol* (**3b**). The main component of fraction 8 gave a broad band R_f 0.62 by prep. TLC, System A. It was further purified by conversion to the picrate, mp 213° (plates from EtOH–H_2O) (Found: C, 49.3; H, 4.6; N, 10.9. $C_{15}H_{19}NO_4 \cdot C_6H_3N_3O_7$ requires: C, 49.8; H, 4.4, N, 11.1%). IR ν_{max}^{KBr} cm^{-1}: 3495 (OH), 1725 (ester C=O); EIMS (probe) 70 eV, *m/z* (rel. int.): 277.1315 $[M]^+$ ($C_{15}H_{19}NO_4$ requires M_r 277.1314) (1), 229 (picric acid), 154.0839 (calc. for $C_8H_{12}NO_2$: 154.0868), 138.0909 (calc. for $C_8H_{12}NO$: 138.0919) (100), 113.0814 [**4b**]$^+$ (calc. for $C_6H_{11}NO$: 113.0841) (48), 105.0319 (calc. for C_7H_5O: 105.0340) (56), 96 (49), 95, 94; ^1H NMR (250 MHz, $CDCl_3$), base recovered from picrate, δ2.18, and 2.24 (4H, *dd*, H_2-2, H_2-4), 2.59 (3H, *s*, NMe), 3.16 and 3.32 (2H, 2 × *br s*, H-1, H-5), 4.12 (1H, *t*, *J* = 4.8 Hz, H-3α), 4.87 (1H, *d*), $J_{6\alpha,7\alpha}$ 6.2 Hz, 7α-H), 5.82 (1H, *d*, $J_{6\alpha,7\alpha}$ 6.2 Hz, 6α-H), 7.5 (3H, *m* Bz-H_3), 8.1 (2H *m*, Bz-H_2).

(+)-6β-*Benzoyloxytropan*-3α-*ol* (**2c**). Five components were sepd by prep. TLC from fraction 9; the principal base had R_f 0.26, and 0.55 (systems B and C, respectively), was dextrorotatory and readily formed a picrate, mp 180° (needles from EtOH). The chromatographic and spectroscopic (IR, MS) properties were identical with those of a sample of semi-synthetic (±)-6β-

benzoyloxytropan-3α-ol prepared in other studies [12].

3α-Trimethoxybenzoyloxynortropan-6β-ol (**2f**) was isolated from fraction 10. [R_f 0.24 (system B)] and afforded a picrate, mp 201° (prisms from EtOH–H_2O) (Found: C, 48.7; H, 5.0; N, 9.8. $C_{17}H_{23}NO_6 \cdot C_6H_3N_3O_7$ requires: C, 48.8; H, 4.6; N, 9.9%). IR ν_{max}^{KBr} cm^{-1}: 3520 (OH), 1716 (ester C=O); EIMS (probe) 70 eV, *m/z* (rel. int.): 337.1512 $[M]^+$ ($C_{17}H_{23}NO_6$ requires M_r 337.1525) (2), 229 (picric acid) (16), 212.0685 [TmbA]$^+$ (56), 195.0660 [Tmb]$^+$ (47), 142.0873 (calc. for $C_7H_{12}NO_2$, 142.0868), 125.0842 (calc. for $C_7H_{11}NO$: 125.0840) (100), 108 (42), 80 (12). For the regenerated base, ^{1}H NMR (250 MHz, $CDCl_3$) δ1.50–1.78 (6H, *m*, H_2-2, H_2-4, H_2-7), 2.50 (2H, exch. with D_2O, NH, OH) 3.47 (1H, *br s*, H-1), 3.68, (*d*, *J* = 6.3 Hz, H-5), 3.91 (9H, *s*, 3 × OMe), 4.56 (1H, *dd*, *J* = 6.9 and 2.2 Hz, H-6), 5.00 (1H, *m*, H-3), 7.28 (2H, *s*, *o*-Tmb-H_2).

6β-Benzoyloxy-3α-(3,4,5-trimethoxycinnamoyloxy)tropan-7β-ol (**3c**). A base of fraction 11 of the eluate from the initial column had R_f 0.70 (system B) and R_f 0.83 (system C); it was purified by repeated recrystallization of the picrate, mp 234° from EtOH–H_2O. IR ν_{max}^{KBr} cm^{-1}: 3460 (OH), 1725, 1715 (2 × ester C=O); EIMS (probe) 70 eV, *m/z* (rel. int.): 497 $[M]^+$ (2), 333 (2), 238.0843 [TmcA]$^+$ (calc. for $C_{12}H_{14}O_5$: 238.0842) (12), 221.0797 [Tmc]$^+$ (calc. for $C_{12}H_{13}O_4$: 221.0814) (8), 138 (42), 122.0968 (calc. for $C_8H_{12}N$: 122.0969) (9), 122.0365 (calc. for $C_7H_6O_2$: 122.0368) (5), 105 (74), 94 (100). ^{1}H NMR (250 MHz, $CDCl_3$), base recovered from picrate, δ2.24 (4H, *m*, H_2-2, H_2-4), 2.75 (3H, *s*, NMe), 3.2 and 3.4 (2H, 2 × *br s*, H-1, H-5), 3.90 and 3.95 (9H, 2 × *s*, 3 × OMe); 4.87 (H, *br s*, H-7), 5.25 (1H, *t*, H-3), 5.87 (H, *br s*, H-6,), 6.35 and 7.77 (2H, 2 × *d*, *J* = 16 Hz, CH=CH), 6.9 (2H, *s*, *o*-Tmc-H_2), 7.50 (3H, *m*, Bz-H_3), 8.06 (2H, *m*, Bz-H_2).

7β-Acetoxy-6β-benzoyloxy-3α-(3,4,5-trimethoxycinnamoyloxy)tropane (**3d**). Fraction 12 was sepd from fraction 11 by prep. TLC and had R_f 0.76 (System B) and 0.87 (System C). The principal base was purified by picrate formation, [plates, mp 155° from EtOH–H_2O] (Found: C, 54.2; H, 4.9; N, 7.2. $C_{29}H_{33}NO_9 \cdot C_6H_3N_3O_7$ requires: C, 54.7; H, 4.9; N, 7.3%). IR ν_{max}^{KBr} cm^{-1}: 1750, 1725, 1715 (3 × ester C=O); EIMS (probe) 70 eV, *m/z* (rel. int.): 337.1512 $[M]^+$ ($C_{17}H_{23}NO_6$ requires M_r 539.2155) (5), 434 $[M - PhCO]^+$ (1), 333.1599 [**4d**]$^+$ (calc. for $C_{18}H_{23}NO_5$: 333.1576) (2), 318 (13), 302.1390 $[M - (MeO)_3C_6H_2CH{:}CHCOO]^+$ (13), 238.0834 [Tmc]$^+$ (calc. for $C_{12}H_{14}O_5$: 238.0842) (6), 229 (picric acid), 181 (1), 180.1018 $[MeCOO{\cdot}C_8H_{11}N]^+$ (calc. for $C_{10}H_{14}NO_2$: 180.1025) (14), 138 $[C_8H_{12}NO]^+$ (14), 122.0963 $[C_8H_{12}N]^+$ (10), 122.0356 $[C_7H_6O_2]^+$ (5), 105.0293 $[C_7H_5O]^+$ (54) 94 (100), 43 (3). Base $[\alpha]_D^{20}$ −24.0° (EtOH: Me_2CO (1:1), *c* 0.5) ^{1}H NMR (250 MHz, base in $CDCl_3$), δ1.87 (3H, *s*, COMe), 2.23 (4H, *m*, H_2-2, H_2-4), 2.60 (3H, *s*, NMe), 3.27 and 3.38 (2H, 2 × *br s*, H-1, H-5), 3.81 and 3.85 (9H, 2 × *s*, 3 × OMe), 5.21 (1H, *t*, *J* = 4.5 Hz, H-3), 5.77 and 5.92 (2H, 2 × *d*, *J* = 6.4 and 6.2 Hz, respectively, H-6α, H-7α), 6.29 and 7.74 (2H, 2 × *d*, *J* = 16.1 Hz, CH=CH), 6.88 (2H, *s*, *o*-Tmc-H_2), 7.45 (3H, *m*, Bz-H_3), 7.95 (2H, *m*, Bz-H_2).

6β-Benzoyloxy-3α-(3,4,5-trimethoxycinnamoyloxy)tropane (**2d**). A minor component of fraction 12 was partially purified by repeated recrystallization of the picrate, mp 234° from same R_f values (3 systems) and the same mass spectroscopic characteristics as authentic 6β-benzoyloxy-3α-(3,4,5-trimethoxycinnamoyloxy)tropane isolated from natural sources.

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