Synthesis of Condensed Tannins. Part 16.† Stereochemical Differentiation of the First 'Angular' (2*S*,3*R*)-Profisetinidin Tetraflavanoids from *Rhus lancea* (Karree) and the Varying Dynamic Behaviour of their Derivatives

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Four novel 'angular' diastereoisomeric profisetinidin tetraflavanoids, shown to be constituted of (2*S*,3*R*)-(+)-fisetinidol and [4,6]-bi-[(2*S*,3*R*)-(+)-fisetinidol] substituents at C-6 and C-8 on the enantiomeric (2*R*,3*S*)-(+)-catechin moiety, occur in the heartwood of *Rhus lancea*. Structural and stereochemical differentiation was provided by synthesis of their tridecamethyl ether tetra-acetates. Our earlier allocation of a 'linear' arrangement of flavanyl units for one of the isomers is accordingly revised to an 'angular' assignment comprising [4,6:4,8]-bi-[2,3-*trans*-3,4-*cis*-(+)-fisetinidol] and [4,6]-2,3-*trans*-3,4-*trans*-(+)-fisetinidol substituents on (+)-catechin. Its derivative [the revised structure (**11**)] exhibits 'static' and the remainder varying degrees of 'dynamic' behaviour in solution, relative configurations determining their relative rotational stabilities. The first 'branched' profisetinidin pentaflavanoid homologue resulted as synthetic byproduct.

Intramolecular enantiomerism among constituent units of low mass range profisetinidin condensed tannins from the heartwoods of the quebracho (*Schinopsis* spp.) and karree (*Rhus* spp.) is also reflected in their associated precursors (2*S*,3*R*,4*S*)-(−)-leucofisetinidin and (2*R*,3*S*)-(+)-catechin.[1] In these bi- and 'angular' triflavanoid oligomers (2*S*,3*R*,4*S* or 4*R*)-(+)-fisetinidol units serve as substituents at C-6 and/or C-8 of the (+)-catechin moiety.[1] The latter bifunctional substrate, therefore, initiates and also propagates the sequence of electrophilic aromatic substitutions leading to the profisetinidin [4,6:4,8]-triflavanoids.

Our present isolation of four 'angular' tetraflavanoid profisetinidins from *Rhus lancea* and their stereochemical differentiation by synthesis coupled with ^{1}H n.m.r. spectrometry, shows that structural extension occurs *via* regioselective substitution at C-6 of 'upper' 8-linked (+)-fisetinidol units of the triflavanoids, and that this condensation step is also subject to asymmetric induction (*cf.* ref.[2]) The new tetraflavanoids accordingly represent diastereoisomers of those (2*R*,3*S*)-profisetinidin analogues which occur in the heartwood of the wattle (*Acacia mearnsii*).[2]

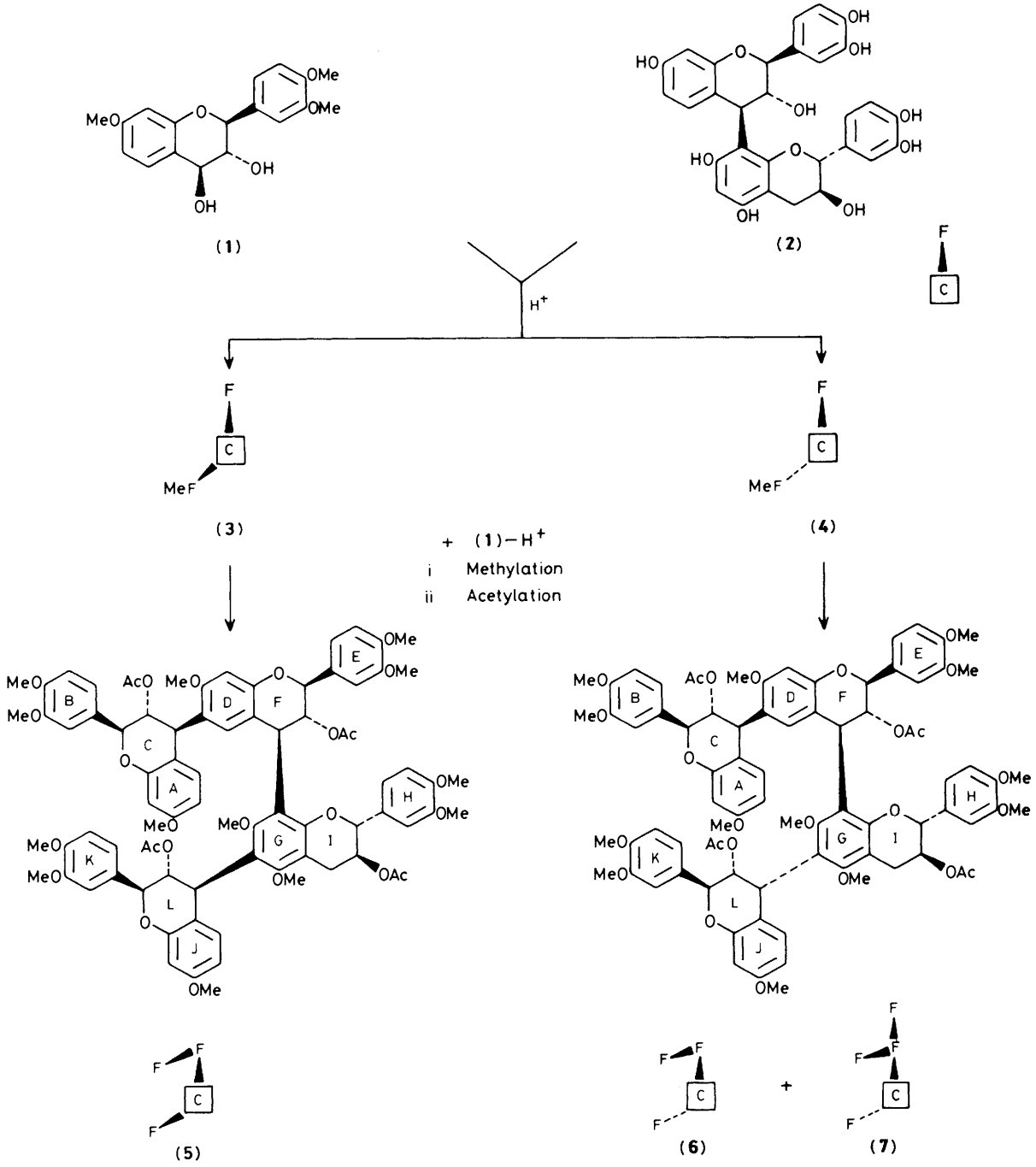
Condensation of (−)-leucofisetinidin tetramethyl ether (**1**) with [4,8]-2,3-*trans*-3,4-*trans*:2,3-*trans*-(+)-fisetinidol-(+)-catechin ‡ (**2**) (*cf.* Scheme 1) gave (after methylation and acetylation) two tetraflavanoid derivatives (**5**) and (**6**) following successive regiospecific substitutions at C-6 of the respective phloroglucinol and resorcinol rings of the biflavanoid. Simultaneous isolation of the methyl ether acetates of the 'angular' [4,6:4,8]-3,4-*trans*:3,4-*trans*-§ and 3,4-*cis*:3,4-*trans*-profisetinidin triflavanoid homologues from the reaction products indicate that their partially methylated analogues [(**3**) and (**4**) respectively] from which they are derived serve as respective intermediates for the tetraflavanoids (**5**) and (**6**). The [4,6:4,8]-3,4-*trans*:3,4-*trans*-[4,6]-3,4-*trans*-§ (**5**) and [4,6:4,8]-3,4-*trans*:3,4-*trans*-[4,6]-3,4-*cis*-(**6**) diastereoisomers are identical with their naturally derived counterparts from *Rhus lancea*.[1]

Prediction of the probable course of continued condensation beyond the tetraflavanoid range was obtained by the additional isolation from the products of synthesis (Scheme 1) of a 'branched' [4,6:4,8:4,8]-3,4-*trans*:3,4-*trans*:3,4-*trans*-[4,6]-3,4-*cis*§-pentaflavanoid homologue (**7**). Its formation reflects regiospecific substitution by the carbenium ion generated from (**1**) at C-8 (D) ‖ of a partially methylated intermediate corresponding to the [4,6:4,8]-3,4-*trans*:3,4-*trans*-[4,6]-3,4-*cis*-tetraflavanoid derivative (**6**).

Independent condensation of (−)-leucofisetinidin trimethyl ether (**1**) with [4,8]-2,3-*trans*-3,4-*cis*:2,3-*trans*-(+)-fisetinidol-(+)-catechin ¶ (**8**) under identical conditions (*cf.* Scheme 2) proceeds as in Scheme 1 but with two exceptions. Only two diastereoisomeric tetraflavanoid derivatives (**11**) and (**12**) identical with natural isomers derived from *R. lancea* were isolated from the reaction products, but no triflavanoid intermediates representative of (**9**) and (**10**). The enhanced combined yields of the pure tetraflavanoids (**11**) and (**12**) (*ca.* 8%) compared with the products (**5**)—(**7**) (*ca.* 4%) may also indicate that the putative triflavanoid intermediates (**9**) and (**10**), which are fully consumed (Scheme 2), are more reactive than those [(**3**) and (**4**)] which were isolated (Scheme 1). These differences may be attributable to steric factors based on stereochemical dissimilarity. Significance may also be attached to agreement between the ratios in which pairs of tetraflavanoid derivatives (**5**) and (**6**) and (**11**) and (**12**) were isolated (1:2.9) from their respective condensations (Schemes 1 and 2 respectively), and in which they were derived from *R. lancea* (1:2.4). On the presumption that the natural tetraflavanoids originate *via* 'angular' [4,6:4,8]-triflavanoids by pathways analogous to those illustrated for their synthetic derivatives, asymmetric induction must again (*cf.* ref. 2) play a dominant role in the final *in vivo* condensation step, since the same stereochemistry [either 3,4-*trans*-(**5**), -(**6**) or 3,4-*cis*-(**11**), -(**12**)] may be assigned to both (+)-fisetinidol units comprising each of their 8-linked biflavanoid moieties.

The stereochemistry, and hence the absolute configuration of the tetraflavanoid derivatives (**5**), (**6**), (**11**), and (**12**), follows directly from the method of synthesis as before[2] when taken in

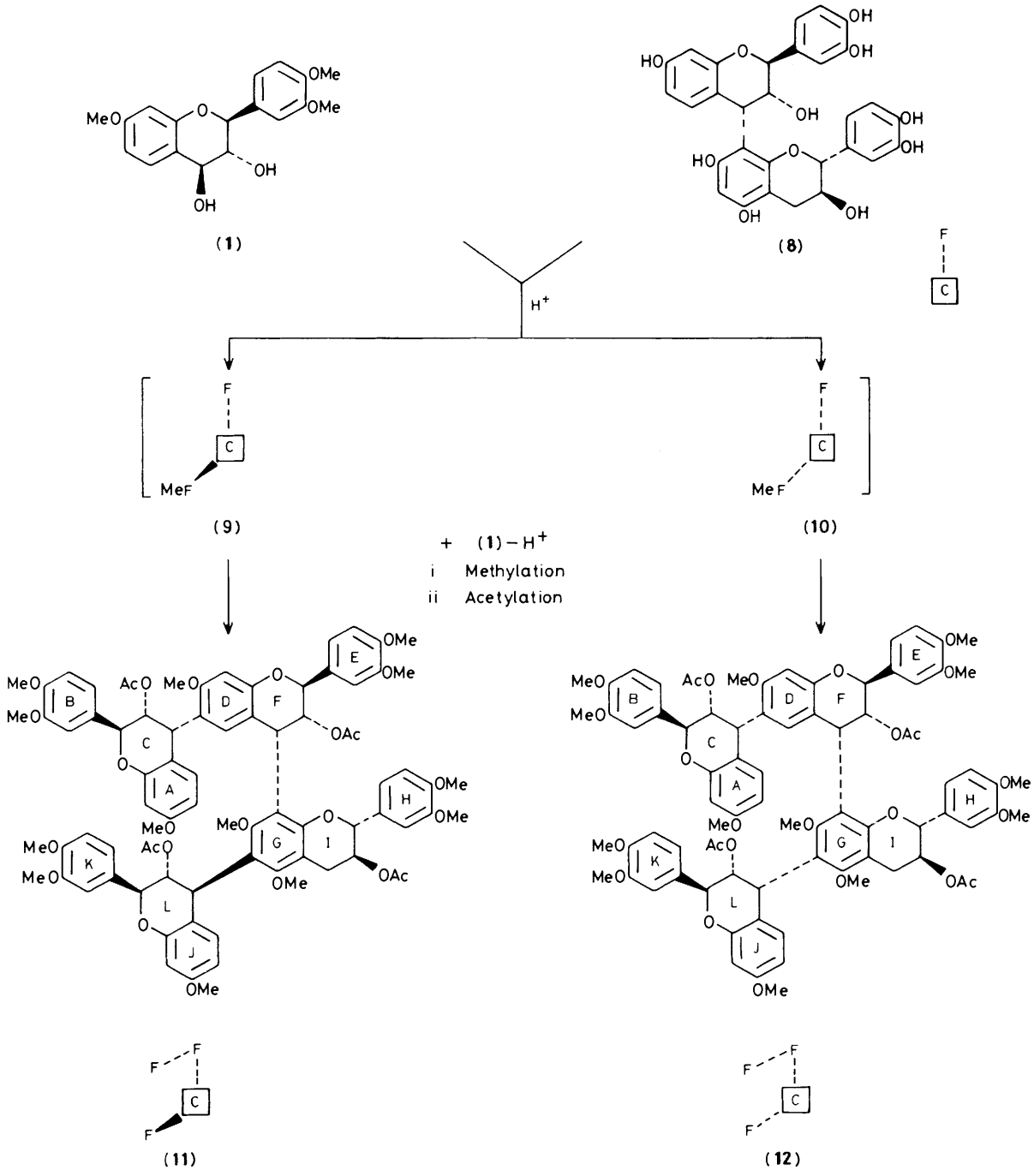
† For part 15 see ref. 2.
‡ For the method of preparation of this synthon *cf.* ref. 3.
§ Since 2,3-*trans* stereochemistry is common to all flavanyl units, only 3,4 allocations are indicated.
‖ Evinced by the disappearance of the sharp highfield singlet in the aromatic region as present in (**6**), and introduction of a heterocyclic AMX system ($J_{2,3} = J_{3,4} = 9.5$ Hz) indicative of a 2,3-*trans*-3,4-*trans* flavanyl unit.
¶ For the method of preparation of this synthon *cf.* ref. 3.



Scheme 1.

conjunction with ^{1}H n.m.r. spectrometry at low [(19 °C) (**11**)], intermediate [(27—72 °C) (**6**), (**11**), (**12**)] and elevated [(170 °C) (**5**), (**11**), (**12**)] temperatures depending on their respective 'static', 'partly dynamic' or 'dynamic' behaviour at ambient temperatures; ^{1}H n.m.r. spectrometry serving as the sole criterion for their purity. Thus, with a single exception (**11**), differing combinations of temperature, magnetic field strengths and solvent systems were required to overcome the line-broadening effects and duplication of resonances contributed by rotational isomerism at ambient temperatures (*cf.* the Table). However, modest lowering of temperature merely intensified the line-broadening of 'dynamic' oligomers due presumably to slower intramolecular rotation.

In general, at elevated temperatures, directly substituted 2,3-*trans*-3,4-*trans*-profisetinidin units at the 6- or 8-positions of the (+)-catechin moiety were distinguished by their consistently deshielded (δ 5.89—6.05) 3-H (F and L) triplet resonances, compared with an upfield shift [3-H(C); δ 5.24—5.50] when 6-substituted on a (+)-fisetinidol unit. 8-Substitution of (2*S*,3*R*)-2,3-*trans*-3,4-*trans*-profisetinidin units on the (+)-catechin moiety induced a pronounced shielding of the 2-H(I) resonances of the latter, and hence a diagnostic shift difference ($\Delta\delta_{2\text{-H},3\text{-H}}$ 0.70—0.94) relative to the effect of similar substitution by a (2*S*,3*R*)-2,3-*trans*-3,4-*cis* unit (0.17—0.27). Consistent coupling constants at high temperatures permit differentiation between 2,3-*trans*-3,4-*trans*-configurations of profisetinidin units ($J_{2,3}$ =



Scheme 2.

$J_{3,4}$ = 9.5—10.0 Hz), irrespective of position in the tetraflavanoid, and those of 2,3-*trans*-3,4-*cis*-configuration when attached to (+)-catechin ($J_{2,3}$ 8.9—9.5, $J_{3,4}$ 6.5—8.75 Hz). However, terminal (ABC) units of the latter type attached to the 6-position of (+)-fisetinidol units exhibit 'abnormal' coupling constants ($J_{2,3}$ 6.0—7.1, $J_{3,4}$ 4.0—5.0 Hz) associated with a twisted boat conformation, and are thus readily distinguished. Evidence of D-ring singlets in the aromatic region and the aforementioned n.m.r. parameters in support of the relative stereochemistry and interflavanoid bonding positions (*cf.* ref. 1) are summarized in the Table. Gaussian enhancement was applied to all high-magnetic field (300 and 500 MHz) spectra especially with the view to examining benzylic and other long-range couplings.

In order to facilitate the interpretation of the course of condensation, an abbreviated structural presentation is adopted in which only the 4α (3,4-*trans*) and 4β (3,4-*cis*) configurations of 4 ⟶ 6 and 4 ⟶ 8 interflavanoid bonds are indicated (*cf.* Schemes 1 and 2). In these formulae the fate of the (+)-catechin unit, and hence of the parent biflavanoid units (**2**) and (**8**), is evident at each step.

The tridecamethyl ether tetra-acetate derivative (**11**) of one of the natural tetraflavanoids, possessing the [4,6:4,8]-3,4-*cis*:3,4-*cis* and [4,6]-3,4-*trans*-configurations of bi- and mono-flavanyl

Table. Significant coupling constants and chemical shifts from ^{1}H n.m.r. spectra of (2*S*,3*R*)-profisetinidin tetraflavanoid tridecamethyl ether triacetates and of a pentaflavanoid homologue.

Compd. 3,4-configuration of constituent 2,3-*trans* flavanyl units	$J_{2,3}$* Hz	$J_{3,4}$* Hz	δ* 5-H(D)	δ* 8-H(D)	δ* 3-H	δ* 2-H(I)	$\Delta\delta_{2\text{-H},3\text{-H}}$
(5)							
ABC 3,4-*trans*	9.5	9.5			5.50		
DEF 3,4-*trans*	9.6	9.75	*ca.* 6.33	*ca.* 6.56	6.00		
GHI	5.5				5.19	4.25	0.94
JKL 3,4-*trans*	9.5	10.0			5.98		
(6)							
ABC 3,4-*trans*	9.5	9.5			5.31		
DEF 3,4-*trans*	9.5	9.5	6.26¶	6.28¶	6.05		
GHI	8.0				5.24	4.36	0.88
	(9.5)†				(5.21)†	(4.51)†	(0.70)†
JKL 3,4-*cis*	8.5	6.5			5.52		
(7)							
ABC 3,4-*trans*	9.7	9.7					
	(9.5)‖	(9.5)‖			5.24		
					(5.09)‖		
DEF 3,4-*trans*	9.7	9.7	6.09§		5.89		
	(10.0)‖	(10.0)‖			(6.06)‖		
GHI					5.19	*a*	
	(10.0)‖				(4.87)‖	(4.67)‖	(0.20)‖[b]
JKL 3,4-*cis*	8.5	6.8			5.47		
	(10.0)‖	(7.2)‖			(5.56)‖		
MNO 3,4-*trans*	9.7	9.7			5.86		
	(9.5)‖	(9.5)‖			(6.09)‖		
(11)							
ABC 3,4-*cis*	7.1	5.0			5.49†		
	(7.1)†	(5.25)†					
DEF 3,4-*cis*	8.75	8.75	6.69†	6.36†	5.53†		
	(10.2)†	(8.75)†					
GHI					5.07†	4.80†	0.27†
	(8.0)†						
JKL 3,4-*trans*	10.0	10.0			5.94†		
	(9.5)†	(9.5)†					
(12)							
ABC 3,4-*cis*	6.0	4.0			5.33		
	(6.3)‡	(4.5)‡					
DEF 3,4-*cis*	8.5	8.5	*a*	*a*	5.52		
	(9.5)‡	(8.5)‡					
GHI	6.0				5.03	4.86	0.17
					(4.95)‡	(4.77)‡	(0.18)‡
JKL 3,4-*cis*	9.5	8.0			5.50		
	(9.3)‡	(7.0)‡					

* [^{2}H$_6$]DMSO; 80 MHz; 170 or 180 °C (unless otherwise indicated). † $CDCl_3$; 500 MHz; 37°C. ‡ [^{2}H$_6$]DMSO; 300 MHz; 180 °C. § CD_3CN; 300 MHz; 19 °C. ‖ $CDCl_3$; 300 MHz; 19 °C. ¶ $CDCl_3$; 300 MHz; 27 °C.

[a] No definition possible. [b] This 'anomalous' shift difference may be attributed to the low temperature (19 °C) used, compared with standardization at 170 °C.[1]

substituents on (+)-catechin, is 'static' (n.m.r. time scale) at ambient temperatures. This permits unambiguous allocation of all heterocyclic and aromatic protons by spin-decoupling procedures at both 300 and 500 MHz, although the connectivities in terms of benzylic couplings between 4-H(C), 5-H(D) and 4-H(F) in the biflavanoid substituent could only be discerned at the higher magnetic field strength. The allocations were further confirmed by a COSY spectrum at 300 MHz optimized for long range (*ca.* 0.8 Hz) benzylic couplings. In general, long range couplings were also observed to exist between 4-H and 8-H of profisetinidin units, particularly between those of the respective F- and D-ring systems. Allocation of the 3,4-*cis* stereochemistry to the F-ring AMX system proved to be problematical in view of the abnormally large coupling constants ($J_{2,3}$ 10.2, $J_{3,4}$ 9.2 Hz at 500 MHz) compared with those [1] usually associated with 2,3-*trans*-3,4-*cis* stereochemistry ($J_{2,3}$ 7.0—8.5, $J_{3,4}$ 7.0—8.5 Hz) but under dynamic conditions. This problem was overcome by temperature elevation to 170 °C at 80 MHz (during which the initially sharp resonances collapsed and sharpened again) when the coupling constants of the F-ring system ($J_{2,3} = J_{3,4} = 8.75$ Hz) approximated to those previously observed.[1] In addition, the small chemical shift difference ($\Delta\delta_{2\text{-H},3\text{-H}}$ 0.28) for the heterocyclic system of the (+)-catechin moiety indicated [1] that the 3,4-*cis* stereochemistry of the parent biflavanoid (**8**) remains intact during synthesis. The presence of a (4 ⟶ 6) interflavanoid link involving a resorcinol-type flavanyl unit was previously demonstrated[4] by alkaline fusion of the free-phenolic form of (**11**) which afforded recognition of 4,6-dihydroxyisophthalic acid (in addition to resorcinol, phloroglucinol, β-resorcylic and protocatechuic acids) among the

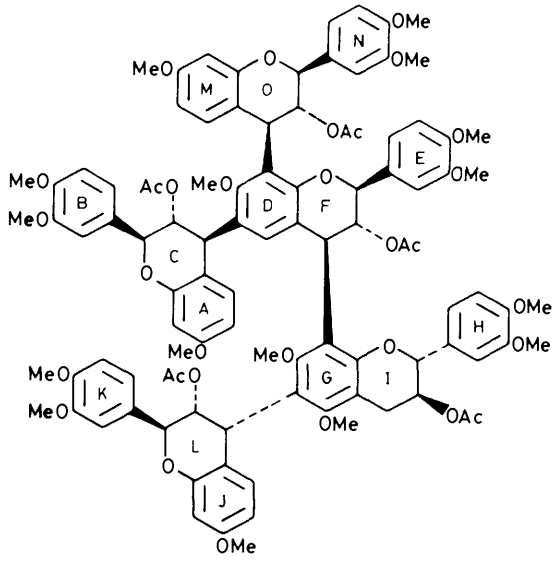
degradation products. However, our previous 'linear' structure[4] proposed some 14 years ago for this most prominent and readily accessible of the tetraflavanoids from *Rhus lancea* now requires correction to the 'angular' formula (**11**). The main differences are the allocation of 2,3-*trans*-3,4-*cis* stereochemistry to the large couplings of the F-ring AMX system as indicated above in place of previous 2,3-*trans*-3,4-*trans* assignment, and reassessment of aromatic bonding positions based on complete analysis of ^{1}H aromatic resonances at 500 MHz in conjunction with the aforementioned degradative evidence and the present method of synthesis.

The isomeric tetraflavanoid derivative (**6**) with a [4,6:4,8]-3,4-*trans*:3,4-*trans* and [4,6]-3,4-*cis* configuration of substituents on (+)-catechin gives sharp definition at ambient temperatures (33 °C at 500 MHz) of the heterocyclic protons except for 3-H(C) and 4-H(C). These resonances emerged from the base line at δ 5.19 and 4.66 respectively at 68 °C (300 MHz), and finally sharpened at 170 °C (80 MHz). This behaviour presumably indicates that the 'upper' 2,3-*trans*-3,4-*trans*-profisetinidin unit rotates slowly relative to the remaining 'static' triflavanoid 'core', since alternative rationalization based on the possible effects of a conformational equilibrium in this unit may be excluded (*cf.* discussion below). The latter finds support in the sharp definition of its 2-proton [2-H(C), δ 4.90] and large coupling constant ($J_{2,3}$ 9.5 Hz), both indicative of conformational stability. Low power decoupling 4-H(C) (δ 4.66) at 300 MHz (68 °C) sharpened the doublet of doublets at δ 6.55 (*J* 0.8, 8.5 Hz) attributable to 5-H(A) by eliminating benzylic coupling, while simultaneously partially sharpening the doublet at δ 6.26 [5-H(D), *J* 0.8 Hz]. The latter effect is maximized during similar decoupling of 4-H(F) (δ 4.55) when in the aromatic region only 5-H(D) sharpened significantly. These phenomena establish the connectivity between the C- and F-ring heterocyclic proton systems.

The synthetic pentaflavanoid homologue (**7**)* which represents an 8(D-ring)-2,3-*trans*-3,4-*trans*-flavanyl derivative of the tetraflavanoid (**6**) showed varying degrees of rotational mobility of its constituent units at ambient temperatures. The heterocyclic L- and O-ring protons of 'terminal' units were all represented by sharp resonances at 300 MHz (19 °C; CD_3CN), whilst those of the F-ring were all broadened, and all resonances of the C- and I-rings appeared as unresolved 'humps' or were lost in the base line. These phenomena indicated that the terminal JKL and MNO profisetinidin units rotate rapidly about their respective interflavanoid bonds (n.m.r. time-scale); that rotation of the profisetinidin unit DEF is partially restricted; and that the heterocyclic protons of the ABC profisetinidin and GHI catechin units occur in a number of molecular environments. The equivalent ABC unit of the tetraflavanoid homologue (**6**) shows hindered rotation on the same basis.

The remaining tetraflavanoid units with all-3,4-*cis*-(**12**) and all-3,4-*trans*-(**5**) arrangements of substituents required elevated temperatures for adequate definition of their spectra (*cf.* the Table). From the aforementioned and from comparison with the (2*R*,3*S*)-group of tetraflavanoid analogues,[2] it is evident that the relative configuration of the diastereoisomer determines its relative rotational stability at ambient temperatures.

Specific attention is now given to the effect of dynamic behaviour on line broadening and duplication of resonances (*cf.* ref. 5) in the majority of ^{1}H n.m.r. spectra of the above tetraflavanoid compounds at ambient temperatures, and to



(**7**)

the observed increasing temperature requirements for the coalescence of such resonances with increasing magnetic field strengths. Considering that a conformational equilibrium exists in each flavanyl unit in the monomeric form at ambient temperatures, the above examples indicate a rotational equilibration on an average—fast time scale. On the assumption, for simplicity, that two rotamers (isomers) predominate,† chemical shifts of the different protons will in general differ for the two isomers. Thus if proton i possesses the chemical shifts (in Hz) ν_i^A and ν_i^B in the isomers A and B, and if the first-order speed of the rotational exchange $k_{exch.} \gg 2\pi|\nu_i^A - \nu_i^B|$, then the 'fast' exchange limit is operative. Narrow resonance absorptions are obtained with the shift $\nu_{average} = P_A\nu_i^A - P_B\nu_i^B$ where P_A and P_B represent the populations of species A and B respectively. Since ν_i is in Hz, *higher temperatures* are required at *higher fields* to satisfy the inequality above. When $k_{exch.} \ll 2\pi|\nu_i^A - \nu_i^B|$ two resonance signals will be obtained, one for each isomer with line-widths proportional to $k_{exch.}$. However, when $k_{exch.}$ is slightly faster than $\nu_i^A - \nu_i^B$ then a broad coalesced resonance will be obtained with a line-width proportional to $(\nu_i^A - \nu_i^B)^2$ and inversely proportional to the kinetics.

The above provides field-dependent line-widths which usually differ for every resonance, since $\nu_i^A - \nu_i^B$ differs for every proton i. This fact does not permit differentiation between line-broadenings of individual protons as indicative of different modes of movement.‡ However, it nevertheless appears that protons, which are positioned close to the axis of movement, are broadened when subject to strong shielding–deshielding effects, while those on the outer perimeter of the molecule generally appear sharper at different temperature levels. Corresponding observations are detailed above.

The pronounced shielding effects observed for the 2-protons [2-H(I)] of the (+)-catechin moieties in the tetraflavanoid derivatives (**5**) and (**6**) [$\Delta\delta_{2\text{-H},3\text{-H}}$ 0.94 and 0.88 (0.70)

* ^{1}H N.m.r. spectra exhibited 16 methoxy and 5 acetoxy resonances, and a broad highfield aromatic singlet [5-H(D)] in agreement with the formula (**7**); the c.d. spectrum resembled that of the parent tetraflavanoid (**6**); and desorption chemical ionization mass spectrometry indicated molecular ions in accord with the calculated value of 1 812.7. The structure also follows logically from the method of synthesis.

† Most 'trimers' and 'tetramers' show only duplication of, for example, acetyl resonances at ambient temperatures, or otherwise predominant duplication attended by evidence of minor rotamers.

‡ For example, the remarkable concurrence of the exceptionally sharp 2-H(C-ring) resonances of the tetraflavanoid (**6**) and 'submergence' of the broadened resonances of both 3-H(C) and 4-H(C) in the base-line at ambient temperatures, implies an identity of chemical shifts of 2-H(C) in different environments, but considerable shift differences for the remaining protons comprising the AMX (C-ring) system in the 'slowly' rotating ABC profisetinidin unit.

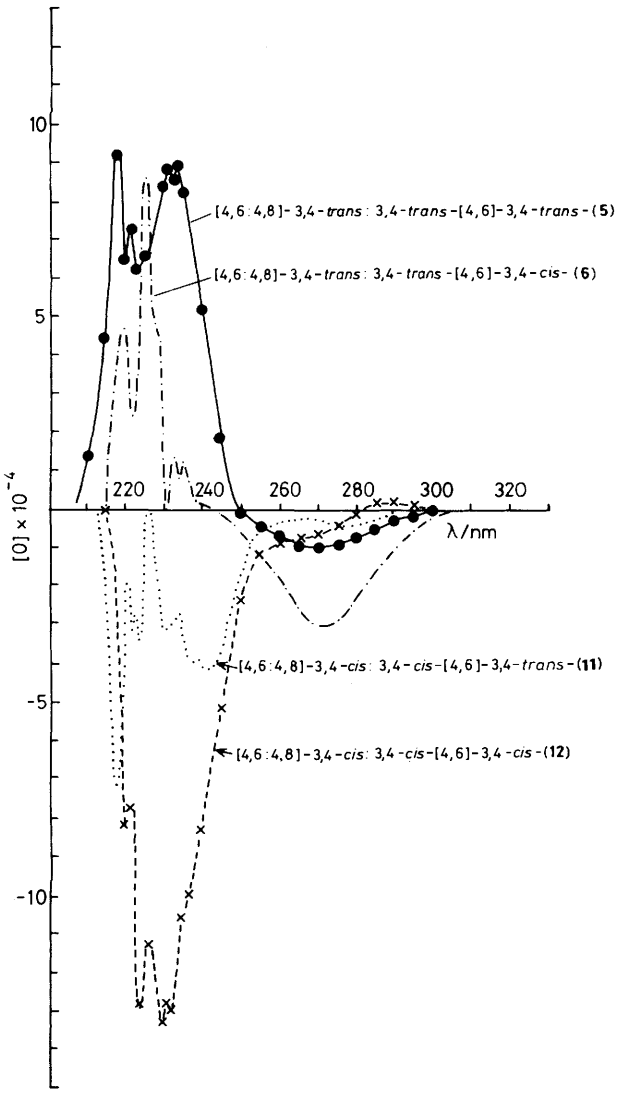


Figure. C.d. spectra of the tridecamethyl ether triacetates of (2*S*,3*R*)-profisetinidin tetraflavanoids*

respectively] relative to smaller effects for (**11**) and (**12**) ($\Delta\delta_{2\text{-H},3\text{-H}}$ 0.27 and 0.17 respectively) signify[1,2] that the respective 3,4-*trans* and 3,4-*cis* stereochemistry as in the parent biflavanoids (**2**) and (**8**) remain intact during substitution (*cf.* Schemes 1 and 2). The absolute configurations of the natural tetraflavanoids (*cf.* formulae in Schemes 1 and 2) follow from the method of synthesis and from the relative configurations allocated on the basis of coupling constants (Table).

C.d. spectra of the methyl ether acetate derivatives of the natural (2*S*,3*R*)-profisetinidins (**5**), (**6**), (**11**), and (**12**) show that their high-amplitude Cotton-effects† in the low wavelength region are the reverse of those of their (2*R*,3*S*)-isomers,[2] as expected (*cf.* the Figure). These Cotton-effects also exhibit an almost mirror-image relationship where all profisetinidin units have 3,4-*cis* (negative effect) or 3,4-*trans* (positive) configurations as in (**12**) and (**5**) respectively, while the combined 3,4-*cis*-(**11**) or 3,4-*trans*-(**6**) stereochemistry of the biflavanoid moieties in derivatives of 'mixed' stereochemistry appear to exert dominant effects (negative and positive respectively) at low wavelengths only (*cf.* the Figure).

The (2*S*,3*R*) group of profisetinidin tetraflavanoids from *Rhus lancea* [the free-phenolic equivalents of (**5**), (**6**), (**11**), and (**12**)] may also be regarded as prototypes of quebracho tannins of commerce extracted from the heartwoods of *Schinopsis* spp., in view of the identity of the phenolic content of these Anacardiaceous species.[1] Similarly their (2*R*,3*S*)-profisetinidin diastereoisomers from wattle wood (*Acacia mearnsii*)[2] are probably representative of prorobinetinidin homologues[7] of commercial wattle bark ('Mimosa') extract from the same tree.

Experimental

T.l.c. was performed on DC-Plastikfolin Kieselgel 60 PF_{254} (0.25 mm) and the plates sprayed with H_2SO_4–HCHO (40:1 v/v) after development. Preparative plates (p.l.c.) [Kieselgel PF_{254} (1.0 mm)] were air-dried and used without prior activation. Methylations were performed with an excess of diazomethane in methanol–diethyl ether at −15 °C for 48 h, whilst acetylations were carried out with acetic anhydride–anhydrous pyridine. Evaporations were performed under reduced pressure at *ca.* 50 °C. ^{1}H N.m.r. spectra were recorded on Bruker WP-80, AM-300, and WH-500 FT instruments in [$^2H_6$]DMSO at 170 °C locked on the 'central' resonance (δ 2.49 *vs.* $SiMe_4$) of the protonated Me_2SO impurity, and in $CDCl_3$ at 19 and 31 °C with $SiMe_4$ as the internal standard; mass spectral data on a Finnigan MAT model 8230 double focussing instrument using the desorption chemical ionization mode with NH_3 as the reagent gas, and on an AEI MS-9 spectrometer; and circular dichroism (c.d.) in methanol on a Jasco J-20 spectropolarimeter. Analysis (C & H) were performed by Analytische Laboratorien, Fritz-Pregl-Strasse 24, 5270 Gummersbach 1 Elbach, Germany.

Isolation of Tetraflavanoids as Derivatives from the Heartwood of Rhus lancea.—Drillings (720 g) were exhaustively extracted in a Soxhlet apparatus with methanol to yield the extract (135 g) as a brown powder. The solids (40 g) were dissolved in the lower phase (400 ml) of a water–butan-2-ol-hexane (5:3:2 v/v) counter-current system distributed in the first eight tubes. After 115 transfers (equilibration time 5 min, phase separation time 60 min) every fifth tube was examined by two-dimensional paper chromatography (upward migration), using water-saturated butan-2-ol for the first and 2% HOAc for the second direction. The tetraflavanoids were distributed between the lower phase content of tubes 1—22 (30.5 g).

Solids (16 g) obtained from tubes 1—22 were subjected to chromatography on a Sephadex LH-20 column (5 × 120 cm) with EtOH as the eluant. Fractions (each 15 ml) were grouped as follows: 680—860 (750 mg), 1 110—1 340 (600 mg), and 1 341—1 990 (1 550 mg).

Fractions 680—860 was shown to consist of two tetraflavanoids by two-way chromatography with R_F values 0.63 and 0.17, and 0.57 and 0.17 [free phenolic forms of (**12**) and (**11**) respectively] in butan-2-ol and 2% acetic acid (HOAc) respectively. The fraction (750 mg) was accordingly methylated and the product separated by t.l.c. in benzene–acetone (6:4 v/v) to give their respective tridecamethyl ethers at R_F 0.47 (172 mg) and 0.39 (104 mg). Acetylation of each and their purification by t.l.c. in benzene–acetone (8:2 v/v) gave their respective tetra-acetates at R_F 0.44 (78 mg) (**12**) and R_F 0.39 (52 mg) (**11**) respectively.

Methylation of fractions 1 110—1 340 (600 mg) and following the identical procedure of purification of the tridecamethyl ether (R_F 0.48, 95 mg) and its tetra-acetate (R_F 0.46, 26 mg) gave compound (**6**).

Similarly fraction 1 341—1 990 (1 550 mg) gave the tri-

* Configurations of the profisetinidin substituents on (+)-catechin are indicated.

† Indicative of 4*R* or 4*S* configurations.[6]

decamethyl ether (R_F 0.53, 203 mg) and its tetra-acetate (R_F 0.54, 28 mg) corresponding to (**5**).

The purity of these diastereoisomers was monitored by high temperature (170 °C) ^{1}H n.m.r. spectrometry.

Synthesis of Tridecamethyl Ether Tetra-acetates of Tetraflavanoid Profisetinidins.

Condensation of [4,8]-3,4-trans-(+)-*Fisetinidol*-(+)-*catechin* (**2**) *with* (−)-*Leucofisetinidin Trimethyl Ether* (**1**).—The [4,8]-3,4-*trans*-biflavanoid (562 mg, 1 mmol) and (−)-leucofisetinidin trimethyl ether (996 mg, 3 mmol) dissolved in MeOH (15 ml) was treated with HCl (1M; 0.4 ml) and the solution maintained at 50 °C for 4 days. Thereafter, water (20 ml) was added and the reaction mixture was extracted with EtOAc (3 × 30 ml), the extract was evaporated and the product was methylated. The mixture of methyl ethers was separated by p.l.c. on 50 (20 × 20 cm) plates in 1,2-dichloroethane–acetone (8:2 v/v, ×2) to give fractions at R_F 0.38 (47.4 mg), 0.27 (119 mg) and 0.18 (104.2 mg).

The methyl ether fractions were acetylated. Purification of the acetate derived from the R_F 0.38 methyl ether fraction by p.l.c. on 8 plates in 1,2-dichloroethane–acetone (9:1 v/v) gave the 8-(2,3-*trans*-3,4-*trans*)-6-(2,3-*trans*-3,4-*cis*)-'trimeric' derivative (R_F 0.38, 5 mg) [corresponding in structure to the partially methylated triflavanoid (**4**)] identical to that derived from *Rhus* and *Schinopsis* spp. and prepared synthetically.[1]

Purification of the acetates derived from the R_F 0.27 methyl ether fraction by p.l.c. on 24 plates in 1,2-dichloroethane–acetone (9:1 v/v) gave two fractions at R_F 0.39 (12.9 mg) and 0.29 (22.8 mg). The former (R_F 0.39) compound was shown to be the 6,8-bi-(2,3-*trans*-3,4-*trans*)-triflavanoid derivative [*cf.* (**3**)] by comparison with the known [1] reference compound.

(2R,3S)-2,3-trans-3-*Acetoxy*-6-[(2S,3R,4S)-2,3-trans-3,4-cis-3-*acetoxy*-3′,4′,7-*trimethoxyflavan*-4-*yl*]-8-{(2S,3R,4R)-2,3-trans-3,4-trans-3-*acetoxy*-6-[(2S,3R,4R)-2,3-trans-3,4-trans-3-*acetoxy*-3′,4′,7-*trimethoxyflavan*-4-*yl*]-3′,4′,7-*trimethoxyflavan*-4-*yl*}-3′,4′,5,7-*tetramethoxyflavan* (**6**). The tridecamethyl ether tetra-acetate, R_F 0.29 (22.8 mg), from the above separation was isolated as a *colourless solid* (Found: C, 66.5; H, 5.9. $C_{81}H_{84}O_{25}$ requires C, 66.7; H, 5.8%); δ ([$^2H_6$]DMSO; 80 MHz; 170 °C) 7.31—6.31 (m, 18 × ArH), 6.55 [s, 5-H(D)], 6.25 [s, 8-H(D)], 6.05 [t, Σ*J* 19.5 Hz, 3-H(F)], 5.52 [dd, Σ*J* 15.0 Hz, 3-H(L)], 5.33 [d, *J* 8.5 Hz, 2-H(L)], 5.31 [t, Σ*J* 19.0 Hz, 3-H(C)], 5.24 [m, 3-H(I)], 4.90 [d, *J* 9.5 Hz, 2-H(C)], 4.87 [d, *J* 9.5 Hz, 2-H(F)], 4.72 [dd, *J* 0.8 and 6.5 Hz, 4-H(L)], 4.49 [br d, *J ca.* 9.5 Hz, 4-H(C + F)], 4.36 [d, *J* 8.0 Hz, 2-H(I)], 3.78, 3.77, 3.75, 3.74, 3.71, 3.71 (×2), 3.70, 3.66 (×2), 3.60, 3.34 (br), 3.20 (br) (each s, 13 × OMe), 1.72, 1.59, 1.55, and 1.54 (each s, 4 × COMe); δ ($CDCl_3$; 300 MHz; 72 °C) Irradiation of 4-H(F) (dd, *J* 1.2 and 10.0 Hz, δ 4.70) decoupled 5-H(D) (d, *J* 1.2 Hz, δ 6.26) to give a singlet; 8-H(D) (s, δ 6.28); Irradiation of 4-H(C) (br, δ 4.66) similarly removed benzylic coupling from 5-H(A) (dd, *J* 1.0 and 8.5 Hz, δ 6.545); 8-H(A) (d, *J* 2.5 Hz, δ 6.542); 6-H (A) (dd, *J* 2.5 and 8.5 Hz, δ 6.392); δ ($CDCl_3$; 500 MHz; 37 °C) 7.020 [dd, *J* 2.5 and 8.5 Hz, 6-H(K)], 6.950 [d, *J* 2.5 Hz, 2-H(K)], 6.840 [d, *J* 8.5 Hz, 5-H(B)], 6.834 [d, *J* 8.5 Hz, 5-H(K)], 6.740 [d, *J* 2.0 Hz, 2-H(B)], 6.636 [br d, *J* 8.0 Hz, 6-H(B)], 6.558 [dd, *J* 8.5 and 0.8 Hz, 5-H(A)], 6.555 [d, *J* 2.5 Hz, 8-H(A)], 6.382 [dd, *J* 2.5 and 8.5 Hz, 6-H(A)], 6.282 [s, 8-H(D)], 6.245 [br s, 5-H(D)], 6.212 [t, *J* 9.5 and 9.5 Hz, 3-H(F)], 5.544 [dd, *J* 7.0 and 10.0 Hz, 3-H(L)], 5.334 [d, *J* 10.2 Hz, 2-H(L)], 5.210 [m, 3-H(I)], 4.896 [d, *J* 9.5 Hz, 2-H(C)], 4.782 [d, *J* 9.5 Hz, 2-H(F)], 4.702 [d, *J* 7.0 Hz, 4-H(L)], 4.568 [d, *J* 9.5 Hz, 4-H(F)], 4.506 [d, *J* 9.5 Hz, 2-H(I)], 3.176 [dd, *J* 5.8 and 16.0 Hz, 4-H_{eq}(I)], and 2.682 [dd, *J* 10.0 and 16.0 Hz, 4-H_{ax}(I)]; *m/z* 1 475 ($M^+ - H + NH_4$, 100%), 1 474 ($M^+ - 2 \times H + NH_4$, 97%); c.d. spectrum (see Figure).

Purification of the acetates from the R_F 0.18 methyl ether fraction by p.l.c. on 20 plates in benzene–acetone–methanol (85:14:1 v/v ×2) gave two compounds at R_F 0.46 (8.1 mg) and 0.31 (15.1 mg) respectively.

(2R,3S)-2,3-trans-3-*Acetoxy*-6-[(2S,3R,4R)-2,3-trans-3,4-trans-3-*acetoxy*-3′,4′,7-*trimethoxyflavan*-4-*yl*]-8-{(2S,3R,4R)-2,3-trans-3,4-trans-3-*acetoxy*-6-[(2S,3R,4R)-2,3-trans-3,4-trans-3-*acetoxy*-3′,4′,7-*trimethoxyflavan*-4-*yl*]-3′,4′7-*trimethoxyflavan*-4-*yl*}-3′,4′,5,7-*tetramethoxyflavan* (**5**). The tridecamethyl ether tetra-acetate, R_F 0.46 (8.1 mg), from the above separation was isolated as a *colourless solid* (Found: C, 66.5; H, 6.0. $C_{81}H_{84}O_{25}$ requires C, 66.7; H, 5.8%); δ ([$^2H_6$]DMSO; 80 MHz; 170 °C) 7.28—6.26 (m, 18 × ArH), 6.56 [s, 8-H(D)], 6.33 [br s, 5-H(D)], 6.00 [t, Σ*J* 19.5 Hz, 3-H(F)], 5.98 [t, Σ*J* 19.3 Hz, 3-H(L)], 5.50 [t, Σ*J* 19.3 Hz, 3-H(C)], 5.19 [m, 3-H(I)], 5.03 [d, *J* 9.5 Hz, 2-H(L)], 4.97 [d, *J* 9.6 Hz, 2-H(F)], 4.94 [d, *J* 9.5 Hz, 2-H(C)], 4.69 [dd, *J ca.* 0.8 and 10.0 Hz, 4-H(L)], 4.66 [dd, *J ca.* 0.8 and 9.75 Hz, 4-H(F)], 4.43 [br d, *J* 9.5 Hz, 4-H(C)], 4.25 [d, *J* 5.5 Hz, 2-H(I)], 3.88, 3.87 (×2), 3.86, 3.84, 3.82, 3.81, 3.77, 3.75, 3.74, 3.63, 3.57 (br), 3.45 (br), (each s, 13 × OMe), 1.80, 1.66, 1.63, and 1.60 (each s, 4 × COMe); *m/z* 1 474 ($M^+ - 2 \times H + NH_4$, 100%); c.d. spectrum (see Figure).

(2R,3S)-2,3-trans-3-*Acetoxy*-6-[(2S,3R,4S)-2,3-trans-3,4-cis-3-*acetoxy*-3′,4′,7-*trimethoxyflavan*-4-*yl*]-8-{(2S,3R,4R)-2,3-trans-3,4-trans-3-*acetoxy*-6,8-*bi*-[(2S,3R,4R)-2,3-trans-3,4-trans-3-*acetoxy*-3′,4′,7-*trimethoxyflavan*-4-*yl*]-3′,4′,7-*trimethoxyflavan*-4-*yl*}-3′,4′,5,7-*tetramethoxyflavan* (**7**). The hexadecamethyl ether penta-acetate, R_F 0.31 (15.1 mg) from the above separation was isolated as a *colourless solid* (Found: C, 66.6; H, 6.0. $C_{101}H_{104}O_{31}$ requires C, 66.9; H, 5.8%); δ ([$^2H_6$]DMSO; 80 MHz; 170 °C) 7.09—6.03 (m, 25 × ArH), 5.89 [t, *J* 9.7 and 9.7 Hz, 3-H(F)], 5.86 [t, *J* 9.7 and 9.7 Hz, 3-H(O)], 5.47 [dd, *J* 6.8 and 8.5 Hz, 3-H(L)], 5.27 [d, *J* 8.5 Hz, 2-H(L)], 5.24 [t, *J* 9.7 and 9.7 Hz, 3-H(C)], 5.19 [m, 3-H(I)], 4.98 [d, *J* 9.7 Hz, 2-H(C)], 4.85 [d, *J* 9.7 Hz, 2-H(F)], 4.85 [d, *J* 9.7 Hz, 2-H(O)], 4.71 [d, *J* 6.8 Hz, 4-H(L)], 4.70 [d, *J* 9.7 Hz, 4-H(C)], 4.66 [d, *J* 9.7 Hz, 4-H(O)], 4.58 [d, *J* 9.7 Hz, 4-H(F)], 3.78, 3.73 (×4), 3.70 (×3), 3.68 (×2), 3.67, 3.64, 3.56, 3.55, 3.17 (×2) (each s, 16 × OMe), 2.94 [m, 4-H_2(I)], 1.70, 1.66, 1.59, 1.56, and 1.55 (each s, 5 × COMe); δ (CD_3CN; 300 MHz; 19 °C) 6.117 [dd, *J* 0.8 and 8.5 Hz, 5-H(J)], 6.087 [br s, 5-H(D)], and 5.880 [dd, *J* 2.5 and 8.5 Hz, 6-H(J)]; δ ($CDCl_3$; 300 MHz; 19 °C) 6.094 [t, *J* 9.5 and 9.5 Hz, 3-H(O)], 6.063 [t, *J* 10.0 and 10.0 Hz, 3-H(F)], 5.560 [dd, *J* 10.0 and 7.2 Hz, 3-H(L)], 5.353 [d, *J* 10.0 Hz, 2-H(L)], 5.088 [t, *J* 9.5 and 9.5 Hz, 3-H(C)], 5.005 [d, *J* 9.5 Hz, 2-H(C)], 4.985 [d, *J* 10.0 Hz, 2-H(F)], 4.891 [d, *J* 9.5 Hz, 2-H(O)], 4.872 [m, 3-H(I)], 4.717 [d, *J* 9.5 Hz, 4-H(C)], 4.707 [d, *J ca.* 9.5 Hz, 4-H(O)], 4.673 [d, *J ca.* 7.0 Hz, 4-H(L)], 4.665 [d, *J* 10.0 Hz, 2-H(I)], and 4.632 [d, *J ca.* 10.0 Hz, 4-H(F)]; δ (C_6D_6; 300 MHz; 23 °C) 3.850, 3.628, 3.607, 3.550, 3.515, 3.485, 3.470 (×2), 3.407, 3.387, 3.378, 3.327, 3.313, 3.382, 3.372, and 3.235 (each s, 16 × OMe); *m/z* 1 832 ($M^+ + NH_4$, 60%), 1 831 ($M^+ - H + NH_3$, 100%), 1 830 ($M^+ - 2 \times H + NH_4$, 90%); c.d. spectrum $[\theta]_{294}$ 0, $[\theta]_{280}$ −9 000, $[\theta]_{285}$ −8 000, $[\theta]_{270}$ −9 500, $[\theta]_{260}$ −8 000, $[\theta]_{242}$ −31 000, $[\theta]_{237}$ 0, $[\theta]_{232}$ +26 000, $[\theta]_{229}$ +30 000, $[\theta]_{227}$ +28 500, $[\theta]_{223}$ +51 500, $[\theta]_{219}$ +35 000, $[\theta]_{214}$ +60 000, and $[\theta]_{210}$ 0.

Condensation of [4,8]-3,4-cis-(+)-*Fisetinidol*-(+)-*catechin* (**8**) *with* (−)-*Leucofisetinidin Trimethyl Ether* (**1**).—The reaction conditions, quantities used and procedures for recovery of products were the same as above. Methylation and t.l.c. separation on 50 plates in 1,2-dichloroethane–acetone (8:2 v/v) gave two tridecamethyl ethers at R_F 0.23 (255.6 mg) and 0.12 (310 mg).

(2R,3S)-2,3-trans-3-*Acetoxy*-6-[(2S,3R,4S)-2,3-trans-3,4-cis-3-*acetoxy*-3′,4′,7-*trimethoxyflavan*-4-*yl*]-8-{(2S,3R,4S)-2,3-trans-3,4-cis-3-*acetoxy*-6-[(2S,3R,4S)-2,3-trans-3,4-cis-3-*acetoxy*-3′,4′,7-*trimethoxyflavan*-4-*yl*]-3′4′,7-*trimethoxyflavan*-

4-*yl*}-3′,4′,5,7-*tetramethoxyflavan* (**12**). Acetylation of the R_F 0.23 (255.6 mg) methyl ether and purification of the product by p.l.c. on 40 plates in benzene–acetone–methanol (90:8:2 v/v × 4) gave the tetra-acetate as a *colourless solid* (R_F 0.32, 44.9 mg) (Found: C, 66.7; H, 5.9. $C_{81}H_{84}O_{25}$ requires C, 66.7; H, 5.8%); δ ([$^2H_6$]DMSO; 80 MHz; 170 °C) 7.06—6.86 (m, 18 × ArH), 5.52 [t, *J* 8.5 and 8.5 Hz, 3-H(F)], 5.50 [dd, *J* 8.0 and 9.5 Hz, 3-H(L)], 5.33 [dd, *J* 4.0 and 6.0 Hz, 3-H(C)], 5.27 [d, *J* 9.5 Hz, 2-H(L)], 5.10 [d, *J* 6.0 Hz, 2-H(C)], 5.07 [d, *J* 8.5 Hz, 2-H(F)], 5.03 [m, 3-H(I)], 4.86 [d, *J* 6.0 Hz, 2-H(I)], 4.83 [d, *J* 8.5 Hz, 4-H(F)], 4.77 [d, *J* 8.0 Hz, 4-H(L)], 4.68 [d, *J* 4.5 Hz, 4-H(C)], 3.78 (× 2), 3.76, 3.75 (× 2), 3.74, 3.73, 3.72, 3.71, 3.69 (× 2), 3.33, 3.02 (each s, 13 × OMe), 1.84, 1.63, 1.57, and 1.50 (br) (each s, 4 × COMe). Overlap of heterocyclic proton resonances necessitated their examination at higher magnetic field strengths; δ ([$^2H_6$]DMSO; 300 MHz; 180 °C) 5.473 [dd, *J* 8.5 and 8.5 Hz, 3-H(F)], 5.461 [dd, *J* 7.0 and 9.3 Hz, 3-H(L)], 5.313 [dd, *J* 4.5 and 6.3 Hz, 3-H(C)], 5.267 [d, *J* 9.3 Hz, 2-H(L)], 5.075 [d, *J* 6.3 Hz, 2-H(C)], 5.007 [d, *J* 9.5 Hz, 2-H(F)], 4.990 [d, *J* 8.5 Hz, 4-H(F)], *ca.* 4.95 [m, 3-H(I)], *ca.* 4.77 [d, 2-H(I)], 4.763 [d, *J* 7.0 Hz, 4-H(L)], and 4.665 [dd, *J* 0.8 and 4.5 Hz, 4-H(C)]; *m/z* 1 476 ($M^+ + NH_4$, 75%), 1 475 ($M^+ - H + NH_4$, 95%), and 1 474 ($M^+ - 2 \times H + NH_4$, 100%); c.d. spectrum (see Figure).

(2R,3S)-2,3-trans-3-*Acetoxy*-6-[(2S,3R,4R)-2,3-trans-3,4-trans-3-*acetoxy*-3′,4′,7-*trimethoxyflavan*-4-*yl*]-8-{(2S,3R,4S)-2,3-trans-3,4-cis-3-*acetoxy*-6-[(2S,3R,4S)-2,3-trans-3,4-cis-3-*acetoxy*-3′,4′,7-*trimethoxyflavan*-4-*yl*]-3′,4′,7-*trimethoxyflavan*-4-*yl*}3′,4′,5,7-*tetramethoxyflavan* (**11**). Acetylation of the R_F 0.12 (310.5 mg) methyl ether and purification of the product by p.l.c. on 60 plates in hexane–acetone–EtOAc (53:32:15 v/v × 3) gave the tetra-acetate as a *colourless solid* (R_F 0.31, 58.7 mg), m.p. 189 °C (Found: C, 66.8; H, 5.8. $C_{81}H_{84}O_{25}$ requires C, 66.7; H, 5.8%); δ ($CDCl_3$; 500 MHz; 37 °C) 7.040 [dd, *J* 2.0 and 8.5 Hz, 6-H(K)], 7.000 [d, *J* 2.0 Hz, 2-H(K)], 6.882 [d, *J* 2.0 Hz, 2-H(B)], 6.850 [d, *J* 8.5 Hz, 5-H(K)], 6.816 [d, *J* 8.5 Hz, 5-H(B)], 6.780 [dd, *J* 0.8 and 8.5 Hz, 5-H(A)], 6.722 [d, 8.0 Hz, 5-H(E)], 6.708 [d, *J* 8.5 Hz, 6-H(B)], 6.706 [d, *J* 2.0 Hz, 2-H(H)], 6.694 [d, *J* 0.8 Hz, 5-H(D)], 6.650 [d, *J* 8.5 Hz, 5-H(H)], 6.590 [br d, *J ca.* 8.5 Hz, 5-H(J)], 6.582 [d, *J* 2.0 Hz, 2-H(E)], 6.562 [dd, *J* 2.0 and 8.0 Hz, 6-H(E)], 6.550 [d, *J* 2.5 Hz, 8-H(A)], 6.542 [dd, *J ca.* 1.5 and 8.5 Hz, 6-H(H)], 6.516 [dd, *J* 2.5 and 8.5 Hz, 6-H(J)], 6.500 [d, *J* 2.5 Hz, 8-H(J)], 6.404 [dd, *J* 2.5 and 8.75 Hz, 6-H(A)], 6.360 [s, 8-H(D)], 5.936 [t, *J* 9.5 and 9.5 Hz, 3-H(L)], 5.528 [dd, *J* 10.2 and 8.75 Hz, 3-H(F)], 5.488 [dd, *J* 7.1 and 5.25 Hz, 3-H(C)], 5.074 [m, 3-H(I)], 5.068 [d, *J* 7.1 Hz, 2-H(C)], 4.950 [dd, *J* 0.8 and 8.75 Hz, 4-H(F)], 4.925 [d, *J* 10.2 Hz, 2-H(F)], 4.876 [d, *J* 9.5 Hz, 2-H(L)], 4.816 [br d, *J* 5.25 Hz, 4-H(C)], 4.796 [d, *J* 8.0 Hz, 2-H(I)], 4.616 [dd, *J* 0.8 and 9.5 Hz, 4-H(L)], 3.870, 3.858, 3.850, 3.813 (× 2), 3.768, 3760, 3.705, 3.696, 3.673, 3.637, 3.525, 3.065 (each s, 13 × OMe), 3.045 [dd, *J* 5.5 and 16.5 Hz, 4-H_{eq}(I)], 2.800 [dd, *J* 8.5 and 16.5 Hz, 4-H_{ax}(I)], 1.873, 1.637, 1.630, and 1.486 (each s, 4 × COMe); *m/z* 1 456 (M^+, 1.1%), 1 397 (6.3), 1 396 (10.0), 1 367 (2.5), 1 366 (5.3), 1 365 (5.8), 1 338 (4.2), 1 337 (5.8), 1 336 (4.2), 1 305 (2.4), 1 278 (2.2), 1 277 (2.9), 1 276 (1.4), 1 249 (3.8), 1 216 (0.7), 1 203 (5.3), 1 189 (2.0), 1 185 (2.0), 1 175 (2.4), 1 174 (2.7), 1 144 (2.6), 1 143 (3.1), 1 115 (2.3), 1 099 (1.4), 1 069 (0.6), 1 041 (4.2), 1 040 (5.8), 1 039 (13.2), 1 009 (1.0), 981 (2.4), 980 (2.0), 979 (3.1), 743 (0.6), 713 (0.7), 685 (2.2), 684 (6.3), 683 (13.2), 669 (2.1), 668 (2.1), 653 (2.0), 623 (1.5), 593 (1.5), 587 (3.1), 568 (0.8), 447 (2.2), 433 (1.4), 431 (2.4), 403 (1.1), 401 (3.2), 387 (1.0), 357 (1.9), 327 (1.5), 313 (2.3), 299 (2.3), 298 (7.9), 297 (24.7), 283 (2.3), 281 (2.8), 273 (5.3), 269 (4.7), 257 (3.6), 222 (7.9), 219 (5.3), 194 (5.3), 191 (6.8), 181 (7.9), 180 (53.7), 167 (8.8), 165 (21.1), 152 (12.1), 151 (100), and 137 (16.8); also *m/z* 1 476 ($M^+ + NH_4$, 47%), 1 475 ($M^+ - H + NH_4$, 95%), and 1 474 ($M^+ - 2 \times H + NH_4$, 100%); c.d. spectrum (see Figure).

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