coefficient extrapolated to infinite dilution, was found to be 2.03 ± 0.04 × 10^{-7} cm^2 sec^{-1}. The Stokes' radius of the phosphatidylcholine vesicle can be calculated, based on the Stokes–Einstein relation ($a = RT/N6\pi\eta D$), to be 105 ± 4 Å. This result is not inconsistent either with our earlier preliminary observation (a = 114 ± 3 Å)[10] or with the recent conclusion of others (120 ± 4 Å).[16]

The effective specific volume, ϕ', of phosphatidylcholine vesicles in 0.1 M KCl–0.01 M Tris can be calculated from the reciprocal of the isodensity point (Figure 2) as 0.9848 ± 0.0007 ml g^{-1}. Using this value, together with the new value of the diffusion coefficient and the reported value of the sedimentation coefficient ($S^{\circ}_{20,w}$ = 2.63S) determined in 0.1 M KCl–0.01 M Tris (Table I), the vesicle weight of phosphatidylcholine in this medium can be calculated from the relation $M = RTS/(1 - \phi'\rho)D$ to be 1.86 ± 0.18 × 10^6 daltons. In this calculation, D_2O–H_2O is considered to be a one-component system in which preferential binding of the different forms of water to phosphatidylcholine vesicles has been neglected.[9] This value of vesicle weight is fully consistent with our earlier reported value (2.06 ± 0.05 × 10^6 daltons)[10] obtained in 0.1 M NaCl–0.01 M Tris.

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[16] S. M. Johnson, A. D. Bangham, M. W. Hill, and E. D. Korn, *ibid.*, **233**, 820 (1971).

Communications to the Editor

Absolute Configuration of Natural (+)-Abscisic Acid

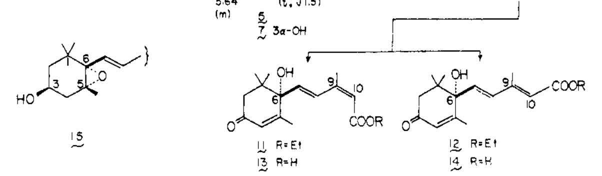
Sir:

The absolute configuration proposed[1] for the plant growth regulator (+)-abscisic acid (ABA)[2] (6β-OH in **13**) and optical data[2,3] appeared to be in conflict with the predicted chiral interaction between its two chromophores. In fact, it was reported that either the configuration of (+)-ABA or violaxanthin required revision;[4] on the other hand, two recent publications[5,6] implied revision of the (+)-ABA configuration.

The evidence presented below establishes the absolute configuration of natural (+)-ABA to be **13**[7] and violaxanthin to be **15** (only the pertinent portion is shown). We also describe preparation of ABA enantiomers employing high speed liquid chromatography (lc) of (+)-α-methoxy-α-trifluoromethylphenyl acetates (MTP esters)[8] **3** for resolution.

Hydrogenation of peroxide **1**[9] (Lindlar's catalyst) gave in quantitative yield the *dl-cis*-diol **2**,[10] which was converted into the diastereomeric MTP esters **3** (96%) with (+)-MTP acetyl chloride (see Scheme I).[8] The crude mixture **3** (300 mg) was successfully separated into 120 mg each of diastereomers **4** and **5** by four recycles through a lc column[11] (3 × 3 ft) of Porasil T with 1% *i*-PrOH in hexane.

Scheme I



The less polar ester **4** was hydrolyzed to the diol **6** in 86% yield with 5% KOH in H_2O–MeOH (1:3, v/v) at room temperature. Oxidation of benzoate **8** with the same amount of $KMnO_4$ for 1 hr in acetone–piperidine (2:1, v/v) gave 6% of the enone benzoate **9** (or **9a**) [mass spectrum 258.1255 (calcd for $C_{16}H_{18}O_3$, 258.1256); ir ($CHCl_3$), 1714, 1677 cm^{-1}; nmr ($CDCl_3$) δ 1.25 (s, 6 H, 1-Me), 1.86 (t, 3 H, J = 1.5 Hz, 5-Me), 2.10 (d of d, 1 H, J = 9, 13 Hz, 2β-H), 2.31 (d of d of d, 1 H, J = 1.5, 6, 13 Hz, 2α-H), 5.89 (m, 1 H, $W_{1/2}$ = 17 Hz, 3-H), and 6.65 ppm (septet, 1 H, J = 1.5 Hz, 4-H)], and 41% of

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[1] J. W. Cornforth, W. Draber, B. V. Milborrow, and G. Ryback, *Chem. Commun.*, 114 (1967).

[2] P. F. Wareing and G. Ryback, *Endeavour*, **29**, 84 (1970).

[3] B. V. Milborrow, *Planta*, **76**, 93 (1967).

[4] R. S. Burden and H. F. Taylor, *Tetrahedron Lett.*, 4071 (1970).

[5] S. Isoe, S. Be Hyeon, S. Katsumura, and T. Sakan, *ibid.*, 2517 (1972).

[6] T. Oritani and K. Yamashita, *ibid.*, 2521 (1972).

[7] According to the presently accepted nomenclature for assigning R and S configurations in carotenoids, the revised configuration at C-6 of (+)-ABA **13** is S. See: R. S. Cahn, C. K. Ingold, and V. Prelog, *Angew. Chem., Int. Ed. Engl.*, **5**, 385 (1966).

[8] A recently developed reagent for judging optical purity of secondary alcohols by nmr: J. A. Dale, D. L. Dull, and H. S. Mosher, *J. Org. Chem.*, **34**, 2543 (1969). The MTP ester was used for separation of diastereomers by Dr. D. A. Schooley in connection with insect juvenile hormone studies [*cf.* K. Nakanishi, D. A. Schooley, M. Koreeda, and J. Dillon, *Chem. Commun.*, 1235 (1971)].

[9] M. Mousseron-Canet, J. C. Mani, J. P. Dalle, and J. L. Olive, *Bull. Soc. Chim. Fr.*, 3874 (1966).

[10] Spectroscopic data of all compounds prepared were in agreement with their structures.

[11] A Waters ALC-100 high-speed liquid chromatograph was employed.

Table I. CD and Uv Data[a]

		CD, Δε, nm		
Compd	Solvent	π–π*	n–π*	Uv, nm (ε)
6	MeOH	−6.0 (232)	+0.18 (316)	227 (15,500)
8	MeOH	−5.3 (230)	+0.50 (317)	228 (28,800)
9	MeOH	−19.0 (238) +3.21 (219) [b]	+0.68 (336)	231 (19,800)
10	MeOH	+38.4 (242) −30.2 (208) [b]	−2.28 (320)	234 (21,300)
13	MeOH	+34.5 (261) −28.0 (229) [b]	−2.34 (317)	245 (24,800)
	0.005 *N* H_2SO_4 in MeOH[c]	+38.1 (263) −30.0 (231) [b]	−1.97 (319)	261 (24,100)
14	MeOH	+25.5 (254) − 12.6(221) [b]	−2.19 (323)	241 (28,400)

[a] Data for only one of the enantiomers are given although both were measured. [b] Davydov split Cotton effects centered around uv maxima. [c] Conditions employed in ref 3. The reported values for (+)-ABA in this solvent: +39.5 (262) and −34 (230).

starting material. The CD benzoate **9** (Table I) showed a split Cotton effect due to interaction between the benzoate and enone chromophores. The negative first Cotton effect, in light of the exciton chirality method,[12] indicates a negative chirality (**9a**) between the two axes of electric transition moments. The absolute configuration of the benzoate is hence represented by **9** and that of the diol by **6**.[13]

The more polar MTP ester **5** was likewise hydrolyzed to the *cis*-α-diol **7** (84% yield), which was oxidized with 1.1 mol equiv of Jones reagent in acetone for 30 min to afford the bisenone **10** (71%). The chirality between the two chromophores in **10**, as derived from the twin Cotton effects (Table I), shows 6-OH to be α; this corroborates the conclusion from benzoate **9**.

Optically pure **10** (26 mg) was converted into a mixture of cis and trans esters (**11** and **12**) by a Wittig reaction.[14,15] The mixture was separated into the cis ester **11** (9 mg) and trans ester **12** (12 mg) by preparative tlc (4% *i*-PrOH in hexane) and subsequent purification by lc (1% *i*-PrOH in hexane, Corasil II). Hydrolyses of **11** and **12** with 5% KOH in 50% aqueous MeOH for 5 hr at room temperature, followed by lc purification (70% aqueous MeOH, Poragel PN), gave in quantitative yield the corresponding acids, (+)-ABA **13**,[16] mass spectrum 264.1362 (calcd for $C_{15}H_{20}O_4$, 264.1362), and (+)-*trans*-ABA **14**. The split CD Cotton effects of **13** and **14** (Table I) support the absolute configurations depicted.

The enantiomers of **13** and **14** were similarly prepared from the *cis*-β-diol **6** (see footnote *a* in Table I).

Since violaxanthin **15** has been converted[4] into (+)-*trans*-ABA **13** with retention of the C-6 configuration[17] (as would be expected from the probable mechanism for the opening of the epoxide ring), it should be represented by **15**, as was first believed.[17]

A theoretical treatment of the ORD data of (+)-*trans*-ABA has also arrived at configuration **14**.[18] The regulatory activities of (+)-ABA **13**, (+)-*trans*-ABA **14**, and their enantiomers are under study.[19,20]

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(12) N. Harada and K. Nakanishi, *Accounts Chem. Res.*, **5**, 257 (1972).

(13) This conclusion is valid, independent of the conformation, since although the nmr suggested conformer **9a** (quasiaxial 3-H), molecular models show that the negative chirality remains unchanged in the inverted conformation.

(14) D. L. Roberts, R. A. Heckman, B. P. Hege, and S. A. Bellin, *J. Org. Chem.*, **33**, 3566 (1968).

(15) F. Sondheimer, E. C. Galson, Y. P. Chang, and D. C. Walton, *Science*, **174**, 829 (1971).

(16) K. Ohkuma, F. T. Addicott, O. E. Smith, and W. E. Thiessen, *Tetrahedron Lett.*, 2529 (1965).

(17) T. E. de Ville, M. B. Hursthouse, S. W. Russell, and B. C. Weedon, *Chem. Commun.*, 1311 (1969).

(18) N. Harada, *J. Amer. Chem. Soc.*, **95**, 240 (1973).

(19) Support from National Institutes of Health Grant No. CA 11572 is acknowledged.

(20) NOTE ADDED IN PROOF. Natural (+)-ABA has recently been correlated with (*S*)-malic acid and this has led to the same absolute configuration **13**: G. Ryback: *Chem. Commun.*, 1190 (1972).

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Absolute Configuration of (+)-*trans*-Abscisic Acid as Determined by a Quantitative Application of the Exciton Chirality Method

Sir:

The exciton chirality method,[1,2a] a versatile method for determining absolute configurations of natural products using split type Cotton effects, was applied to *trans*-abscisic acid. A quantitative calculation based on the molecular exciton theory indicates that (+)-*trans*-abscisic acid has the *S* configuration **3**.[2b]

The absolute configuration of (+)-*cis*-abscisic acid has remained obscure in spite of its important role as a plant-growth regulator.[3] Although Cornforth, *et al.*, had assigned an *R* configuration[2b] to (+)-*cis*-abscisic acid by application of Mills' rule,[4] Burden, *et al.*, indicated from their chemical correlation with violaxanthin that the absolute stereochemistry of either abscisic acid or violaxanthin was incorrect.[5]

The CD and ORD spectra of (+)-*cis*-abscisic acid show typical coupling type Cotton effects: CD, $\Delta\epsilon_{262} = +39.5$, $\Delta\epsilon_{230} = -34$, $\Delta\epsilon_{318} = -2.5$;[6] ORD, $[\Phi]_{289} = +63{,}400$, $[\Phi]_{269} = 0$, $[\Phi]_{246} = -182{,}200$, $[\Phi]_{225} = 0$.[7,8] This phenomenon can be interpreted as being due to the transition dipole–dipole coupling between enone and diene–carboxylic acid systems.[9] Therefore, it is expected that the theoretical calculation of absolute signs and amplitudes of split type Cotton effects would permit one to determine the absolute configuration of abscisic acid. It is also important to know the applicability of the exciton chirality method to such conformationally flexible compounds and to com-

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(1) N. Harada and K. Nakanishi, *Accounts Chem. Res.*, **5**, 257 (1972).

(2) (a) N. Harada, S. Suzuki, H. Uda, and K. Nakanishi, *J. Amer. Chem. Soc.*, **93**, 5577 (1971). (b) This is based on the presently accepted nomenclature for assigning *R* and *S* configuration to double bonds: R. S. Cahn, C. K. Ingold, and V. Prelog, *Angew. Chem., Int. Ed. Engl.*, **5**, 385 (1966).

(3) Most recent results suggest that (+)-abscisic acid has the *S* configuration: S. Isoe, S. Be Hyeon, S. Katsumura, and T. Sakan, *Tetrahedron Lett.*, 2517 (1972); T. Oritani and K. Yamashita, *ibid.*, 2521 (1972).

(4) J. W. Cornforth, W. Draber, B. V. Milborrow, and G. Ryback, *Chem. Commun.*, 114 (1967).

(5) R. S. Burden and H. F. Taylor, *Tetrahedron Lett.*, 4071 (1970).

(6) B. V. Milborrow, *Planta*, **76**, 93 (1967).

(7) J. W. Cornforth, B. V. Milborrow, and G. Ryback, *Nature (London)*, **210**, 627 (1966).

(8) B. V. Milborrow, *J. Exp. Bot.*, **21**, 17 (1970).

(9) The shape of the calculated ORD curve for conformation **1** at $\phi = 180°$ is as follows: $[\Phi]_{284} = +30{,}300$, $[\Phi]_{270} = 0$, $[\Phi]_{247} = -118{,}000$, $[\Phi]_{224} = 0$, $[\Phi]_{209} = +41{,}000$.