(1*S*,5*S*,6*R*) Absolute Stereochemistry of (—)-*cis*,*trans*-Spiro[4·4]nonane-1,6-diyl Bis(*p*-dimethylaminobenzoate) as Determined by the Exciton Chirality Method

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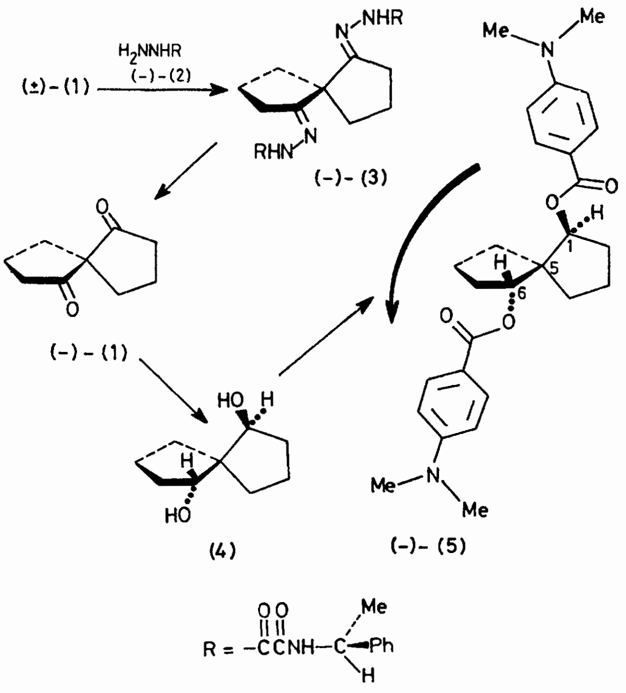
Summary The exciton chirality method has been applied to the title compound (**5**) to establish the (1*S*,5*S*,6*R*) absolute stereochemistry, which corroborates the (5*S*) configuration of (—)-spiro[4·4]nonane-1,6-dione (**1**).

In recent years there has been intensive study[1] of the chiroptical properties of unsaturated spirocyclic molecules which exhibit so-called spiroconjugation. Spiro[4·4]nonane-1,6-dione (**1**) and -1,6-diene[2] are typical examples of this chiral spiroconjugation. However, their absolute configurations have been determined only on an empirical basis by the application of Horeau's method,[2a] in spite of *X*-ray crystallographic studies[3] (relative configuration) and theoretical calculations[4] on the c.d. spectra.

We now report the (1*S*,5*S*,6*R*) absolute stereochemistry of compound (**5**) as determined by the exciton chirality method,[5] which corroborates the (5*S*) absolute configuration of the dione (**1**) in a non-empirical manner.



The racemic diketone (**1**) was resolved† by condensation with the oxamohydrazide (−)-(**2**);[6] two or three careful recrystallizations of the diastereomeric mixture of oxamoylhydrazones from ethanol afforded the optically pure oxamoylhydrazone (−)-(**3**) {m.p. 186—187·5 °C, $[\alpha]_D$ −338° (*c* 0·20335, $CHCl_3$), resolution yield 55%}, which was hydrolysed by refluxing in acetone–water in the presence of iodine, to give the diketone (−)-(**1**) in 50% yield. Reduction of (−)-(**1**) with $NaAlH_2(O[CH_2]_2OMe)_2$ yielded the *cis,trans*-glycol (**4**) as the major product. Benzoylation of (**4**) with *p*-dimethylaminobenzoyl chloride afforded the dibenzoate (−)-(**5**) as a syrup: $[\alpha]_D$ −109° (*c* 0·053, $CHCl_3$); n.m.r. (100 MHz, $CDCl_3$) δ 1·52—2·40 (m, 12H, CH_2), 3·00 and 3·05 (s, 6H each, N-Me), 5·05 and 5·58 (dd, *J* 4·8, 2·2 Hz, 1H each, CH), and 6·55, 6·67, 7·88, and 7·92 (d, *J* 9·0 Hz, 2H each, ArH). Thus, the n.m.r. spectrum shows two different sets of benzoate peaks and two methine protons, which establishes the *cis,trans* relative configuration of the glycol system.[7]

The c.d. spectrum of (−)-(**5**) clearly exhibits negative first and positive second Cotton effects ($\Delta\epsilon_{321}$ −36·6, $\Delta\epsilon_{295}$ +15·7; *A* −52·3, in ethanol) in the region of an intramolecular charge transfer band (u.v. λ_{max} 310·5 nm, ε 49,000, in ethanol) (Figure). Accordingly the exciton chirality between the two long axes of the benzoate chromophores is negative, which establishes the (1*S*,5*S*,6*R*) absolute stereochemistry of (−)-(**5**) and also corroborates the (5*S*) configuration of (−)-(**1**). This result agrees with that obtained by Horeau's method.[2a]

The theoretically calculated c.d. spectrum of the dibenzoate (−)-(**5**) is in good agreement with the observed one,

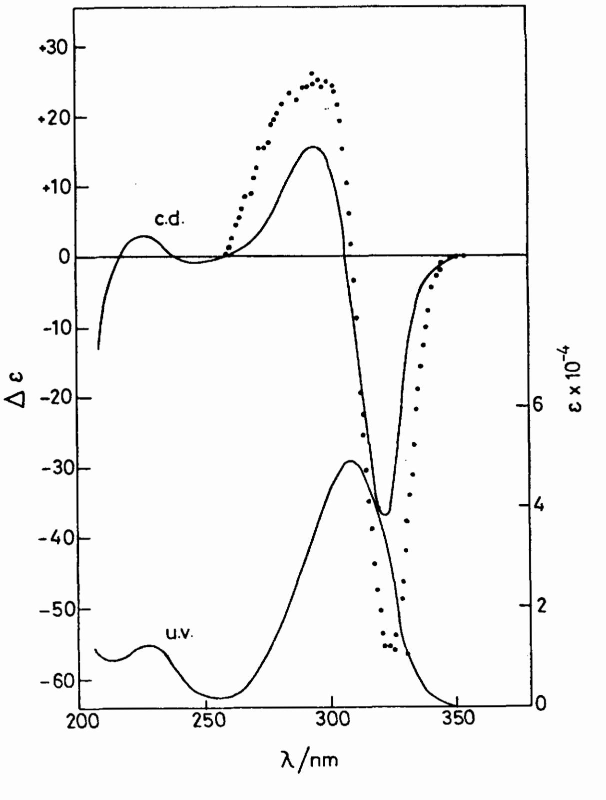


Figure. The u.v., and calculated (· · · ·) and observed (——) c.d. spectra of (−)-(**5**) in ethanol: calculated c.d. values, $\Delta\epsilon_{328}$ −55·6 and $\Delta\epsilon_{295}$ +25·0.

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† The present method is more convenient than the reported procedure, ref. 2a.

although the amplitude is larger than the observed value (Figure);‡ this confirms the above assignment. If two appropriate chromophores for chiral exciton coupling, *i.e.*, 'reporting chromophores' are introduced, the absolute stereochemistry of spiranes can be unambiguously determined.

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‡ The numerical calculation was performed for the conformation depicted in (**5**); the two spiro ring planes are perpendicular to each other and the two benzoate groups adopt the most stable staggered conformation, respectively. For details of the calculation and the parameters used, see: N. Harada, S. L. Chen, and K. Nakanishi, *J. Amer. Chem. Soc.*, 1975, **97**, 5345.

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