

OPTICAL ROTATORY DISPERSION OF NITROBENZENE DERIVATIVES—IV

ABSOLUTE CONFORMATION OF TWISTED NITROBENZENE DERIVATIVES AND ITS CONTROL THROUGH CONFORMATIONAL TRANSMISSION

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Abstract—The origin of Cotton effect shown by *o*-nitrobenzoyl esters is discussed. The Cotton effect observed for 1-(–)-menthyl ester of 3-nitrophthalic acid and of 4-nitrohemimellitic acid (6 and 12), indicated that the favoured twisting direction of the nitrobenzene moiety is determined by the asymmetric menthyl group through the intervening carboxyl groups. This provides a new concept in conformational analysis of aromatic compounds. Extending the concept of conformational transmission to 2,2'-dinitrophenyl derivatives with known absolute configuration (16 and 17), chirality of twisted nitrobenzene was related to the sign of the Cotton effect at 330 nm in accordance with the result of X-ray crystal analysis of 1-(–)-menthyl 4-bromo-2-nitrobenzoate (1).

In the previous paper,¹ we reported that *o*-nitrobenzoate of optically active secondary alcohols show Cotton effects near 330 nm and found a rule between the sign of the Cotton effect and the absolute configuration of the secondary alcohols. In order to find out the principle for the rule some consideration and experiments were attempted.

Conformation of *o*-nitrobenzoyl esters. By X-ray crystal analysis² of 1-(–)-menthyl 4-bromo-2-nitrobenzoate (1) the conformation in crystalline state was established as shown in Fig 1. Though we have no security that the favoured conformation in solution is the same as that in crystalline state, no better methods to determine it could be found. Hence in the following discussion we assume that the same conformation is predominant in solution.

In considering the conformation of *o*-nitrobenzoyl esters of secondary alcohols, three points should be taken into account. First, coplanarity of the nitro and alkoxy carbonyl group with the benzene ring. Three cases are possible: (A) both groups are coplanar, (B) one group is coplanar and the other is not, (C) both are not coplanar. Fig 1 shows that (C) is the case. This means that the steric hindrance between the groups is released by the twisting of both groups and that the loss of resonance stabilization energy in the case (C) is less than that in the case (B), where one group must be far more twisted than in the case (C). Both groups twist in the same direction in Fig 1. This can be expected by

inspection of CPK molecular model, because twisting in opposite direction causes far more steric interaction. This type of conformational restriction can be observed in the crystal structure of mellitic acid³ and of 1,2-diphenylbenzene.⁴ The second point is whether the nitro group is nearer the carbonyl oxygen or ether oxygen. In the previous paper we assumed the latter conformation from consideration of dipole interaction. However the result of X-ray analysis indicated that the former is favoured. Hence, the effect of the supposed dipole repulsion would be less than the steric repulsion between the nitro group and the substituent on the asymmetric carbon. Lastly, the possibility due to the rotation about the O—C(asym) bond (Fig 2). Fig 1 corresponds to (c). Brewster⁵ assumed an equilibrium between (a) and (b) in explaining his benzoate rule. Jennings *et al.*⁶ assumes the conformation (c) in his acetate sector rule. There seems to be no significant energy difference among the conformers a, b and c. Hence, any minor factor seems to change the relative stability of these conformers (e.g. solvent effect, neighboring group etc). Anyway, we will assume the conformer (c) in the following discussion.

On the basis of the above consideration, the conformation shown in Fig 1 can be expressed as (d) and (e) in Fig 3, which are projections along O—C(asym) axis. Conformers (d) and (e) have opposite chirality in the nitrobenzene moiety. They seem to have quite similar energy and the only conceivable source of energy difference is the interaction of the substituent M or L on the asymmetric carbon with the H-atom *ortho* to the carboxyl group. The in-

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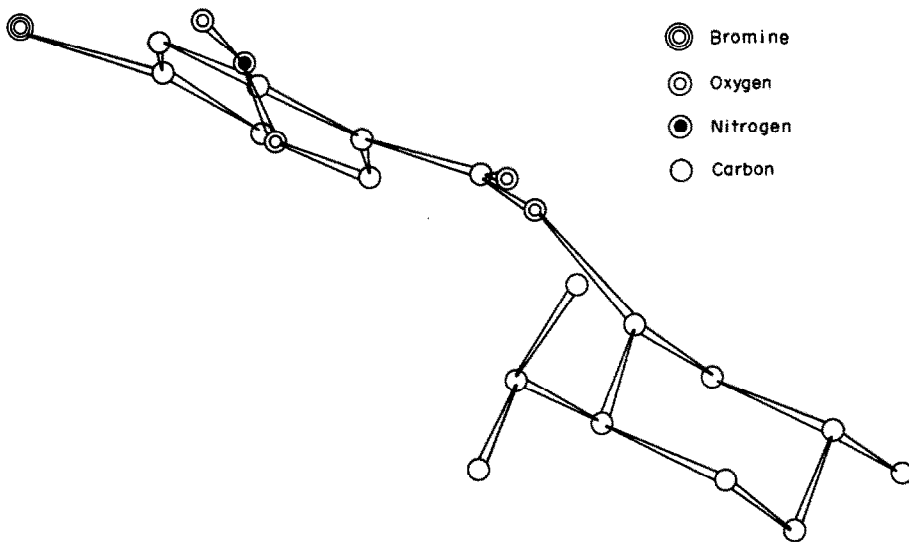


Fig 1. Conformation of 1ν-methyl 4-bromo-2-nitrobenzoate in crystalline state.

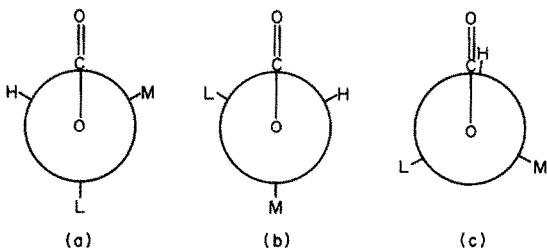


Fig 2. Probable conformers of a sec alkyl ester with S-configuration.

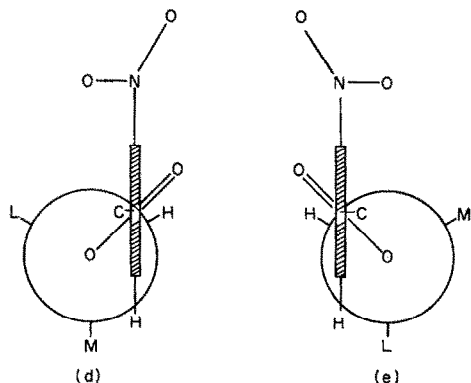


Fig 3. Projection of two probable conformers of a sec alkyl *o*-nitrobenzoate with S-configuration. Shaded area means the benzene ring.

teraction would be slightly larger in (d) than in (e) and make the latter the more abundant conformer.

Origin of the Cotton effect and conformational transmission. The conformer (d) should show strong Cotton effect due to twisted nitrobenzene which constitutes an intrinsically disymmetric chromophore and determines the sign of the Cotton

effect as first order approximation. The conformer (e) also should show a similar Cotton effect of the same order of strength but of opposite sign. Hence, the Cotton effect due to (d) and (e) cancel each other and their populational difference would cause the net Cotton effect observed. However, the energy difference would be very small, so there remains some ambiguity whether there are really effective populational differences or not. If there is no effective energy difference, the origin of Cotton effect should be attributed to minor perturbation by neighboring asymmetric environment due to the alcoholic asymmetric C atom. The perturbation would be controlled by a proper sector rule, which would define Cotton effect of (d) and (e).

In order to discriminate between the two possible origin of the Cotton effect, (-)-menthyl *m*-nitrobenzoate (2) and 3-nitrophthalates (4 and 6) were prepared and their ORD spectra were measured (Fig 4). Compound 2 shows no Cotton effect near 330 nm, but 6 shows a negative Cotton effect similar to those of 1 and 4 in sign and magnitude.

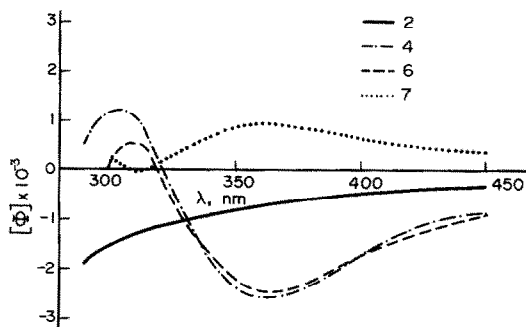


Fig 4. ORD curves of compounds 2, 4, 6 and 7.

The fact can be explained as follows: In 3-nitrophthalate the three bulky and planar groups occupy vicinal positions. They all must be twisted in the same direction because of steric hindrance. The more favoured twisting direction of the methoxycarbonyl group at 2-position is controlled by the chirality of the asymmetric alkoxy carbonyl group at 1-position as discussed above, and it is transferred to the nitro group at 3-position. Thus, the chirality of the alkoxy carbonyl group at C-1 controls the more favoured twisting direction of the nitro group, that is the sign of the Cotton effect at 330 nm of the compound. Since **2** shows no Cotton effect near 330 nm, the possibility that the Cotton effect observed for **6** is due to the direct perturbation by the asymmetric (-)-menthyl group can be excluded. Therefore, the origin of the Cotton effect is of these compounds must be the twisting of nitrobenzene chromophore and slight populational difference of the conformers with opposite twisting direction.

It is very interesting to note that the favoured twisting direction of the nitro group can be controlled by an asymmetric carboalkoxy group in *meta* position through the intervening carbomethoxy group. Expressed in general terms this means that an asymmetric group on an aromatic ring determines the favoured twisting direction of a sp^2 -substituent at *o*-position, which is transmitted to the farther *o*- sp^2 -substituent. This may provide a new approach to the conformational analysis of aromatic compounds.

In order to confirm and to extend this new type of conformational transmission, two compounds **12** and **15**, were synthesised and their ORD measured. Both compounds showed a negative Cotton effect near 330 nm as expected. The reason why **12** behaves in this manner can be easily understood. In the case of compound **15** a similar consideration may be applied because a phenyl group corresponds to a sp^2 -substituent and the compound can be composed by superimposing *o*-phenylbenzoate and *o*-phenylnitrobenzene. All the sp^2 -groups must be twisted in the same direction to avoid steric hindrance as shown in Fig 5, which is the most favoured conformer deduced by analogy with compound **1**.

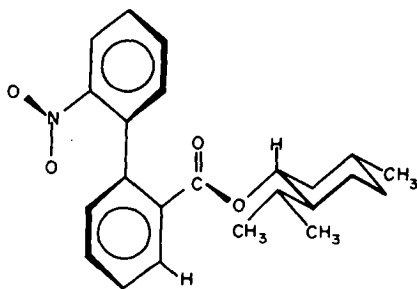


Fig 5. Probable favoured conformation of 1-menthyl 2'-nitrophenyl-2-carboxylate.

ORD and CD curves of bridged 2,2'-dinitrophenyl derivatives (**16** and **17**) of known absolute configuration⁷ have a Cotton effect around 330 nm. Applying the concept of conformational transmission, the favoured twisting direction of the nitro group can be guessed as shown in Fig 6 and it should be responsible for the Cotton effect observed. Now, we have achieved independently a relation between the sign of Cotton effect and the chirality of twisted nitrobenzene and it is in agreement with that from the X-ray analysis of compound **1**. The relation is presented in Fig 6.

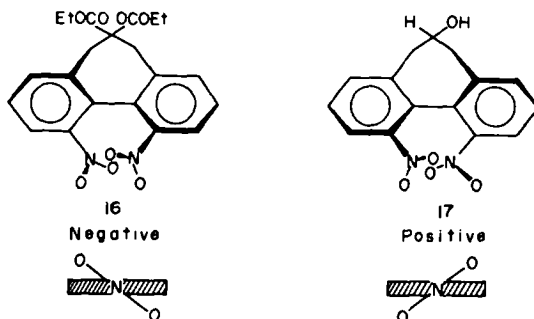


Fig 6. The relation between the twisting direction and the sign of Cotton effect and the favoured conformation of bridged 2,2'-dinitrophenyls. Shaded area means the benzene ring behind the nitro group.

Further confirmation of the concept that nitrobenzene chirality can be controlled through conformational transmission by a remote asymmetric alkoxy carbonyl group was provided by two experiments. If the chirality of the alkoxy group is changed the opposite sign should be observed for the Cotton effect. Therefore, instead of (-)-menthyl esters (**6** and **12**) with *R*-configuration, (+)-bornyl esters (**7** and **13**) with *S*-configuration were prepared and their ORD measured. Their Cotton effect was positive as expected (Fig 4). If the origin of the Cotton effect is due to the populational difference of the conformers with opposite nitrobenzene chirality, the population of the more stable conformer should increase on going to lower temperature and the intensity of the CD-band should be greater. Low temperature CD-spectra of (-)-menthyl *o*-nitrobenzoate showed a much larger $[\theta]$ -value as compared with that at ordinary temperature as expected (Fig 7). The approximate free energy difference of the two conformers was estimated 500 cal mole⁻¹ and the molecular ellipticity of the favoured conformer $[\theta]_{330} = -20000$ from the results.

Preparation of the compounds. The preparation of 3-nitrophthalic acid esters was according to the procedure reported.⁸ The authors assigned the position of alkyl groups on the basis of probable assumption that acid catalysed esterification and base catalysed saponification would proceed easier at 1-carbonyl of 3-nitrophthalic acid than at the 2-

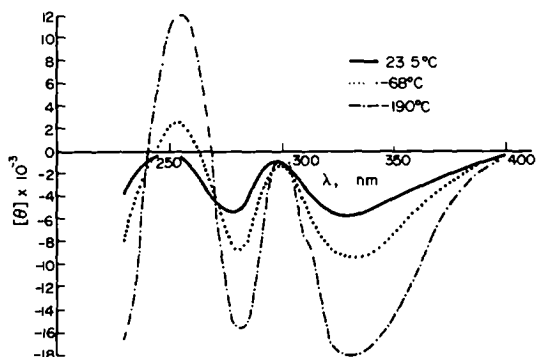
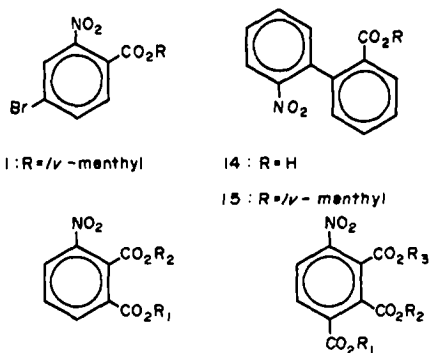


Fig 7: Low temperature CD spectra of 1ν-menthyl *o*-nitrobenzoate measured in EPA.

position. A slight ambiguity remains concerning the relative position of the methyl and (-)-menthyl groups in these compounds. However, this ambiguity does not affect our discussion because both compounds (4 and 6) show very similar Cotton effects. The assignment of the position of the free carboxyl group in compound 11 was based on a similar assumption that the ester at 1-position would be hydrolysed more readily than the others. The fact that 11 was also obtained in good yield by partial hydrolysis of 12, indicates that no alkyl migration occurred during the hydrolysis, chlorination and re-esterification. The chloride was hydrolysed to give 11 in good yield.

Experiments to confirm the structure of these compounds are in progress. It is interesting that the yield of hemimellitic acid was greater than 4-nitrohemimellitic acid (9) when 5-nitroacenaphthene was oxidised with permanganate, because the nitrated ring was expected to offer greater resistance to oxidation than the other.



- 1: R = *ν*-menthyl
 14: R = H
 15: R = *ν*-menthyl
 3: R₁ = Me, R₂ = H
 9: R₁ = R₂ = R₃ = H
 4: R₁ = Me, R₂ = *ν*-menthyl
 10: R₁ = R₂ = R₃ = Me
 5: R₁ = H, R₂ = Me
 11: R₁ = H, R₂ = R₃ = Me
 6: R₁ = *ν*-menthyl, R₂ = Me
 12: R₁ = *ν*-menthyl, R₂ = R₃ = Me
 7: R₁ = *α*-bornyl, R₂ = Me
 13: R₁ = *α*-bornyl, R₂ = R₃ = Me
 8: R₁ = H, R₂ = *ν*-menthyl

Fig 8.

EXPERIMENTAL

M.ps were uncorrected. ORD was measured with JASCO ORD/UV-5 spectropolarimeter.

(-)-Menthyl *m*-nitrobenzoate (2). *m*-Nitrobenzoic acid was chlorinated with thionyl chloride and the chloride was reacted with (-)-menthol in pyridine at room temp. Usual work-up of the mixture gave a slightly yellow oily substance; ORD (c, 0.108 in MeOH) [ϕ]₃₅₀ -197°, [ϕ]₃₅₀ -225°, [ϕ]₃₅₀ -254°, [ϕ]₄₃₀ -366°, [ϕ]₄₀₀ -510°, [ϕ]₃₅₀ -848°, [ϕ]₃₀₀ -1526°. (Found: C, 67.16, H, 7.63, N, 4.51. C₁₇H₂₃O₄N requires: C, 66.86, H, 7.59, N, 4.59%).

1-Methyl 2-hydrogen 3-nitrophthalate (3). A cold soln of 3-nitrophthalic acid (5.0 g) in MeOH (30 ml) was saturated with dry HCl, then heated under reflux for 3 h. The soln was saturated with dry HCl again, left overnight, saturated with dry HCl once more, and refluxed again 1 h. Precipitates formed on leaving the cold reaction mixture after dilution with ca 5-volumes of H₂O were collected and dissolved in Et₂O. The Et₂O soln was shaken with 5%-NaOH_{aq} and the alkaline layer was acidified with 5%-HCl_{aq} to give a ppt of the half ester, which was recrystallised from H₂O (3g-56%), m.p. 160-162°, (lit⁸ 161-163°): (Found: C, 48.01, H, 3.13, N, 6.22. C₉H₇O₆N requires: C, 47.89, H, 3.28, N, 6.23%).

1-Methyl 2-(-)-menthyl 3-nitrophthalate 4. Finely powdered 3 (2 g) and PCl₅ (1.8 g) were mixed and heated on a water-bath until no more evolution of HCl was observed. After evaporation of POCl₅, the residue was recrystallized from benzene-petrol ether to give the chloride (1.5 g-68%) of m.p. 97-99°. The chloride (1.5 g) and (-)-menthol (2 g) were mixed and heated 3 h in an oil-bath at 110-120°. The mixture was steam-distilled to remove unreacted menthol and the residue was extracted with Et₂O. The Et₂O-layer was washed with 5% NaOH_{aq} and H₂O, and dried over Na₂SO₄. After evaporation of Et₂O, the residue was recrystallised from benzene-hexane to give the ester (1 g-48%), m.p. 149-150° (lit⁸ m.p. 149-150°); ORD (c, 0.106 in MeOH) [ϕ]₃₅₀ -308°, [ϕ]₃₅₀ -341°, [ϕ]₃₀₀ -548°, [ϕ]₄₅₀ -820°, [ϕ]₄₀₀ -1746°, [ϕ]₃₆₀ -2635° (tr), [ϕ]₃₀₃ +1230° (pk), [ϕ]₂₉₀ +581°. (Found: C, 62.79, H, 6.93, N, 3.85. C₁₉H₂₃O₆N requires: C, 62.76, H, 6.77, N, 3.82%).

2-Methyl 1-hydrogen 3-nitrophthalate (5). 3-Nitrophthalic anhydride (1 g) was dissolved in anhydrous MeOH (20 ml) and refluxed for 2 h on a water-bath. The mixture was concentrated under reduced press diluted with H₂O until the soln became turbid, and left 2-3 h at room temp. Recrystallization of the crystals formed from H₂O gave the half ester (0.55 g 47%), m.p. 152-153°, (lit⁸ 152-153°). (Found: C, 47.83, H, 3.28, N, 6.24. C₉H₇O₆N requires: C, 48.01, H, 3.13, N, 6.22%).

1-(-)-Menthyl 2-methyl 3-nitrophthalate (6). The half ester 5 (0.55 g) was refluxed for 1 h with SOCl₂ (1.1 g). After removal of excess SOCl₂ the residue crystallized (0.59 g) and (-)-menthol (0.36 g) was heated for 2 h on an oil-bath at 110-120°. The mixture was chromatographed on a silica (10 g) column by eluting with benzene. Prep TLC (silica/benzene) of the earlier eluting fractions gave a viscous liquid (0.19 g-56%), which failed to crystallise (lit⁸, m.p. 66-69°); ORD (c, 0.124 in MeOH) [ϕ]₃₅₀ -526°, [ϕ]₃₅₀ -584°, [ϕ]₃₀₀ -700°, [ϕ]₄₅₀ -933°, [ϕ]₄₀₀ -1753°, [ϕ]₃₆₅ -2515° (tr), [ϕ]₃₁₀ +526° (pk), [ϕ]₃₀₀ 0°. (Found: C, 62.57, H, 6.81, N, 3.83. C₁₉H₂₃O₆N requires: C, 62.79, H, 6.93, N, 3.85%). TLC (silica/benzene) R_f = 0.45 for 6 and 0.33 for 4.

1-(+)-Bornyl 2-methyl 3-nitrophthalate (7). The same procedure as above was followed using (+)-borneol instead of (-)-menthol. Needles from aqueous MeOH, m.p.

118–122° (Kofler); ORD (*c*, 0.06 in MeOH); $[\phi]_{390} + 119^\circ$, $[\phi]_{350} + 195^\circ$, $[\phi]_{300} + 238^\circ$, $[\phi]_{250} + 361^\circ$, $[\phi]_{200} + 632^\circ$, $[\phi]_{163} + 903^\circ$ (pk), $[\phi]_{130} - 45^\circ$ (tr), $[\phi]_{300} + 285^\circ$.

2-(–)-*Menthyl 1-hydrogen 3-nitrophthalate* (8). 3-Nitrophthalic anhydride (1 g) and (–)-menthol (0.8 g) were dissolved in a mixture of dry pyridine (2.5 ml) and dry benzene (7.5 ml) and refluxed for 3 h. The mixture was poured into ice-water, and extracted with benzene. The organic layer was washed with H₂O and dried over Na₂SO₄. Recrystallization of the residue from benzene–hexane gave crystals, m.p. 161–162° (1.1 g–61%). It showed a single spot on TLC (silica/CHCl₃:MeOH = 9 : 1 *R_f*: 0.20); ORD (*c*, 0.118 in MeOH) $[\phi]_{390} - 502^\circ$, $[\phi]_{350} - 530^\circ$, $[\phi]_{300} - 736^\circ$, $[\phi]_{250} - 1064^\circ$, $[\phi]_{200} - 2129^\circ$, $[\phi]_{163} - 3252^\circ$ (tr), $[\phi]_{300} + 1239^\circ$ (pk), $[\phi]_{300} + 1005^\circ$. (Found: C, 61.72, H, 6.69, N, 3.87. C₁₈H₂₁O₅N requires: C, 61.88, H, 6.64, N, 4.01%).

Permanganate oxidation of 5-nitroacenaphthene. 5-Nitroacenaphthene (5.0 g) and H₂O (50 ml) were placed in a flask with a reflux condenser, and heated on a water-bath at ca 70°. A hot aqueous soln of KMnO₄ (37.4 g) was added portionwise to the aqueous suspension under vigorous stirring and the reaction was continued for 6 h. The hot mixture was filtered to remove MnO₂ formed and the MnO₂ was washed well with hot water. The combined filtrate and washings were treated with dil H₂SO₄ and KMnO₄ was added to the soln portionwise until discoloration of KMnO₄ slowed down and the ppt of MnO₂ began to form. This was filtered off and the acidic filtrate was concentrated to ca 100 ml and left overnight. Most of the hemimellitic acid formed and K₂SO₄ crystallised out. The filtrate was evaporated to dryness under reduced press and the residue was extracted with Et₂O. On evaporation of Et₂O crude 4-nitrohemimellitic acid (9) was obtained. But, it contained some hemimellitic acid, which could not be removed by recrystallisation.

Trimethyl 4-nitrohemimellitate (10). Et₂O soln of crude 9 above obtained was treated with CH₂N₂ in Et₂O as usual. After overnight leaving at room temp Et₂O was removed and the residue was recrystallized from EtOH–H₂O. The mother liquor was separated by means of prep TLC (silica/CH₂Cl₂) into 10 and trimethyl hemimellitate (*R_f* = 0.6 and 0.4, respectively). Total yield from 5-nitroacenaphthene was 18.3% (1.36 g), m.p. 83.5–84.0°. IR_{max}^{Nujol} 1750 (ester C=O), 1605, 1580 (phenyl), 1530, 1360 (NO₂) cm⁻¹. NMR: δ (CDCl₃), 3.92 (9H, s), 8.10 (2H, s) ppm; (DMSO-*d*₆) 3.82 (6H, s), 3.88 (3H, s), 8.20 (1H, d, *J* = 8.4 Hz), 8.35 (1H, d, *J* = 8.4 Hz) ppm. (Found: C, 48.58, H, 3.85, N, 4.53. C₁₂H₁₁NO₅ requires: C, 48.49, H, 3.73, N, 4.71%).

2,3-Dimethyl 1-hydrogen 4-nitrohemimellitate (11). 10 (1.2 g) was dissolved in MeOH (12 ml). An aqueous soln of equimolar amount of KOH (0.42 g/ml; 0.54 ml) was added dropwise under stirring. The mixture was refluxed 10 min on a water-bath of 72–73°. MeOH was removed under reduced press and the resulting aqueous soln was diluted with H₂O to make the operation easier, and extracted with Et₂O to remove unsaponified starting material. The aqueous layer was acidified by adding 1N–HCl (2.5 ml) and crystals formed were recrystallized from EtOH–H₂O to give 11 (0.74 g–64%) of m.p. 186.0–186.5°. IR_{max}^{Nujol} 2800–2500 (carboxyl OH), 1750, 1740 (ester C=O), 1705 (carboxyl C=O), 1660, 1590 (phenyl C=C), 1540, 1360 (NO₂) cm⁻¹. NMR: δ (DMSO), 3.80 (3H, s), 3.84 (3H, s), 8.19 (1H, d, *J* = 7.8 Hz), 8.33 (1H, d, *J* = 7.8 Hz) ppm. (Found: C, 46.68, H, 3.19, N, 5.01. C₁₁H₉O₅N requires: C, 46.65, H, 3.20, N, 4.96%).

1-(–)-*Menthyl 2,3-dimethyl 4-nitrohemimellitate* (12). 11 (100 mg) was chlorinated with SOCl₂ (2.5 ml) by refluxing for 4 h. After removal of SOCl₂ under reduced press, the residue (101 mg; m.p. 127–130°; IR_{max}^{Nujol} 1770 (acid chloride C=O) cm⁻¹) was reacted with (–)-menthol (52 mg) in pyridine (1.0 ml) without purification. The mixture was sealed in a tube, heated to make it homogeneous and left overnight at room temp. After evaporation of pyridine under reduced press, the residue was directly separated by means of prep TLC (silica/CH₂Cl₂), recrystallized from EtOH–H₂O, yield: 84 mg–65% from 11, m.p. 94.0–94.5°; IR_{max}^{Nujol} 1745, 1735, 1710 (ester C=O), 1595, 1580 (phenyl C=C), 1535, 1360 (NO₂) cm⁻¹; NMR: δ (CDCl₃) 0.80 (3H, d, *J* = 10 Hz), 0.91 (6H, d, *J* = 9 Hz), 3.91 (6H, s), 4.90 (1H, m), 8.10 (2H, s) ppm; ORD (*c*, 0.102 in MeOH): $[\phi]_{390} - 660^\circ$, $[\phi]_{350} - 783^\circ$, $[\phi]_{300} - 989^\circ$, $[\phi]_{250} - 1490^\circ$, $[\phi]_{200} - 2892^\circ$, $[\phi]_{163} - 4134^\circ$ (tr), $[\phi]_{315} + 1330^\circ$ (pk), $[\phi]_{300} - 2160^\circ$. (Found: C, 59.49, H, 6.52, N, 3.37. C₂₁H₂₇NO₅ requires: C, 59.85, H, 6.46, N, 3.32%).

1-(+)-*Bornyl 2,3-dimethyl 4-nitrohemimellitate* (13). The same procedure as above was followed using (+)-borneol instead of (–)-menthol, needles from aqueous MeOH, m.p. 84–87° (Kofler); ORD (*c*, 0.10 in MeOH): $[\phi]_{390} + 356^\circ$, $[\phi]_{350} + 440^\circ$, $[\phi]_{300} + 566^\circ$, $[\phi]_{250} - 796^\circ$, $[\phi]_{200} + 1446^\circ$, $[\phi]_{163} + 2055^\circ$ (pk), $[\phi]_{317} - 146^\circ$ (tr), $[\phi]_{300} + 1551^\circ$.

Partial hydrolysis of 1-(–)-menthyl 2,3-dimethyl 4-nitrohemimellitate (12). 12 (26.4 mg) was dissolved in MeOH (1 ml) containing KOH (3.5 mg) and refluxed on a water-bath at 70° until the mixture became neutral (ca 25 min). The mixture was separated by means of prep TLC developing with *i*-PrOH:conc NH₃:H₂O = 10:3.5:2. The lower UV-absorbing band was scratched off, extracted with H₂O, filtered and evaporated to dryness under reduced press. The residue (12 mg) was dissolved in H₂O (1.5 ml) and acidified with a drop of 4N HCl. The crystals which formed were filtered off, washed with H₂O and dried. They showed m.p. 178–179° and no depression when mixed with the sample obtained by partial hydrolysis of 10.

Hydrolysis of the chloride of (11). 11 (100 mg) was chlorinated as above. The chloride (35 mg) was treated with H₂O (2 ml) and pyridine (a few drops to dissolve the crystal) for 2 days. After removal of the solvent the residue was recrystallized from EtOH–H₂O to give 11 (26 mg, 74.3%); which showed no depression of m.p. on admixture with the starting material (m.p. = 181–182°, m.m.p. = 181–182°).

2'-*Nitrobiphenyl-2-carboxylic acid* (14). Biphenyl-2-carboxylic acid (2.1 g) was treated with conc HNO₃ (*d* = 1.40) at –5–0°, 1.5 h. The mixture was poured into water (85 ml) and the ppt formed was filtered off and washed well with H₂O. Crystallization of the yellow cake from EtOH gave 4'-nitrobiphenyl-2-carboxylic acid. The mother liquor was concentrated to give crude 14 (440 mg), which was recrystallized from CHCl₃ to yield purer 14 containing still a small amount of the starting material. It was purified by means of prep TLC (silica/CHCl₃–MeOH: 10%). Purified 14 showed m.p. 163–165° (lit° m.p. 170°).

(–)-*Menthyl 2'-nitrobiphenyl-2-carboxylate* (15). 14 (80 mg) was refluxed with SOCl₂ (5 ml) for 2.5 h. After removal of excess SOCl₂, the residue was treated with (–)-menthol (55 mg) and pyridine (2 ml) 2 days. The mixture was poured into cold 2N HCl and extracted with Et₂O. The Et₂O soln was washed with 2N HCl and H₂O, and dried over Na₂SO₄. The residue was purified by prep TLC

(silica/CHCl₃) to give **15** (55 mg) m.p. 68–71°; ORD (c, 0.094 in MeOH): [ϕ]₅₉₀ –446°, [ϕ]₅₅₀ –446°, [ϕ]₅₀₀ –446°, [ϕ]₄₅₀ –709°, [ϕ]₄₀₀ –1520°, [ϕ]₃₆₀ –2353° (sh), [ϕ]₃₃₇ –2532° (tr), [ϕ]₃₁₈ 0°, [ϕ]₂₉₄ +686° (pk). CD (c, 2.46 × 10⁻³ M in MeOH): [θ]₄₂₀ 0, [θ]₄₀₀ –203, [θ]₃₅₀ –2032, [θ]₃₁₈ –5691 (max), [θ]₃₀₀ –2439, [θ]₂₉₂ 0. (Found: C, 72.10, H, 7.07, N, 3.47. C₂₃H₂₇NO₄ requires: C, 72.42, H, 7.13, N, 3.67%).

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