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# CD Spectra of Bis(2,4-dinitrophenyl) Derivatives of Acyclic Diamino Compounds Having Two Asymmetric Centers

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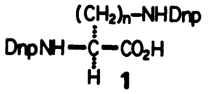
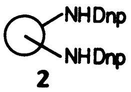
(Received September 30, 1985)

**Synopsis.** Chiroptical properties of bis(2,4-dinitrophenyl) derivatives of acyclic diamino compounds were discussed. The derivatives of diamines in which the two $NH_2$-bearing carbons are asymmetric having the same chirality exhibited Cotton effects of much larger intensity than the corresponding diamine derivatives having only one asymmetric carbon atom. Relation between sign and magnitude of Cotton effect at the longest wavelength of bis(2,4-dinitrophenyl) derivatives and structure and stereochemistry of parent diamino compounds was summarized in a tabulated form.

Bis(2,4-dinitrophenyl) (di-Dnp) derivatives of α,ω-diamino acids exhibit characteristic pattern of CD spectra above 300 nm and sign of the Cotton effect at the longest wavelength was found to be negative for the diamino acid derivatives with L-configuration (**1**, $n$=1—4). The Cotton effect was assumed to be due to exciton coupling of the electric transition moments of 400 nm band of the two DnpNH chromophores. Direction of the transition moment was calculated to be oriented approximately parallel to the C–NHDnp bond. Thus, conformers **2** having negative chirality of the two C–NHDnp bonds were assumed to be responsible for the characteristic negative Cotton effect at the longest wavelength, and a rule named di-Dnp chirality rule was proposed, which correlates sign of the Cotton effect around 400 nm with chirality of the two C–N bonds of the di-Dnp derivatives.[1)]

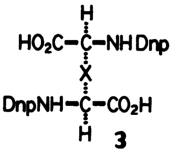

$$\mathrm{DnpNH{-}}\overset{\overset{\textstyle (CH_2)_n-NHDnp}{\vdots}}{\underset{\underset{\textstyle H}{\vdots}}{C}}\mathrm{{-}CO_2H}$$

**1**

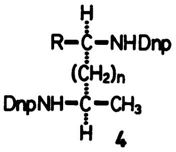


**2**

CD spectrum of di-Dnp derivative of L-cystine (**3**, X=$CH_2SSCH_2$) was very similar to those of L-α,ω-diamino acid derivatives **1** exhibiting negative Cotton effect around 400 nm. Magnitude of the Cotton effect of the L-cystine derivative ($[\theta]_{412}$ −21100), however, was much larger than that of L-lysine derivative (**1**, $n$=4; $[\theta]_{427}$ −6400),[1)] in spite of apparent larger separation of the two DnpNH chromophores by intervening six atoms in the former compound than in the latter which contains five intervening carbon atoms. Larger intensity of Cotton effects of the cystine derivative was assumed to be due to presence of additional chiral center, which restricts relative steric arrangement of the two chromophoric groups more effectively to interact with each other to give characteristic Cotton effects. Since the Cotton effects in concern are generated by electronic interaction of the two DnpNH chromophores, effect of presence and/or introduction of nonaromatic groups such as $CO_2H$ upon the spectra can be considered essentially steric in nature.


$$\mathrm{HO_2C{-}}\overset{\overset{\textstyle H}{\vdots}}{C}\mathrm{{-}NHDnp}$$
$$\mathrm{X}$$
$$\mathrm{DnpNH{-}}\underset{\underset{\textstyle H}{\vdots}}{C}\mathrm{{-}CO_2H}$$

**3**


$$\mathrm{R{-}}\overset{\overset{\textstyle H}{\vdots}}{C}\mathrm{{-}NHDnp}$$
$$(CH_2)_n$$
$$\mathrm{DnpNH{-}}\underset{\underset{\textstyle H}{\vdots}}{C}\mathrm{{-}CH_3}$$

**4**

In order to ascertain the assumption di-Dnp derivatives of (2*S*,5*S*)-diaminoadipic and (2*S*,6*S*)-diaminopimelic acids [**3**, X=$(CH_2)_n$, $n$=2 and 3] were prepared, which correspond to derivatives of L-ornithine and L-lysine (**1**, $n$=3 and 4),[1)] respectively, having an extra carboxyl group creating additional asymmetric center. As expected the di-Dnp derivatives **3** [X=$(CH_2)_n$, $n$=2 and 3] showed a similar pattern of CD spectra with the intensity two to three times as large as the corresponding **1** ($n$=3 and 4), respectively (Table 1).

Di-Dnp derivatives of alkanediamines (**4**, R=$CH_3$, $n$=0 and 1) were also synthesized and their CD spectra were recorded as summarized in Table 1. The (2*R*,3*R*)-butanediamine derivative (**4**, R=$CH_3$, $n$=0)[2)] can be considered as an analog of (*R*)-1,2-propanediamine derivative (**4**, R=H, $n$=0)[1)], whose methylene group is substituted by a methyl group generating an additional chiral center of the same chirality. Cotton effects of the butanediamine derivative were much larger than those of the propanediamine derivative, which also demonstrated the effect of introducing another chiral center. (2*R*,4*R*)-Pentanediamine derivative (**4**, R=$CH_3$, $n$=1) is an analog of the propanediamine derivative having an additional methyl group as well as an intervening methylene group between the two chromophore-bearing carbon atoms. While the additional chiral center is considered to restrict the two DnpNH groups in favorable conformation to give characteristic CD spectrum, the extra methylene group has an effect of spatially separating two chromophores and also giving more conformational freedom than the case of the propanediamine derivative. The two opposing effects seem to cancell each other to result in observed Cotton effects of comparable intensity.

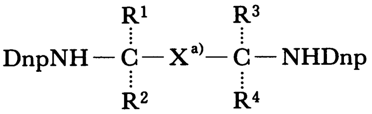
From the results described above the sign and magnitude of Cotton effect around 400 nm of di-Dnp derivatives of chiral acyclic diamines can be summarized as given in Table 2. Positive and negative Cotton effects, respectively, are observed if absolute configuration of the asymmetric center corresponds to that of D- and L-α,ω-diamino acid derivatives. If the compound possesses two chiral centers of the same chirality larger Cotton effect is expected than that having only one chiral center, while chiral centers of different chirality evidently afford achiral meso compounds designated as 0 in Table 2 (entry c).

Table 1. CD Spectral Data of di-Dnp Derivatives of Acyclic Chiral Diamines[a]

| Compound | Molecular ellipticity ($[\theta]/10^2$) and wavelength ($\lambda$/nm) in parentheses |
|---|---|
| **1**, $n=3$[b] | −210 (415), 0 (388), +516 (361), 0 (340), −186 (327), 0 (275), +75 (260) |
| **1**, $n=4$[b] | − 64 (427), 0 (390), +125 (357), 0 (333), − 15 (320), 0 (290), +15 (262) |
| **3**, $X=CH_2SSCH_2$ | −211 (412), 0 (378), +158 (361), 0 (342), − 90 (324), 0 (275) |
| **3**, $X=(CH_2)_2$ | −490 (405), 0 (380), +1060 (356), 0 (336), −616 (319), 0 (274), +259 (259) |
| **3**, $X=(CH_2)_3$ | −148 (405), 0 (377), +196 (354), 0 (332), − 45 (315), 0 (275), +20(260) |
| **4**, $R=CH_3$, $n=0$[c] | −842 (420), 0 (382), +155 (356), 0 (329), −229 (318), 0 (300) |
| **4**, $R=CH_3$, $n=1$[c] | −503 (427), 0 (379), +503 (357), 0 (325), − 13 (321), 0 (314), +238 (273) |
| **4**, $R=H$, $n=0$[b] | −477 (423), 0 (386), +632 (357), 0 (325), − 77 (310), − 19 (282), − 49 (270) |
| **5**, $R=CH_3$ | +111 (398), 0 (373), −176 (363), 0 (326), + 21 (317), 0 (310), −249 (270) |
| **5**, $R=CH(CH_3)_2$ | +144 (398), 0 (365), − 90 (348), − 35 (310), −278 (274), −238 (263) |

a) Recorded in methanol solution unless otherwise noted. b) Ref 1. c) Recorded in methanol-tetrahydrofuran (1 : 1 v/v).

Table 2. Relation between Absolute Configuration and Sign of Cotton Effect at the Longest Wavelength of di-Dnp Derivatives of Acyclic Diamino Compounds

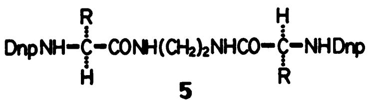


$$DnpNH-\underset{R^2}{\overset{R^1}{C}}-X^{a)}-\underset{R^4}{\overset{R^3}{C}}-NHDnp$$

| Entry | $R^1$ | $R^2$ | $R^3$ | $R^4$ | $[\theta]^{max}_{\approx 400}$ |
|---|---|---|---|---|---|
| a | R[b] | H | H | R | ++[c] |
| b | R | H | H | H | + |
| c | R | H | R | H | 0[d] |
| d | H | R | H | H | − |
| e | H | R | R | H | −− |

a) X implies an achiral chain. b) R implies a non-aromatic group. c) ++ and −− mean that larger Coton effect is expected than + and − if comparisons are made among the compounds with the same or similar intervening group X. d) 0 means no chirality.

It is interesting that bis(Dnp-L-α-aminoacyl) derivatives **5** of ethanediamine correspond to general formula of entry a in Table 2 for which positive Cotton effect around 400 nm is expected in spite of L-configuration of the constituent amino acids. As expected the L-alanine derivative (**5**, $R=CH_3$) exhibited positive Cotton effect ($[\theta]_{398}+11100$) and a similar CD spectrum is observed also for the L-valine derivative (**5**, $R=CH(CH_3)_2$; $[\theta]_{398}+14400$).



$$DnpNH-\underset{H}{\overset{R}{C}}-CONH(CH_2)_2NHCO-\underset{R}{\overset{H}{C}}-NHDnp$$

**5**

## Experimental

Melting points were measured on a Yanagimoto micro melting point apparatus and uncorrected. All the derivatives synthesized exhibited reasonable $^1H$ NMR spectra with a Varian XL-200 or a HITACHI R-24A spectrometer and gave satisfactory elemental analysis for C, H, and N ($<\pm0.4\%$). CD spectra were recorded on a JASCO J-40C spectropolarimeter as summarized in Table 1.

**(2*S*,5*S*)-Bis(2,4-dinitroanilino)hexanedioic Acid [3, X=(CH₂)₂].** (2*S*,5*S*)-Diaminoadipic acid[3] was 2,4-dinitrophenylated according to Sanger.[4] Yellow needles from ethyl acetate-benzene; mp 220—223 °C.

**(2*S*,6*S*)-Bis(2,4-dinitroanilino)heptanedioic Acid [3, X=(CH₂)₃].** This compound was prepared similarly from (2*S*,6*S*)-diaminopimelic acid.[3,5] Yellow prisms from methanol; mp 114—118 °C.[6]

**(2*R*,4*R*)-*N*²,*N*⁴-Bis(2,4-dinitrophenyl)-2,4-pentanediamine (4, R=CH₃, *n*=1).** (2*R*,4*R*)-Pentanediamine (*R*,*R*)-di-*O*-benzoyltartrate[7] was dinitrophenylated with 1-fluoro-2,4-dinitrobenzene-$NaHCO_3$ in acetone-$H_2O$. Yellow prisms from acetone; mp 218—219 °C.

**(2*S*,3*S*)-*N*²,*N*³-Bis(2,4-dinitrophenyl)-2,3-butanediamine (enantiomer of 4, R=CH₃, *n*=0).** This compound was prepared from (2*S*,3*S*)-butanediamine *R*,*R*-tartrate.[8] Yellow prisms from acetone; mp 217—218 °C.

***N*,*N*'-Bis[*N*-(2,4-dinitrophenyl)-L-alanyl]ethanediamine 5 (R=CH₃).** This compound was synthesized by coupling of Dnp-L-alanine (153 mg, 0.6 mmol) and ethanediamine (15 mg, 0.25 mmol) in *N*,*N*-dimethylformamide(DMF)-tetrahydrofunan (2:1) using dicyclohexylcarbodiimide (124 mg, 0.6 mmol). Yellow powder (107 mg, 80%) from DMF-methanol; mp 277—280 °C.

***N*,*N*'-Bis[*N*-(2,4-dinitrophenyl)-L-valyl]ethanediamine 5 [R=(CH₃)₂CH].** This compound was synthesized from Dnp-L-valine similarly as above. Yellow powder; mp>300 °C.

We wish to thank Dr. Ukon Nagai of Mitsubishi-Kasei Institute of Life Sciences for helpful discussions.

### References

1) M. Kawai, U. Nagai, and T. Kobayashi, *Tetrahedron Lett.* **1974**, 1881.

2) The compound actually synthesized was the enantiomer of 4 ($R=CH_3$, $n=0$) as described in experimental. For the purpose of making comparison easier, CD spectral data which are antipodal to those really observed are given in Table 1.

3) R. Nakashima, J. Matsumoto, Y. Shigemasa, and N. Ueda, to be published.

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5) Y. Izumi, *Nippon Kagaku Zasshi*, **75**, 1152 (1954).

6) Elemental analysis was consistent with dihydrated formula $C_{19}H_{18}N_6O_{12}\cdot 2H_2O$.

7) B. Bosnich and J. MacB. Harrowfield, *J. Am. Chem. Soc.*, **94**, 3425 (1972).

8) M. Gullotti, A. Pasini, P. Fantucci, R. Ugo, and R. D. Gillard, *Gazz. Chim. Ital.*, **102**, 855 (1972).