Conformational Studies by Dynamic NMR. 86.[1] Structure, Stereodynamics, and Cryogenic Enantioseparation of the Stereolabile Isomers of *o*-Dinaphthylphenyl Derivatives

Carlo Dell'Erba,[§] Francesco Gasparrini,*[,†] Stefano Grilli,[‡] Lodovico Lunazzi,*[,‡] Andrea Mazzanti,[‡] Marino Novi,[§] Marco Pierini,[||] Cinzia Tavani,[§] and Claudio Villani[||]

Dipartimento di Chimica e Chimica Industriale, Università di Genova, Via Dodecaneso 31, Genova 16146, Italy, Dipartimento di Studi di Chimica e Tecnologia delle Sostanze Biologicamente Attive, Università "La Sapienza", P.le A. Moro 5, Roma 00185, Italy, Dipartimento di Chimica Organica "A. Mangini", Università di Bologna, Viale Risorgimento 4, Bologna 40136, Italy, and Dipartimento Scienze del Farmaco, Università "G. D'Annunzio", Via dei Vestini 31, Chieti 66013, Italy

lunazzi@ms.fci.unibo.it

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Static and dynamic stereochemistry of the hydrocarbon comprising a phenyl ring bearing two α-naphthyl substituents in the *ortho* positions, i.e., 1,2-di-(4-methyl-naphth-1-yl)-benzene **1**, has been studied by a combination of variable temperature NMR, cryogenic HPLC, and MM calculations. Whereas in solution both *syn* (meso) and *anti* (chiral) forms were observed and the corresponding interconversion barrier was determined ($\Delta G^{\ddagger} = 19.5$ kcal mol^{-1}), only the diastereoisomer *anti* was found to be present in the crystalline state (X-ray diffraction). When the molecule is rendered asymmetric by introduction of a nitro group in the phenyl ring as in 1,2-di-(4-methyl-naphth-1-yl)-4-nitrobenzene **2**, the chiral *syn* and *anti* diastereoisomers are simultaneously present both in solution and in the solid state, albeit in different proportions. Cryogenic chromatography on a HPLC chiral stationary phase at −20 °C allowed the stereolabile diastereoisomers and the corresponding enantiomers to be separated.

Introduction

The stereomutation processes occurring in aryl derivatives bearing two aromatic substituents in close proximity (e.g., *ortho* or *peri* positions) have recently attracted considerable attention.[2−9] In a number of cases the presence of conformational stereoisomers has been identified by NMR spectroscopy, and in at least one case two such diastereoisomers could be isolated.[10] The physical separation of the conformational enantiomers in this class of compounds, on the contrary, has never been achieved. In the present work we report a successful attempt to identify the structure and the conformation of appropriate derivatives of this type, to determine the barriers involved in their stereomutation processes, and to obtain the cryogenic enantioseparation of the resulting stereolabile isomers.

In the course of an extension of a previous work concerning the transformation of 3,4-dinitrothiophene into 1,2-diaryl-4-nitrobenzenes,[11] the bis(1-naphthyl) derivative turned out to be quite appropriate for the stereodynamic investigation mentioned above. Therefore the latter compound and two cognates were purposely synthesized through the Suzuki coupling reaction and investigated here.

Results and Discussion

Hydrocarbon **1**, i.e., 1,2-di-(4-methyl-naphth-1-yl)-benzene, comprises a pair of diastereoisomers (Scheme 1) since the two *ortho* naphthyl substituents, which have their planes almost orthogonal to that of the phenyl ring, can be either parallel (*syn*) or antiparallel (*anti*) to each other. The first diastereoisomer corresponds to a meso form (M,P ≡ P,M, with C_s symmetry), the second to a chiral form (C_2 symmetry), which thus comprises a pair of P,P and M,M enantiomers.

The ^{1}H NMR spectrum of **1** in C_2Cl_4 shows that both diastereoisomers are present at the equilibrium in a 1.6:1 ratio, the corresponding free energy difference is thus $\Delta G° = -RT \ln K = 0.28$ kcal mol^{-1}.

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§ Università di Genova.
† Università "La Sapienza".
‡ University of Bologna.
|| Università "G. D'Annunzio".

(1) For part 85 see: Leardini, R.; Lunazzi, L.; Mazzanti, A.; Nanni, D. *J. Org. Chem.* **2001**, *66*, 7879.
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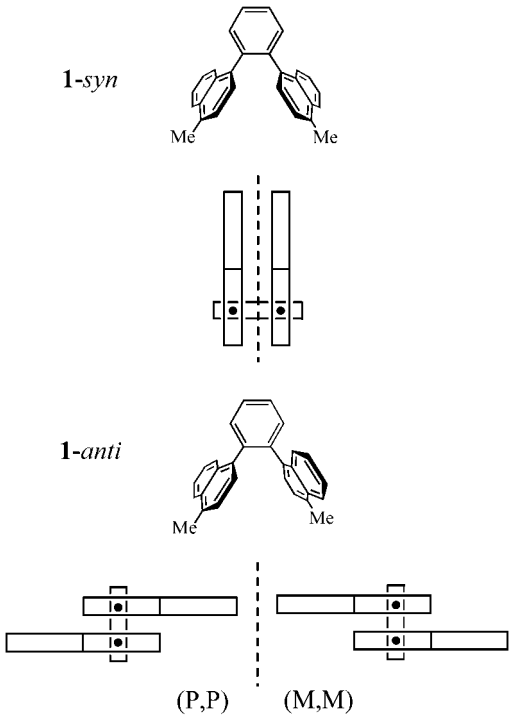
Scheme 1. Top View of the Two Conformational Diastereoisomers of Hydrocarbon 1, Having the Naphthalene Rings Parallel (*syn*) or Antiparallel (*anti*)



When the spectrum of **1** is taken in CD_2Cl_2, the ratio measured for the two diastereoisomers at ambient temperature (1.4:1) is lower than that observed in C_2Cl_4 (1.6:1) in the same conditions, indicating that the proportion of the two species depends on the solvent employed. Molecular Mechanics calculations [14] predict the *anti* to be more stable than the *syn* form, the energy difference being, respectively, 0.15 or 0.23 kcal mol^{-1}, depending on whether the dielectric constant is assumed equal to 8.9 (as for CD_2Cl_2) or 2.3 (as for C_2Cl_4). According to the Boltzmann equation, these values correspond to a variation of the theoretical ratio from 1.3 to 1.5 at +25 °C, a result in good agreement with the experimentally observed ratios. On this basis we are entitled to conclude that in solution the chiral (*anti*) is more stable than the meso (*syn*) isomer.

In Figure 1 (lower trace, left) the methyl signals are displayed, each of them exhibiting a doublet splitting due to the long range coupling with one of the naphthyl hydrogens (the *J* values are 0.8 and 0.9 Hz for the major and minor species, respectively). On raising the temperature the diastereoisomers begin to interconvert more rapidly into each other, eventually exhibiting an averaged signal above +100 °C. Computer line shape simulation (Figure 1, right) provides the rate constants, from which

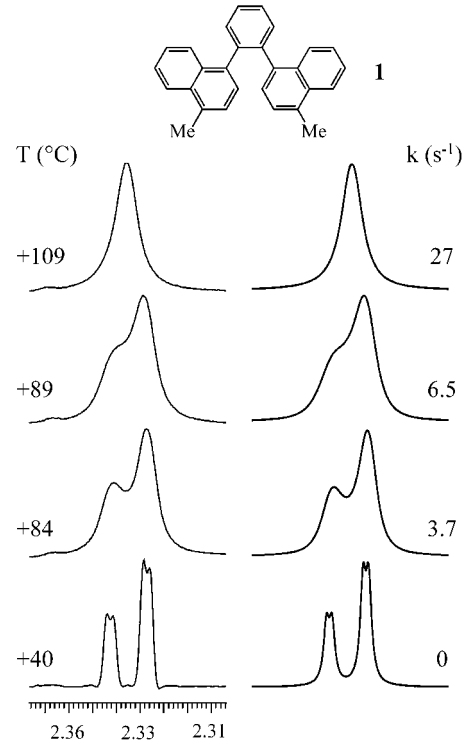


Figure 1. (left) Experimental ^1H NMR (300 MHz) methyl signals of **1** in C_2Cl_4 as function of temperature. (right) Computer simulation obtained with the rate constants reported.

the free energy of activation [12] for the process exchanging the more into the less stable stereoisomer ($\Delta G^{\ddagger} = 19.5 \pm 0.2$ kcal mol^{-1}) is obtained: a 1/2 transmission coefficient has been taken into account, since the diastereomerization may occur by two possible pathways, i.e., M′, M″ → M′, P″ and M′, M″ → P′, M″.

On the basis of the measured barrier the lifetime of these diastereoisomers is expected to be very long (even a few weeks) below −50 °C. We thus dissolved a crystal of **1** in CD_2Cl_2 at −55 °C and recorded the NMR spectrum without ever raising the temperature so that, not having attained the equilibrium conditions, the solution spectrum at that temperature reflects the situation occurring in the solid state.[13]

A unique methyl signal, due to one of the two diastereoisomers, was observed in this experiment (Figure 2, bottom), indicating that a single diastereoisomer is present in the crystal. On raising the temperature to +25 °C and waiting for the equilibrium conditions to be attained, the signals of both diastereoisomers were subsequently detected (Figure 2, top). It thus appears that the single diastereoisomer present in the solid state corresponds to the more stable of the two observed in solution. Single-crystal X-ray diffraction of **1** indicates that this diastereoisomer has the *anti* configuration and that its structure is essentially equal to that theoretically computed[14] (see Supporting Information, page S1). As a consequence we expect that cryogenic high performance liquid chromatography (HPLC) on enantioselective stationary phases will show, at an appropriate low temperature, that the more stable diastereoisomer displays two peaks, owing to the presence of two enantiomers, i.e., the atropisomers (P,P) and (M,M) of Scheme 1, whereas an unique peak would be displayed by the less stable (meso) diasteroisomer.

(12) Within the experimental errors the $\Delta G^{\ddagger}$ values determined by NMR were found to be essentially independent of temperature, indicating a negligible value for $\Delta S^{\ddagger}$. This feature has been often observed in conformational processes; see for instance: Lunazzi, L.; Macciantelli, D.; Grossi, L. *Tetrahedron* **1983**, *39*, 305. Anderson, J. E.; Tocher, D. A.; Casarini, D., Lunazzi, L. *J. Org. Chem*. **1991**, *56*, 1731. Borghi, R.; Lunazzi, L.; Placucci, G.; Cerioni, G.; Foresti, E.; Plumitallo, A. *J. Org. Chem*. **1997**, *62*, 4924.

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(14) MMX force field as in PC-Model V 7.5, Serena Software, Bloomington, IN.

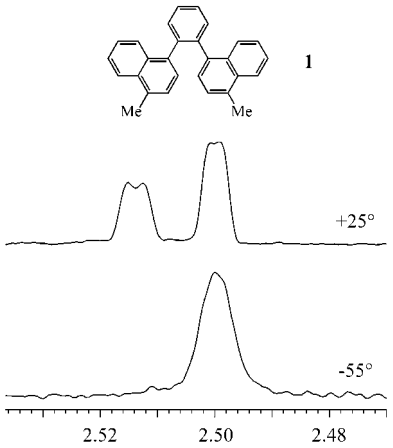

Figure 2. (top) ^{1}H NMR (300 MHz) methyl signals of **1** in CD_2Cl_2 in conditions of equilibrium at ambient temperature, displaying a 1.4:1 relative proportion. (bottom) Spectrum obtained dissolving the compounds at −55 °C, without ever raising the temperature, showing the presence of only the major signal which corresponds to the situation in the solid state.

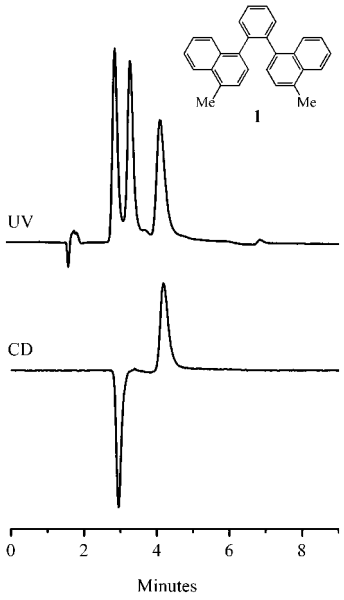

Figure 3. Chromatography of **1** on enantiopure cellulose tris-(3,5-dimethylphenyl carbamate). Column temperature, −20 °C; eluent, pentane/2-propanol/methanol (98.5:1.2:0.3); flow rate, 2 mL/min; detection by UV (top) and CD (bottom) at 230 nm.

In Figure 3 (top) it is shown how chromatography of **1** on an enantioselective HPLC column[15] cooled to about −20 °C displays three peaks in the UV detection mode: one peak belongs to the meso and the other two to the (M,M) and (P,P) enantiomers. This is confirmed by the CD detection mode (Figure 3, bottom), which shows the traces of only two oppositely phased peaks, corresponding to the pair of the enantiomers. The central peak, observed in the UV detection mode, has disappeared since the symmetric meso form is CD invisible. The ratio of the *anti* to *syn* form, determined by low-temperature HPLC (1.6:1), agrees with that measured by NMR spectroscopy.

(15) Chiralcel-OD (25 cm × 0.46 cm) packed with cellulose tris(3,5-dimethylphenyl carbamate). Okamoto Y.; Honda, S.; Okanoto, I.; Yuki, H.; Murata, S.; Noyori, R.; Takaya, H. *J. Am. Chem. Soc.* **1981**, *103*, 6971.

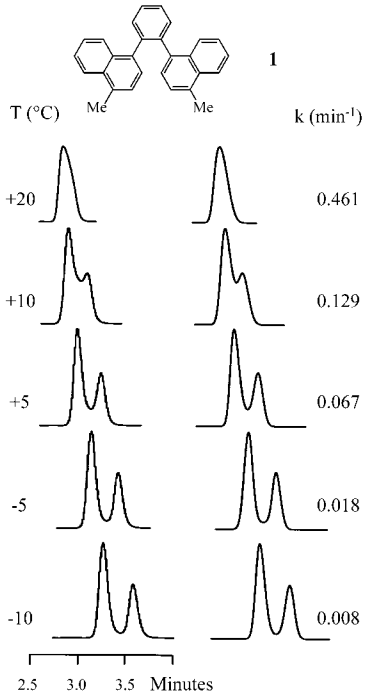

Figure 4. Temperature-dependent chromatographic profiles of **1** on the racemic version of the DACH chiral stationary phase. (left) Experimental chromatogram (eluent pentane/CH_2Cl_2/2-propanol 80/19.5/0.5, flow rate 1 mL/min, UV detection at 230 nm) as function of temperature. (right) Computer simulation obtained with the apparent rate constants reported for the chiral to meso conversion, using a 1.6:1 ratio.

Analysis of the chromatographic peaks as function of temperature yields kinetic information for the on-column interconversion process,[16] in a way analogous to the dynamic NMR technique. Since the mathematical model used for the simulation (see Experimental Section) can handle only two interconverting species, we performed a series of variable temperature HPLC runs on the racemic version of the DACH-DNB chiral stationary phase.[16a] The racemic version of the DACH-DNB phase combines the high affinity for aromatic compounds of the parent chiral phase with high diastereoselectivity and operates in a low viscosity organic eluent. Affinity and diastereoselectivity of the phase stem from the two π-acidic dinitrobenzoyl rings located on the cyclic diaminocyclohexane skeleton. Only two species are visible on the racemic phase because it loses enantio- but retains diastereoselectivity.[17]

Computer simulation (Figure 4) of the chromatographic profiles obtained for **1** provided the rate constants for the interconversion of the *anti* into the *syn* diastereoisomer.

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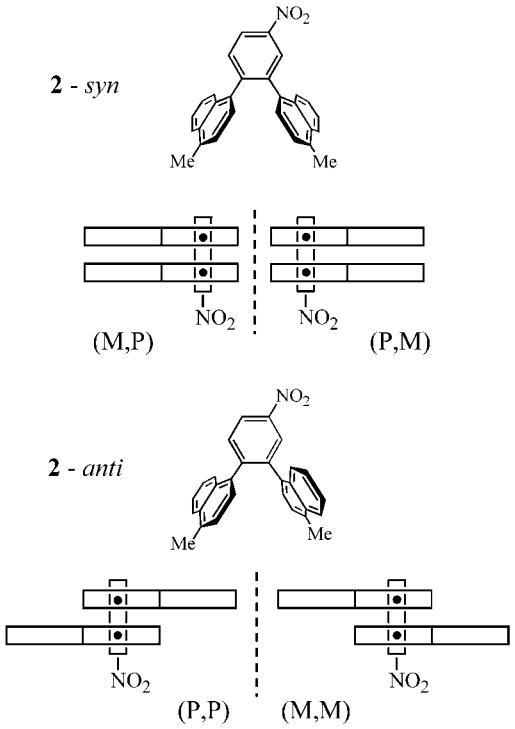
(17) The racemic version of the DACH chiral stationary phase was used because conventional, non-enantioselective phases for normal phase HPLC like bare silica, amino silica, or cianopropyl-silica have low affinity and selectivity toward unfunctionalized aromatics. Reversed phase packings (C_{18} and C_8, etc.) and water-based eluents, on the other hand, are not suited for low temperature applications. The racemic version of the chiral column frequently shows much higher diastereoselectivity in comparison to the truly achiral commercially available phases and represents a new powerful tool in this field.

Scheme 2. Top View of the Two *syn* and *anti* Conformational Diastereoisomers (Both Chiral) of the Nitro Derivative 2, Having the Naphthalene Rings Either Parallel or Antiparallel



The free energy of activation obtained in this way ($\Delta G^{\ddagger}$ = 19.5 ± 0.2 kcal mol^{-1}) agrees very well with that measured by dynamic NMR.

Introduction of a substituent in the phenyl ring, as for instance the nitro group of 1,2-bis(4-methyl-1-naphthyl)-4-nitrobenzene **2**, removes the molecular symmetry, yielding a pair of asymmetric C_1 diastereoisomers (Scheme 2). Again the NMR spectra in C_2Cl_4 (and likewise in toluene-d_8) show the two species to be present in a 1.6:1 ratio. Line shape simulation as function of temperature provides a $\Delta G^{\ddagger}$ of 19.4 ± 0.15 kcal mol^{-1} for interconverting the more into the less stable isomer.[12] Apparently the presence of the nitro group in **2** does not modify the barrier with respect to hydrocarbon **1**.

Experimental evidence that each diastereoisomer of **2** comprises a pair of enantiomers is obtained by recording the spectrum in an environment made chiral by addition of an enantiopure Chiral Solvating Agent (CSA).[18] Thus in Figure 5 (trace a) is reported the signal of the H-3 hydrogen of the phenyl ring (i.e., the doublet due to the *meta* coupling with H-5) taken in condition of equilibrium at −25 °C in toluene-d_8, obtained by cooling a solution previously prepared at ambient temperature.[19a] In Figure 5 (trace b) is displayed the spectrum (taken at the same temperature of −25 °C) after addition of an appropriate amount of CSA, which renders the solution a chiral environment: in these conditions all of the spectral lines are split into pairs,[19b] making distinguishable the four different signals expected for the two pairs of the enantiomers reported in Scheme 2.

(18) Use was made of (*R*)-*l*-1-(9-anthryl)-2,2,2,-trifluoroethanol as in Pirkle, W. H. *J. Am. Chem. Soc.* **1966**, *88*, 1837.

(19) (a) Within the experimental errors the ratio was not appreciably affected by variations of the temperature. (b) Cooling the sample resulted into a better separation of the NMR signals of the enantiomeric forms in the chiral environment.

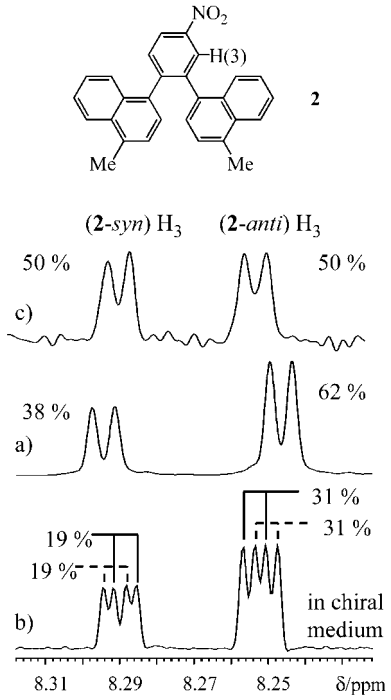


Figure 5. (a) ^{1}H NMR (400 MHz) of the H-3 signals of **2** in toluene-d_8 taken at −25 °C in conditions of equilibrium, displaying a signal ratio equal to 62:38. (b) The same spectrum taken in a chiral environment[18] showing a 1:1 splitting of all the lines. (c) Spectrum obtained at −50 °C by dissolving compound **2** at −50 °C without ever rising the temperature. In nonequilibrium conditions the ratio is 50:50, corresponding to the situation in the solid state.

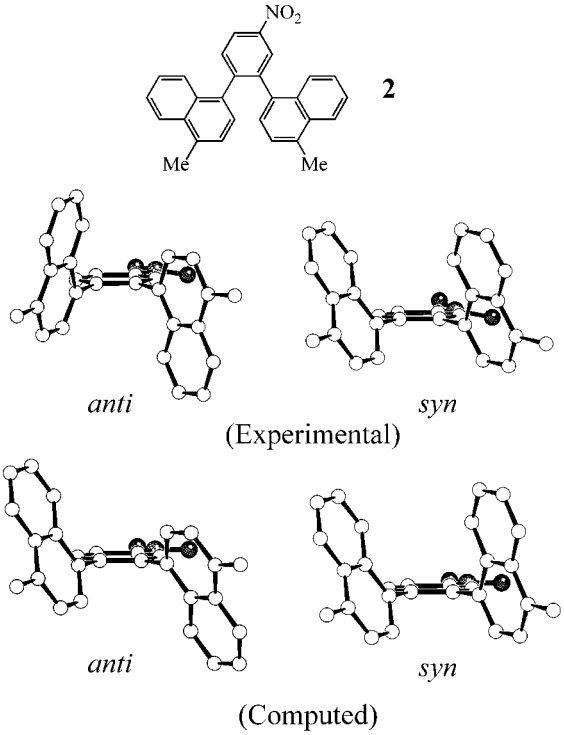
The same type of experiment previously described for **1** was repeated by dissolving **2** in toluene-d_8 at −50 °C and recording the spectrum without allowing the temperature to increase. The result (trace c of Figure 5) is however different in this case since two equally intense signals were observed, proving that two diastereoisomers are present in a 1:1 ratio in the crystals of **2**.

This was confirmed by a single-crystal X-ray diffraction determination showing the presence, in a 1:1 proportion, of both the *syn* and *anti* structures, each of them exhibiting the two enantiomeric forms. These structures are displayed in Scheme 3 (one single enantiomer has been arbitrarily selected for each diastereoisomer) together with those computed by Molecular Mechanics calculations.[14]

Whereas the X-ray structure of diastereoisomer *syn* is almost identical to the computed one (for instance the two naphthyl−phenyl dihedral angles are calculated to be −67° and 101°, to be compared with the experimental values of −68° and 105°), the diastereoisomer *anti* has, in the crystal, a structure somewhat different from that calculated for the isolated molecule. In particular the computed naphthyl−phenyl dihedral angles (−65° and −68°) have absolute values lower than those experimentally determined (respectively, −99° and −92°): the latter shape, being more compact, presumably fits better into the crystal cell. However, the energy difference between these two versions (i.e., the *anti* experimental and the *anti* computed) has been calculated to be as low as 0.36 kcal mol^{-1}.

The presence in the solid state of both diastereoisomers in equal proportions makes the X-ray diffraction of no use for identifying the structure of the more stable species

Scheme 3. X-ray Determined (top) and MMX Computed (bottom) Structures of the *anti* and *syn* Conformational Diastereoisomers of 2



observed in solution. Likewise this assignment cannot be accomplished, as in **1**, by means of cryogenic enantioselective chromatography: the NMR spectrum of Figure 5 (trace b) indicates in fact that both diastereoisomers can be separated into a pair of enantiomers.

Also in the present case, however, we observed that in a more polar solvent like CD_2Cl_2 the ratio of the two diastereoisomers is lower than in the less polar toluene or tetrachloroetylene (1.2:1, rather than 1.6:1). Computations[14] predict the *anti* to be more stable than the *syn* diastereoisomer by 0.14 kcal mol^{-1} when the dielectric constant is assumed equal to 8.9 (as in CD_2Cl_2) and by 0.20 kcal mol^{-1} when assumed equal to 2.3 (as in C_2Cl_4 or in toluene-d_8). At +25 °C these values entail, respectively, theoretical ratios equal to 1.25:1 and to 1.4:1, in satisfactory agreement with the experimental trend. One might reasonably hypothesize that the *anti* diastereoisomer of **2** is the more stable species in solution at the equilibrium.

Chromatography of **2** on a non-enantioselective HPLC column[17] shows a single peak at ambient temperature, which broadens and eventually splits into a pair of peaks (intensity ratio 1.4:1) when cooled below 0 °C. The simulation of exchange-broadened chromatographic profiles yields rate constants corresponding to a $\Delta G^{\ddagger}$ value of 19.0 kcal mol^{-1}, confirming the NMR observation that the barrier of **2** is essentially equal to that of **1**.

When an enantioselective HPLC column is employed,[15] the chromatogram of **2** at appropriate low temperatures displays three peaks for the four expected enantiomers because two of these peaks are not sufficiently separated. A completely resolved chromatogram was, however, obtained by eluting, on the same enantioselective column, the analogous nitro derivative lacking the two methyl substituents, i.e., 1,2-bis(1-naphthyl)-4-nitrobenzene **3**. As shown in Figure 6 (top) two pairs of peaks (ratio 1.3:1) were observed at −20 °C in the UV detection mode: within each pair the two equally intense peaks correspond to the enantiomeric forms, as proved by the CD detected trace (Figure 6, bottom) where two peaks display a phase opposite to that of the other two.[20] As reasonably expected, the barrier measured by dynamic HPLC in the case of **3** was found (19.0 kcal mol^{-1}) equal to that of **2**.

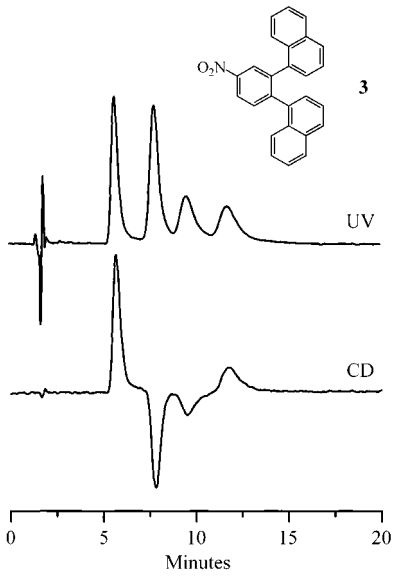


Figure 6. Chromatography of **3** on enantiopure cellulose tris-(3,5-dimethylphenyl carbamate). Column temperature, −20 °C; eluent, pentane/2-propanol/methanol 75/21/4; flow rate, 2 mL/min; detection by UV (top) and CD (bottom) at 220 nm.

Conclusion

The existence of stereolabile isomers due to the restricted rotation about the naphthyl−phenyl bond has been observed by low-temperature NMR in a number of appropriate derivatives and their physical separation achieved by means of cryogenic chromatography on enantioselective HPLC columns. The racemic, non-enantioselective version of a chiral stationary phase was used for the first time in order to maintain diastereoselection and extract energy barriers from simplified chromatograms. The interconversion barriers independently determined by the two methods have essentially the same values: accordingly, dynamic NMR and dynamic HPLC can be used as complementary techniques. The results of X-ray diffraction determinations outline the difference of the conformational behavior in the crystal with respect to the solution.

Experimental Section

Materials. 1,2-Bis(4-methyl-1-naphthyl)benzene (**1**) was prepared following the procedure proposed by Suzuki.[21] To a stirred solution of 1,2-dibromobenzene (2 mmol in 10 mL of benzene), K_2CO_3 (1 M solution, 2 mL) and 4-methyl-1-naphthylboronic acid[22] (3 mmol, suspension in 4 mL of ethanol),

(20) It is worth outlining the sign sequence of the peaks observed by CD detection in Figure 6. Assuming the *anti* and *syn* isomers have similar CD spectra, the column elution order for the *anti* isomer (major, first two peaks) is opposite (positive followed by negative) to that of the *syn* isomer (negative followed by positive).

(21) Miyaura, N.; Yanagi, T.; Suzuki, A. *Synth. Commun.* **1981**, *11*, 513.

(22) Prepared according to Thompson, W. J.; Gaudino, J. *J. Org. Chem.* **1984**, *49*, 5237.

$Pd(PPh_3)_4$ (0.4 mmol) were added at room temperature. The stirred solution was refluxed for about 4 h, the reaction being monitored by TLC (eluent petroleum ether/Et_2O 2:1). To the cooled solution a second amount of 4-methyl-1-naphthylboronic acid (5 mmol in 7 mL of ethanol), K_2CO_3 (1 M solution, 2 mL) and $Pd(PPh_3)_4$ (0.4 mmol) was subsequently added. After refluxing for 4 h, $CHCl_3$ and H_2O were added and the extracted organic layer dried (Na_2SO_4) and evaporated. The crude was purified by chromatography on silica gel (eluent petroleum ether/Et_2O 2:1) to yield 0.66 mmol (33%). Crystals suitable for X-ray diffraction were obtained by slow recrystallization from Et_2O/petroleum ether (1:1 v/v). Mp 219−220 °C; ^{1}H NMR (C_6D_6/C_2Cl_4, 400 MHz) δ 2.343 (d, minor, 2 Me), 2.327 (d, major, 2 Me), (since the signals of the two unequally intense species cannot be identified in the aromatic region the corresponding integrals are not reported), 6.60 (dd), 6.70 (d), 6.87 (dd), 6.90−6.96 (m), 7.20−7.45 (m), 7.22−7.42 (m), 7.55 (d), 7.64−7.78 (m). Anal. Calcd for $C_{28}H_{22}$: C, 93.81; H, 6.19. Found: C, 93.85; H, 6.13.

1,2-Bis(4-methyl-1-naphthyl)-4-nitrobenzene (**2**) was prepared from 1,2-dibromo-4-nitrobenzene following the same procedure described above for **1**. Crystals suitable for X-ray diffraction were obtained by slow recrystallization from Et_2O/ethanol (1:1 v/v). Mp 201−202 °C; ^{1}H NMR (C_6D_6/C_2Cl_4, 400 MHz) δ 2.53(s), 6.58−6.68 (m, 2H), 6.84−7.14 (m, 4H), 7.28−7.36 (m, 2H), 7.42−7.66 (m, 4H), 7.72−7.78 (m, 1H), 8.13−8.18 (m, 1H), 8.26−8.32 (m,1H). Anal. Calcd for $C_{28}H_{21}NO_2$: C, 83.35; H, 5.25; N, 3.47. Found: C, 83.30; H, 5.31; N 3.42.

1,2-Bis(1-naphthyl)-4-nitrobenzene (**3**) was prepared both from 3,4-dinitrothiophene, with a proper adaptation of a reported procedure,[11,23] and according to the Suzuki coupling reaction[21] from 1,2-dibromo-4-nitrobenzene and 1-naphthylboronic acid,[22] as described for **1** and **2**. In this case a single addition of 1-naphthylboronic acid (2.5:1 molar ratio) was sufficient to complete the reaction in only 2 h. Mp 166.5−167.0 °C; HRMS calcd for $C_{26}H_{17}NO_2$ 375.125929, found 375.126306; ^{13}C NMR ($CDCl_3$, 75.5 MHz), 17 quaternary carbon lines out of the 18 expected for the two stereolabile isomers (the ratio at the equilibriunm was about 1.5:1) were resolved, δ 147.40, 147.16, 147.09, 146.94, 142.02, 141.87, 136.68, 136.54, 136.44, 136.42, 133.33, 133.29, 133.19, 131.91, 131.73, 130.96, 130.83; 25 CH carbon lines out of the 34 expected for the two stereolabile isomers were resolved, δ 132.74, 128.34, 128.19, 128.14, 128.08, 128.05, 126.82, 126.62, 126.59, 126.43, 126.34, 125.85, 125.80, 125.61, 125.59, 125.47, 125.40, 125.33, 125.25, 124.70, 124.67, 124.44, 124.37, 122.07, 121.88. Anal. Calcd for $C_{26}H_{17}NO_2$: C, 83.18; H, 4.56; N, 3.73. Found: C, 83.25; H, 4.60; N 3.80.

X-ray Diffraction. Crystal data for 1,2-bis(4-methyl-1-naphthyl)benzene (1): $C_{28}H_{22}$ (358.46), orthorhombic, space group P_{bcn}, $Z = 4$, $a = 13.8718(5)$, $b = 16.7831(6)$, $c = 8.5391(3)$ Å, $V = 1988.00(12)$ Å ^{3}, $D_c = 1.198$ g cm^{-3}, $F(000) = 760$, $\mu_{Mo} = 0.068$ cm^{-1}, $T = 293$ K. Data were collected using a graphite monochromated Mo Kα X-radiation ($\lambda = 0.71073$ Å) in the range $1.90° < \theta < 30.03°$. Of 24865 reflections measured, 2905 were found to be independent ($R_{int} = 0.0321$), 1964 of which were considered as observed [$I > 2\sigma(I)$] and were used in the refinement of 128 parameters leading to a final R_1 of 0.0460 and a R_{all} of 0.0684. The structure was solved by direct method and refined by full-matrix least squares on F^2, using SHELXTL 97 program packages. In refinements were used weights according to the scheme $w = [\sigma^2(F_o^2) + (0.0711P)^2 + 0.0000P]^{-1}$ where $P = (F_o^2 + 2F_c^2)/3$. The hydrogen atoms were located by geometrical calculations and refined using a "riding" method. wR_2 was equal to 0.1463. The goodness of fit parameters S was 1.261. Largest difference density between peak and hole was 0.178 and −0.154 eÅ^{-3}. Crystallographic data (excluding structure factors and including selected torsion angles) have been deposited with the Cambridge Crystallographic Data Center (CCDC 177456).

Crystal data for 1,2-bis(4-methyl-1-naphthyl)-4-nitrobenzene (2): $C_{28}H_{21}NO_2$ (403.46), monoclinic, space group C_2/c, $Z = 8$, $a = 28.989(4)$, $b = 7.7407(10)$, $c = 18.999(2)$, $\beta = 105.795(3)$ Å, $V = 4102.4(9)$ Å^3, $D_c = 1.306$ g cm^{-3}, $F(000) = 1696$, $\mu_{Mo} = 0.082$ cm^{-1}, $T = 213$ K. Data were collected using a graphite monochromated Mo Kα X-radiation ($\lambda = 0.71073$ Å) in the range $1.46° < \theta < 30.16°$. Of 21078 reflections measured, 6025 were found to be independent ($R_{int} = 0.0888$), 1635 of which were considered as observed [$I > 2\sigma(I)$] and were used in the refinement of 222 parameters leading to a final R_1 of 0.0986 and a R_{all} of 0.2579. The structure was solved by direct method and refined by full-matrix least squares on F^2, using SHELXTL 97 program packages. In refinements were used weights according to the scheme $w = [\sigma^2(F_o^2) + (0.1000P)^2 + 0.0000P]^{-1}$ where $P = (F_o^2 + 2F_c^2)/3$. The hydrogen atoms were located by geometrical calculations and refined using a "riding" method. wR_2 was equal to 0.2879. The goodness of fit parameters S was 1.038. Largest difference density between peak and hole was 0.517 and −0.420 eÅ^{-3}. Part of the structure was disordered [namely, the phenyl ring and one 2-(4-methyl-1-naphthyl) group] and was split into two parts that, after refining, led to the identification of the *syn* and *anti* structures in a 50:50 ratio. Final refining was then performed by assigning an occupancy factor of 0.5, and isotropically refinement to each of the two split parts of the molecule (a $R_1 = 0.0776$ was obtained using anisotropic refinement for all the atoms of the split parts) Crystallographic data (excluding structure factors and including selected torsion angles) have been deposited with the Cambridge Crystallographic Data Center (CCDC 177455).

Chromatography. Chiralcel-OD column (25 cm × 0.46 cm) was obtained from Chiral Technologies, Exton, PA, USA. The racemic version of the DACH column (15 cm × 4.5 cm) was obtained from Regis Chemical Company, Morton Groove, IL. Simulation of variable temperature experimental chromatograms were performed by use of an appropriate computer program.[24]

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Supporting Information Available: Pictures of experimental (X-ray diffraction) and computed[14] structure of **1**, experimental and computer-simulated temperature-dependent dynamic NMR spectra of **2**, and details on the preparation of **3** and of its precursors from 3,4-dinitrothiophene. This material is available free of charge via the Internet at http://pubs.acs.org.

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(23) Compound **3** obtained from 3,4-dinitrothiophene showed physical and spectroscopic properties in agreement with those herein reported. Details on the synthesis of **3** and of its precursors according to this method are available in the Supporting Information.

(24) Use was made of the program Auto-DHPLC-y2k (Auto-Dynamic HPLC), which is an improved version for PC of the program SIMUL (Jung, M. QCPE N. 620, Indiana University, Bloomington, IN) implemented with a Simplex algorithm for automatic fitting of experimental data.