

Chiroptical Properties of Some (*S*)-*N,N'*-Bis[(1-phenyl-5-alkyl-4,5-dihydro-6-oxo-1,2,4-triazin-3-yl) ethylidene] propane-1,3-diamine nickel(II)

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Summary: Model chiral 3-acetyl-4,5-dihydro-1,2,4-triazinones **1a-c** were reacted, utilizing the template effect, with 1,3-diaminopropane in the presence of nickel acetate. The resulting chiral open chain tetraaza-type nickel complexes **2a-c** were characterized by elemental analysis and NMR spectral data. Their CD spectra in organic solvents revealed the same features for the masked *aliphatic* and *aromatic* amino acid residues of the same *L*-configuration. The stereochemistry at C-5 is correlated with the signs of the observed CE bands.

Introduction

The direct interaction between the bidentate triazinone oxime ligand of **1c** with nickel acetate gave square planar nickel (II) complex. In this template reaction, an interesting carbon-carbon coupling between the benzylic carbon of one triazinone and the chiral carbon of the other has taken place [1]. This has spurred us to attempt to incorporate the triazinone moiety into a macrocyclic ring system. For this purpose, we have reported on the template reaction of 1,3-diaminopropane with the *L*-5-isopropyl-1,2,4-triazinone (**1b**) in the presence of nickel acetate [2]. However, this reaction yielded the nickel complex **2b** (Scheme 1) wherein no carbon-carbon coupling takes place. Preliminary investigation of the chiroptical properties of **2b**, the structure of which has been confirmed by X-ray analysis [2], by the CD technique shows rather interesting Cotton effects. Their signs can be correlated to the configuration at C-5. Electronic circular dichroism (ECD) spectroscopy has been widely used for the determination of the configuration of stereocenters in chiral molecules [3]. The biological function of coordinated compounds is strongly determined by the ligand donor group set, and the geometry of the coordination sphere of the complex formed. This information can be obtained by spectroscopic measurements. In the case of transition metal complexes of small chiral molecular models containing stereocenters with potential donor

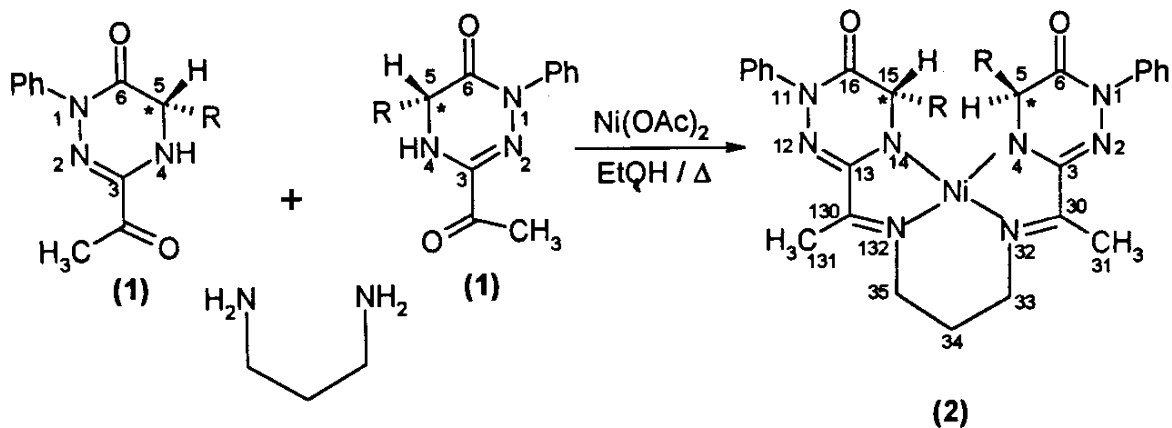
groups on, CD spectroscopy proved to be especially useful in configurational assignments. The contribution of stereocenters to the overall optical activity in the transition metals d-d electronic transition and ligand to metal or metal to ligand charge transfer transition region may also be determined [3]. Consequently, we sought to prepare a few more complexes of the series for proper investigation of their CD spectral data. In the present work, we found that the 5-methyltriazinone (**1a**) and the 5-benzyl analogue (**1c**) show similar behaviour to **1b** in their reaction with 1,3-diaminopropane, and yield structurally analogous nickel complexes **2a** and **2c**, respectively, (Scheme 1).

Results and Discussion

Synthesis

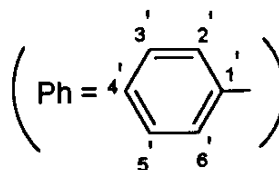
Direct interaction between 1-phenyl-hydrazono-1-chloroacetone and the particular *L*- α -amino ester in the presence of triethylamine gave the respective 3-acetyldihydrotriazinones **1a-c** [4]. The latter compounds were utilized in the template reaction with 1,3-diaminopropane in the presence of nickel acetate and yielded the corresponding nickel(II) complexes **2a-c** (Scheme 1). The structure of these complexes exemplified by **2b** was confirmed by X-ray diffraction [2]. Their NMR spectral data are in full agreement with assigned structures and are

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Comps 1 and 2

	a	b	c
R	CH ₃	CH(CH ₃) ₂	CH ₂ Ph



Scheme-1

presented in the experimental part. These data reveal one set of signals for each type of hydrogen and carbon atoms in both triazinone wings of the complexes 2.

UV and CD Spectral Data (Table 1)

Electronic absorption spectra in the visible region for compounds 2a-c exhibit a medium band in the range 480-500 nm and a shoulder around 440 nm. A weak absorption appears as an inflection in the range 560-590 nm on the rising tail of the stronger maxima around 480 nm. The former well-resolved spectral band correlates with the band observed in square planar nickel(II) complexes [5]. The spectra also display in the UV region three other well-resolved bands around 350, 300 and 250 nm that are probably of $\pi-\pi^*$ origin.

The CD technique serves as a chirality measurement, which yields a value and sign characterizing the types of optical transitions, and gives information about the absolute configuration of molecules with conformational and constitutional chirality. The CD spectra of compounds 2a-c reveal that the electronic transitions become dissymmetrically perturbed by the chiral surroundings and give rise to CE bands. The main

features of the spectra of the masked *aliphatic* amino acid residue 2a, b are similar to that of the *aromatic* analogue 2c of the same *L*-configuration. Both series display in the solvent THF two strong CE bands of opposite signs in the visible region around 570 and 480 nm (negative and positive, respectively) that can be attributed to charge-transfer transitions or to the low energy d-d transitions of the nickel complex [5]. In addition, three well resolved bands around 400, 280 and 220 nm are also observed and are accompanied by two negative bands at ca 320 and 250 nm. These CE bands coincide with the Vis-UV absorption maxima. A negative CE maximum around 380 nm coincides with a UV minimum suggesting that the associated transition is probably magnetic-dipole allowed, but electric-dipole forbidden in the zero order.

Comparable CD trends are likewise observed in the solvents CH₃CN and TFE. Thus, the organic solvent used does not influence the shape of the CD curves, the $\Delta\epsilon$ values of the CE's being slightly altered, but their signs being retained. Cooperativity between the two heterocyclic wings of the complexes and the added interaction between the aromatic chromophores attached therein give rise to an exciton-coupled CE in the ¹L_b region (around 250 and 220 nm).

Table 1 : CD and UV spectral data of compounds 2a-c.

No.	Solvent*	CD ($\Delta\epsilon$)	UV	
			λ_{max} ($\epsilon \times 10^3$)	
2a	THF	576 (-9.4), 495 (+7.5), 423 (-12.3), 378 sh (-7.4), 326 (+6.1), 297 sh (-4.0), 280 (-7.7), 250 (+22.2), 224 (-12.1), 207 (+2.5).	492 (10.1), 441 sh (7.4), 353 sh (8.0), 295 (18.0), 254 (18.6).	
	TFE	561 (-8.4), 473 (+8.8), 390 (-8.6), 367 sh (-7.6), 311 (+10.2), 277 (-14.7), 245 (+8.4), 218 (-14.8).	470 (8.5), 440 i (6.9), 348 (6.0), 277 sh (12.5), 240 (18.2).	
	CH ₃ CN	570 (-11.1), 487 (+8.6), 414 (11.1), 375 sh (-7.6), 319 (+4.8), 277 (-10.2), 248 (+14.1), 223 (-10.6).	477 (9.3), 353 sh (7.7), 297 sh (16.0), 247 sh (21.1), 190 (28.9).	
2b	THF	560 (-7.3), 476 (+7.8), 388 (-10.3), 377 sh (-9.1), 316 (+10.1), 280 (-17.6), 244 (+13.8), 219 (-18.4).	498 (9.7), 448 sh (7.3), 349 sh (7.0), 298 (18.7), 245 (21.1).	
	CH ₃ CN	580 (-6.7), 491 (+6.9), 397 (-9.7), 377 sh (-8.2), 323 (-5.0), 300 sh (-4.5), 277 (-11.3), 248 (+24.4), 225 (-15.8).	485 (10.6), 437 sh (8.0), 350 (8.0), 300 (18.6), 253 (22.6).	
2c	THF	585 (-6.6), 500 (+9.2), 427 (-9.4), 318 sh (-5.3), 329 (+6.4), 303 sh (1.0), 282 (-6.4), 253 (+28.2), 224 (17.8).	498 (9.5), 445 sh (6.2), 359 sh (7.3), 312 sh (15.7), 251 (25).	
	CH ₃ CN	570 (-9.3), 491 (+9.8), 420 (-7.5), 371 sh (-4.3), 320 (+7.5), 300 sh (+2.9), 280 (-6.7), 251 (+23.4), 225 (-21.0).	485 (5.1), 437 sh (3.6), 353 sh (4.3), 306 sh (7.6), 248 (16.4), 224 (16.4).	

Abbreviations used: THF = tetrahydrofuran, TFE = 2,2,2-trifluoroethanol

In conclusion, for these square planar, rigid nickel complexes the signs of the observed CE bands can be correlated well with their geometrical *L*-configuration at the C-5 stereocenter.

Experimental

Apparatus

Melting points (uncorrected) were determined using a Gallenkamp melting point apparatus. Magnetic moments were determined on Johnson Matthey Magnetic Susceptibility balance. Optical rotations were measured with a Perkin Elmer 141. photoelectric spectrophotometer. NMR spectra were obtained with a Bruker WM-400 spectrometer in CDCl₃ with TMS as an internal reference. Mass spectra (EI) were obtained using a Finnigan MAT TSQ-70 spectrometer at 70 eV. Ion source temperature = 200°C. MS-FAB spectra were obtained with a VG Analytical Ltd. ZAB HS mass spectrometer, equipped with xenon gun operating at 8 keV and 0.8 mA emission, using as sample containing matrix, TG/G (thioglycerol/glycerol), CHCl₃ or NBA (3-nitrobenzyl alcohol). UV spectra were run on a UV spectrophotometer model UVIKON 930 (KONTRON). Circular dichroism spectra were taken with a Circular Dichrograph model JASCO 720, equipped with a Hewlett Packard 7475A plotter, using 0.01 and 0.1 cm cells. Elemental analyses were performed at Laboratories of Quantitative Technologies Inc., (QTI), New Jersey, USA.

Preparation of *L*-3-Acetyl-5-methyl-1-phenyl-4,5-dihydro-1,2,4-triazin-6-one (1a)

This compound was prepared *via* direct interaction between 1-chloro-1-phenylhydrazino-2-propane [6,7] with *L*-alanine methyl ester hydrochloride (Aldrich) in the presence of excess triethylamine according to the general procedure described for the synthesis of analogous chiral triazinones [4]. Yield (83%), mp: 64-66°C. EI-MS: *m/z* (% rel. int.) 231.09771 (*M*⁺, 55%, requires: 231.10078), 188 (100), 170 (4), 146 (22), 118 (7), 91 (25), 77 (13). ¹H NMR (400 MHz, CDCl₃): δ 1.48 (d, 3H, *CHCH₃, *J* = 6.6 Hz), 2.45 (s, 3H, CH₃C = O), 4.22 (dq, 1H, H-5, *J* = 6.6 Hz, *J* = 1.4 Hz), 5.83 (br d, 1H, N(4)-H, *J* = 1.4 Hz, exchangeable with D₂O), 7.27 (dd, 1H, H-4', *J* = 7.5 and 1.7 Hz), 7.40 (dd, 2H, H-2'/6', *J* = and 1.7 Hz), 7.56 (2t, 2H, H-3'/5', *J* = 7.5 and 7.3 Hz). Anal. calcd. for C₁₂H₁₃N₃O₂ (231.26) : C 62.32, H 5.67, and N 18.17. Found : C 62.15, H 5.77, and N 18.43%.

Preparation of *L*-3-Acetyl-1-phenyl-5-isopropyl-4,5-dihydro-1,2,4-triazin-6-one (1b)

This compound has been previously described [2].

Preparation of *L*-3-Acetyl-1-benzyl-1-phenyl-4,5-dihydro-1,2,4-triazin-6-one (1c) :

This compound has been previously described [1].

Preparation of N,N'-Bis[(1-phenyl-5-methyl-4,5-dihydro-6-oxo-1,2,4-triazin-3-yl)-ethylidene] propane-1,3-diamine nickel (II), (2a)

Compound 1a, (2.08 g, 9 mmol), nickel acetate tetrahydrate (1.12 g, 4.5 mmol) and 80 ml of absolute ethanol were stirred at room temperature for few min. 1,3-Diaminopropane (0.36 g, 4.75 mmol) in absolute ethanol (20 ml) was then added dropwise over a period of 10 min. The reaction mixture was brought to reflux under constant stirring for 15 h. During the first hour of the reflux time the reaction mixture assumed blue color, then green during the second and third hours and finally deep-red color persisted for the rest of the reflux time. The solvent was removed in *vacuo* and an oily residue was obtained. This oil was dissolved in a small volume of dichloromethane and applied to a 4 x 35 cm column (Silica gel, 70-230 mesh, 60 Å, Aldrich), eluted with dichloromethane (300 ml) and discarded. The deep-red colored zone was further eluted with dichloromethane (700 ml). A black-red colored by-product zone was irreversibly adsorbed at the top of the column. The dichloromethane solvent was removed in *vacuo* and the deep-red solid residue was recrystallized from CH₂Cl₂/C₆H₆ solvent pair (1 : 4 v/v). Yield = 0.82 g (33%), mp. > 300 °C. MS (+ ve) FAB in NBR, m/z = 557, corresponding to [M + H]⁺, (+ ve FAB) HRMS : 557.1923. These values are consistent with Ni C₂₇H₃₀N₈O₂ (2a). ¹H NMR (400 MHz, CDCl₃) : δ 1.46 (d, 3H, *CH-CH₃, J = 6.6 Hz), 1.92 (dist. quintet, 2H, -CH₂CH₂CH₂-), 2.17 (s, 3H, CH₃-C≡N), 3.21 (dist. triplet, 4H, -CH₂-CH₂-CH₂-), 3.49 (q, 1H, H-5, J = 6.6 Hz). ¹³C NMR (100 MHz, CDCl₃) : δ 15.8 (CH₃C = N-), 20.9 (*CH-CH₃), 27.8 (CH₂CH₂CH₂), 48.2 (CH₂CH₂CH₂), 53.3 (C-5), 124.0 (C-2'/6'), 125.8 (C-4'), 128.3 (C-3'/5'), 141.3 (C-1'), 156.3 (C-3), 162.3 (C-6), 177.1 (CH₃-C=N-). Anal. calcd. for NiC₂₇H₃₀N₈O₂ (557.30) : C 58.19, H 5.43, and N 20.11. Found : C 60.70, H 5.62, and N 18.38%. Drying a sample for long periods of time indicated the presence of 0.5 mole of benzene per mole of compound. Anal. calcd. for NiC₂₇H₃₀N₈O₂. 0.5 C₆H₆ (596.36) : C 60.43, H 5.58, and N 18.79%.

Preparation of N,N'-Bis[(1-phenyl-5-isopropyl-4,5-dihydro-6-oxo-1,2,4-triazin-3-yl) ethylidene] propane-1,3-diamine nickel(II), (2b)

This complex has been previously described [2].

Preparation of N,N'-Bis[(1-phenyl-5-benzyl-4,5-dihydro-6-oxo-1,2,4-triazin-3-yl) ethylidene] propane-1,3-diamine nickel(II), (2c)

This complex was prepared from 1c (1.84 g, 6 mmol), nickel acetate tetrahydrate (0.75 g, 3 mmol), and 1,3-diaminopropane (0.24 g, 3.25 mmol) following a similar procedures described as above for 2a. The crude oil was chromatographed similarly on a silica column, eluting first with CH₂Cl₂ (100 ml) to remove the fast moving yellow zone impurity. The deep-red zone that follows was eluted with 500 ml of CH₂Cl₂: CH₃CN (1 : 1 v/v). The orange colored by-product zone was irreversibly adsorbed at the top of the column. The solvent was removed in *vacuo* and the deep-red solid residue was recrystallized from CH₂Cl₂/C₆H₆ solvent pair (1 : 4 v/v). Yield = 1.45 g (68%), mp > 300 °C. MS (+ ve) FAB in NBR, m/z = 709, corresponding to [M + H]⁺, (+ ve FAB) HRMS : 709.2549. These values are consistent with Ni C₃₉H₃₈N₈O₂. ¹³C NMR (100 MHz, CDCl₃) : 15.1 (CH₃-C=N-), 27.4 (CH₂CH₂CH₂), 38.7 (CH₂Ph), 47.6 (CH₂CH₂CH₂), 59.2 (C-5), 124.0 (C-2'/6'), 125.8 (C-4'), 125.9 (C-4"), 127.7 (C-2"/6"), 128.3 (C-3'/5'), 131.2 (C-3"/5"), 138.6 (C-1"), 141.3 (C-1'), 155.7 (C-3), 161.0 (C-6), 174.6 (CH₃-C=N-). Anal. calcd. for NiC₃₉H₃₈N₈O₂ (709.55) : C 66.21, H 5.13, and N 15.84. Found : C 65.94, H 5.42, and N 15.67%.

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