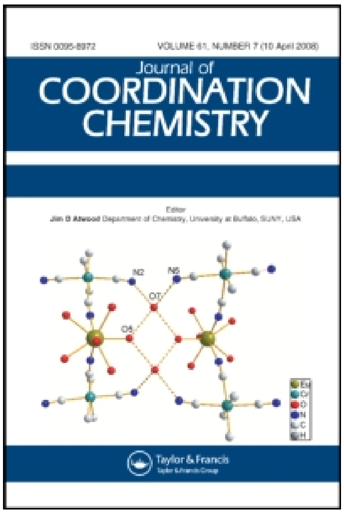

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Synthesis and Binding of a Triazamacrocyclic Ligand Bearing Pendant Pyridyl Groups

Jonathan L. Sessler[a]; Jeffrey Hugdahl[a]; Hiromasa Kurosaki[a]; Yoro Sasaki[a]
[a] Department of Chemistry, The University of Texas at Austin, Austin, Texas, U.S.A.

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SYNTHESIS AND BINDING OF A TRIAZAMACROCYCLIC LIGAND BEARING PENDANT PYRIDYL GROUPS

JONATHAN L. SESSLER*, JEFFREY HUGDAHL, HIROMASA KUROSAKI, AND YORO SASAKI
Department of Chemistry, The University of Texas at Austin, Austin, Texas 78712, U.S.A.

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Abstract The synthesis and preliminary binding studies of a triazacyclononane bearing three pendant pyridyl arms is described.

Keywords: Triazacyclononane pendant, pyridyl arms

INTRODUCTION

There has been much interest in preparing models which mimic the essential spectroscopic, structural and functional features present at the active site of hemerythrin, one of a number of proteins bearing oxo-bridged binuclear iron centers. These models rely on triazacyclononanes or trispyrazolylborate anions to provide capping ligands for the bimetallic core.[1-3] Recent syntheses of azamacrocyclic ligands bearing pendant ligating groups[4,5] led us to believe that such systems could provide a ligand environment suitable for supporting the unusual coordination environments found at the active sites of metalloproteins. Here we report the synthesis and preliminary binding studies of (**1**), a triazacyclononane bearing three pendant coordinating pyridyl groups.

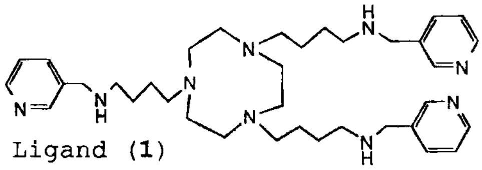
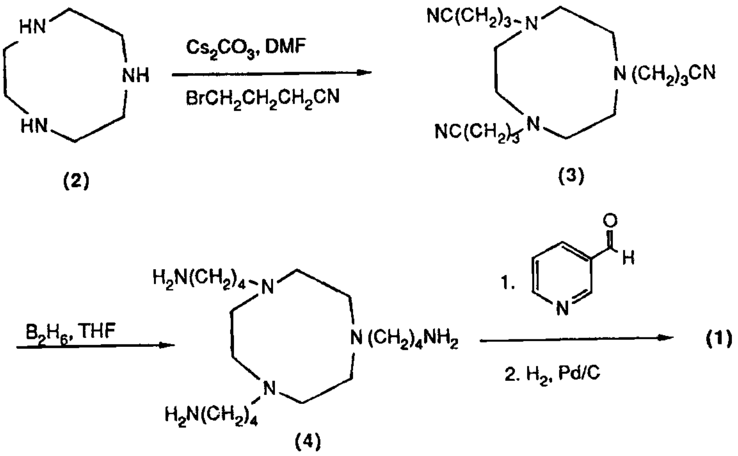


FIGURE 1 Ligand (**1**)

SYNTHESIS

The ligand was synthesized as shown in Scheme 1, with all new compounds giving satisfactory spectroscopic and analytical data. Alkylation of triazacyclononane (**2**), with an excess of 4-bromobutyrylnitrile gave the trinitrile (**3**) which was purified by flash chromatography to give an oil in 12% yield. Reduction of the nitrile with diborane in refluxing tetrahydrofuran gave the triamine (**4**) in 66% yield which was used without further purification. Addition of 3-pyridinecarboxaldehyde to a solution of (**4**) in dry methanol gave a triimine which was not purified. Subsequent reduction utilizing 5% palladium on carbon catalyst and atmospheric pressure hydrogen followed by flash column chromatography gave the tris pyridyl ligand (**1**) as an oil in 11% yield.



SCHEME 1 Synthesis of Ligand (**1**)

BINDING STUDIES

Binding of zinc acetate by ligand (1) was examined using ^{13}C n.m.r. Studies indicate that the ligand possesses two different binding sites. As shown in Figure 2, treatment of the ligand with 1.0 eq. of Zn^{2+} leads to noticeable shifts of resonances corresponding to the alkyl carbons of both the triazacyclononane and pyridyl arms. Addition of a second equivalent of Zn^{2+} leads to shifts of the resonances due to the aromatic carbons of the pyridyl ligands, but little further shift of the peaks in the alkyl region. This suggests that the triazacyclononane provides a stronger binding site than that derived from the pyridine nitrogens.

Quantitative binding constants were obtained by using a modification of a method originally introduced by Drago (equation (1)).[6]

$$K^1 = \frac{\Delta\delta_{obs}}{(\Delta\delta_T - \Delta\delta_{obs})\left([Zn]_0 - \frac{\Delta\delta_{obs}[L]_0}{\Delta\delta_T}\right)} \qquad (1)$$

where:

$\Delta\delta_{obs} = \delta_{obs} - \delta_S$

$\Delta\delta_T = \delta_F - \delta_S$

δ_{obs} = chemical shift observed at intermediate zinc concentrations

δ_S = chemical shift of uncomplexed ligand

δ_F = chemical shift of fully bound ligand

$[Zn]_0$ = concentration of total added zinc

$[L]_0$ = total concentration of ligand

and K^1 represents the process:

$$L + Zn \rightleftharpoons LZn$$

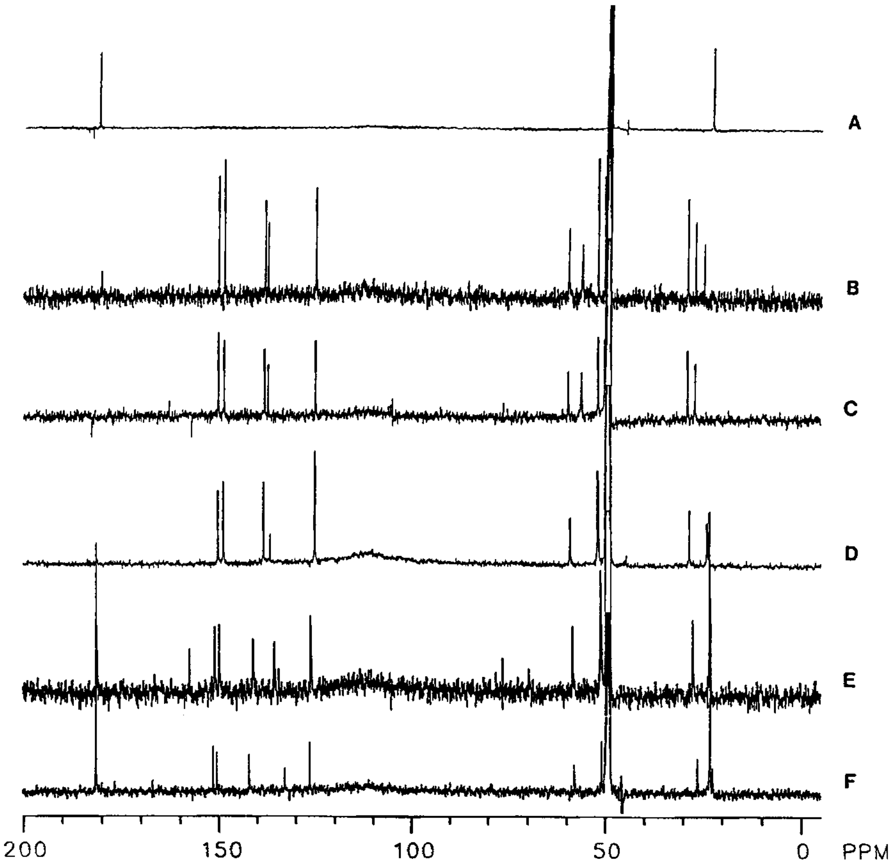


FIGURE 2 Carbon n.m.r. spectra produced during the titration of ligand **(1)** in MeOH-d_4 with $Zn(OAc)_2$. Spectra A, pure $Zn(OAc)_2$; spectra B, **(1)** and 1.0 equiv. NaOAc; spectra C, pure **(1)**; spectra D, **(1)** and 1.0 equiv. $Zn(OAc)_2$; spectra E, **(1)** and 2.0 equiv. $Zn(OAc)_2$; spectra F, **(1)** and ca. 10 equiv. $Zn(OAc)_2$.

Inversion and rearrangement of equation (1) to a form similar to that employed by Hildebrand and Benesi[7] gives equation (2).

$$\frac{[Zn]_0}{\Delta\delta_c} + [L]_0\Delta\delta_c = K^{-1} + ([L]_0 + [Zn]_0) \qquad (2)$$

where: $\Delta\delta_C = \dfrac{\Delta\delta_{obs}}{\Delta\delta_T}$

and K^{-1} refers to the process:

$$LZn \rightleftharpoons L + Zn$$

The value for K^{-1} was then obtained as the Y intercept from the observed straight line plot of eq. (2). Repeated experiments gave a consistent value for the first binding constant of $K^1 = 45\ M^{-1}$. After a correction for bound zinc was applied, a similar analysis suggested that a 1:1 complex was also being formed from the second pyridine-derived binding site. An approximate value for K^1 of $1.5\ M^{-1}$ was obtained. In this case, eq. (2) was solved in an iterative fashion. This allowed both K^{-1} and δ_F to be calculated as independent variables.

Bis-pyridyl and mono-pyridyl triazacyclononane ligands have also been synthesized and their properties will be reported elsewhere.

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REFERENCES

1. W. H. Armstrong, and S. J. Lippard, J. Am. Chem. Soc., 105, 4837 (1985).
2. K. Wieghardt, K. Pohl, and W. Gerbert, Angew. Chem. Int. Ed. Engl., 22, 727 (1983).
3. W. H. Armstrong, A. Spool, G. C. Papaefthymiou, R. B. Frankel, and S. J. Lippard, J. Am. Chem. Soc., 106, 3653 (1984).
4. T. A. Kaden, Top. Curr. Chem., 121, 157 (1984).
5. N. W. Alcock, K. P. Balakrishnan, and P. Moore, J. Chem. Soc., Chem. Commun., 1731 (1985).
6. R. S. Drago, Physical Methods in Chemistry (W. B. Saunders Company, Philadelphia, 1977), p. 253.
7. J. A. Hildebrand, and H. A. Benesi, J. Am. Chem. Soc., 71, 2703 (1949).