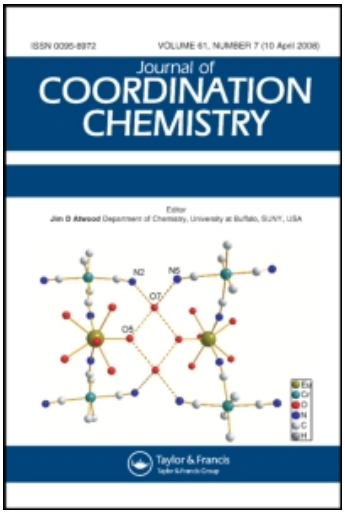

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A Mechanistic Study of Metal Template Syntheses of Dibenzo-tetraaza(14)annulene Macrocyclic Complexes

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SHORT COMMUNICATION
A Mechanistic Study of Metal Template Syntheses of Dibenzo-tetraaza(14)annulene Macrocyclic Complexes.

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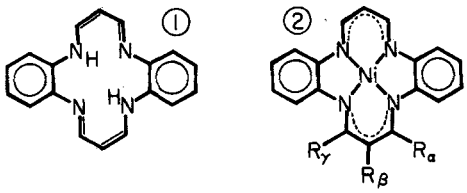
A variety of tetraaza-macrocycles are known[1], and their relationships to the naturally occurring porphyrins has stimulated the considerable effort recently expended in these areas. In this context the dibenzotetraaza[14] annulene (**1**) has been considered as a model for porphyrins[2,3], and the chemistry of its fully delocalized nickel complex (**2**) resembles that of the metalloporphyrins.[3,4]

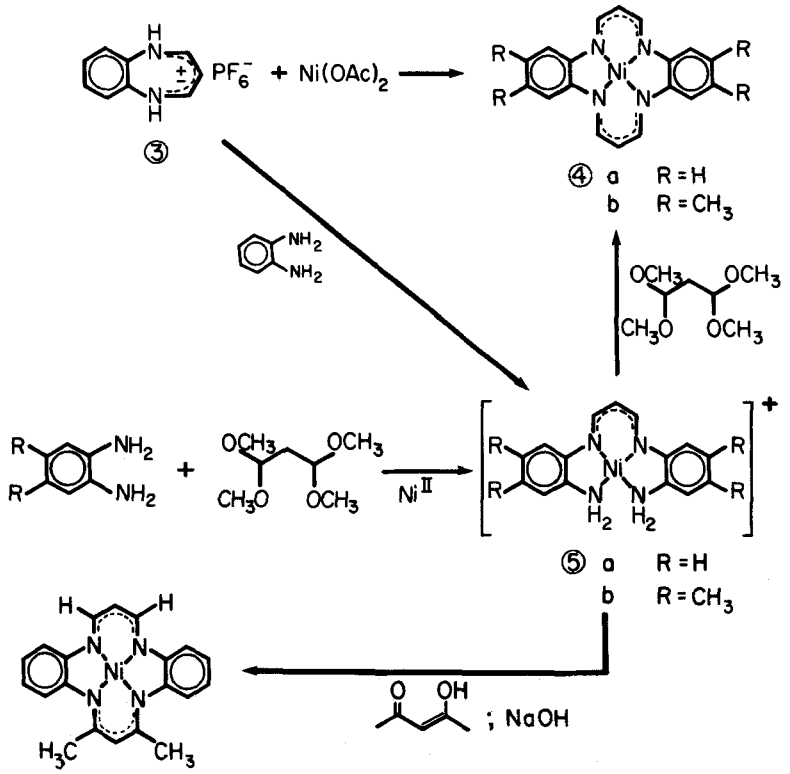


Three procedures have been reported for synthetic entry into the complex of type **2**. Systems bearing at least one alkyl or aryl substituent $R_{\alpha(\gamma)}$ are available via cyclization of the corresponding β-ketoiminato nickel complex in *molten* *o*-phenylenediamine, and acyl substituents at R_β enhance this mode of cyclization.[4,5] However, the nickel complex of the parent macrocycle (**2**, $R_{\alpha\beta\gamma}$ = H) was prepared by either metallation of **1**, available from the condensation of *o*-phenylenediamine with propargylaldehyde, or by condensation of the latter reagents with nickel acetate.[3] A final template procedure has been recently reported in which bromomalonaldehyde and bis-(*o*-phenylenediamine) nickel acetate cyclize under mild conditions to **2**, R_β = Br.[6]

We wish to report here facile template syntheses of **4** via two procedures.[7] The first employed the 1,5-benzodiazepinium salt (**3**)[8,9] which in the presence of nickel acetate gave, in either refluxing aqueous methanol or DMF, a brown precipitate from which the chelate **4a** was isolated in up to 20% yields. However an alternative *in situ* synthesis proved more efficient.[10] Thus after refluxing an aqueous solution of *o*-phenylenediamine, 1,1,3,3-tetramethoxypropane and nickel acetate (2:2:1) the analytically pure chelate **4a** precipitated, within a three hour period, in greater than 85% yield. A longer reflux time (9 hours) was required when aqueous DMF was used. Similarly the methyl substituted complex **4b** precipitated in a 90% yield from aqueous DMF after 10 hours.

Both synthetic procedures entail metal-template mediated mechanisms. The absence of nickel salts from either reaction provided intractable yellow solids devoid of the metal-free chelate **1**. Malonaldehyde, generated by the hydrolysis of 1,1,3,3-tetramethoxypropane, and *o*-phenylenediamine also afforded an uncharacterized polymeric material.[12] These results ruled out the stepwise condensation of malonaldehyde and *o*-phenylenediamine to **1**, followed by sequestration as the nickel complex **4a**.

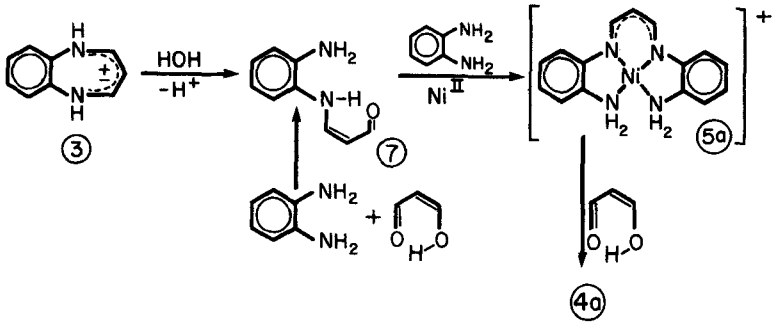
Of more significance is the isolation of the uncyclized nickel chelate **5a** from the reactions of *o*-phenylenediamine and 1,1,3,3-tetramethoxypropane with nickelous ion. When the reaction was carried out in aqueous-DMF the buildup of **5a**, (λ_{max}^{DMF} 473 nm) and its conversion to **4a** (λ_{max}^{DMF} 403, 424 nm) was monitored by absorption spectroscopy. Similarly the uncyclized chelate **5a**, as its chloride salt, was isolated as the terminal product from a refluxing aqueous solution of nickel chloride, *o*-phenylenediamine and tetramethoxypropane. The addition of excess ammonium hexafluorophosphate facilitated the isolation and purification (from acetone-ether) of the PF_6^- salt of **5a** in high yield.[13] The reaction of 4,5-dimethyl-*o*-phenylenediamine and



tetramethoxypropane with aqueous nickel acetate or chloride afforded the previously reported[11] but uncharacterized uncyclized chelate **5b** which we have shown is a precursor to **4b**.

Reaction of the non-cyclized complex **5a** (as its PF_6^- salt in refluxing aqueous-DMF) with 1,1,3,3-tetramethoxypropane gave a quantitative yield of the cyclized macrocycle **4a**. In addition, reaction of **5a** with acetylacetone in ethanolic sodium hydroxide gave, in low yield, the unsymmetric macrocycle **6**.[14] Clearly the reaction with **5a** and other β-diketones presents synthetic routes to a variety of other unsymmetric systems.

Mixtures of either the benzodiazepinium salt **3** and nickelous ion or *o*-phenylenediamine, tetramethoxypropane and nickelous ion give the macrocycle **4a** via the non-cyclized intermediate **5a**. Hydrolytic ring opening of benzodiazepinium salts to the corresponding monoanil have been reported[15] and this suggests that the monoanil **7**[16] is an intermediate in the above reactions. In support of this, **3** and *o*-phenylenediamine in the presence of nickelous ion condense to **5a**, which we have shown is the precursor to the macrocycle **4a**.



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REFERENCES

1. (a) T. J. Truex and R. H. Holm, *J. Amer. Chem. Soc.*, 94, 4529 (1972).
   (b) D. H. Busch, F. Farmery, V. Goldkin, V. Katovic, A. C. Melnyk, C. R. Sperati and N. Tokel, *Adv. Chem. Ser., No. 100* 44 (1971).
   (c) L. F. Lindoy and D. H. Busch, *Prep. Inorg. React.*, 6, 1 (1971).
   (d) L. F. Lindoy, *Chem. Soc. Rev.*, 4, 421 (1975).
2. C. L. Honeybourne, *Tetrahedron*, 29, 1549 (1973).
3. H. Hiller, P. Dimroth and H. Pfitzner, *Justus Liebigs Ann. Chem.*, 717, 137 (1968).
4. (a) E.-G. Jäger, *Z. Anorg. Allg. Chemie.*, 364, 177 (1969).
   (b) E.-G. Jäger, *Z. Chem.*, 4, 437 (1964).
5. P. Bamfield, *J. Chem. Soc. (A)*, 2021 (1969).
6. C. L. Honeybourne, *Inorg. Nucl. Chem. Lett.*, 11, 191 (1975).
7. All new compounds gave satisfactory elemental analyses. Mass spectra of the neutral nickel chelates were in agreement with the structural assignment. Qualitatively, the mass spectra only exhibited intense peaks corresponding to the singly and double charged parent ion regions. Electronic spectra of the neutral nickel chelates corresponded closely with those previously published.[3,4a]
8. D. Lloyd, R. H. McDougall and D. R. Marshall, *J. Chem. Soc.*, 3785 (1965). We found it advantageous to employ **3** as its moderately soluble PF_6^- salt, which was prepared by treating an alcoholic solution of *o*-phenylenediamine sequentially with aqueous HPF_6 and then with the 1,1,3,3-tetramethoxypropane. The resulting red solid (**3**) was purified by reprecipitation from acetone-ether. Nmr (acetone-d_6) δ 8.70 (d, J = 11 Hz, 2H, Ar–CH); 6.15–7.75 (br. m., 5H, Ar–H + C–H).
9. For a recent review on 1,5-benzodiazepinium salts, D. Lloyd and H. P. Cleghorn, *Advan. Heterocycl. Chem.*, 17, 27 (1974).
10. Honeybourne *et al.* carried out similar reactions using nickel and copper chlorides with sufficient hydrochloric acid to hydrolyze the 1,1,3,3-tetramethoxypropane.[11] However their produces, formulated as hydrogen chloride adducts of the desired metal chelates of **2**, could not be converted to the neutral metal chelates of **2**.
11. P. Chave and C. L. Honeybourne, *Chem. Commun.*, 279 (1969).
12. J. O. Halford and R. M. Fitch, *J. Amer. Chem. Soc.*, 85, 3354 (1963).
13. The nmr of **5a**, (PF_6^-) is consistent with magnetically nonequivalent protons on each coordinated amine group; (acetone-d_6) δ 8.02 (d, J = 6 Hz, 2H, ArNCH); 7.84–6.85 (complex multiplet; 8H, ArHO; 5.68 (t, J = 6 Hz, 1H, C–H); 5.68 (br. s., 2H, N–H); 3.36 (br. s., 2H, N–H). Both N–H absorptions disappeared upon addition of D_2O.
14. Nmr of **6** ($CDCl_3$) δ 7.23 (d, J = 6 Hz, 2H, ArNCH); 7.10–6.5 (complex multiplet, 8H, Ar–H); 5.15 (t, J = 6 Hz, 1H, N–CH–CH); 4.96 (s, 1H, N–C(CH_3)–CH); 2.27 (s, 6H, CH_3). Acetylacetone does not cyclize **5a** to **6** in the absence of base.
15. Similar hydrolytic ring openings are documented for 2,4-disubstituted-1,5-benzodiazepinium salts.[8,17] Benzodiazepinium salts possessing unsubstituted 2(4) positions are apparently even more susceptible to hydrolysis.[16,18]
16. W. Ruske and E. Hüfner, *J. Prakt. Chem.*, 18, 156 (1962).
17. (a) J. Thiele and G. Steimmig, *Ber.*, 40, 955 (1907).
   (b) J. A. Barltrop, C. G. Richards, D. M. Russel and G. Ryback, *J. Chem. Soc.*, 1132 (1959).
18. M. Weissenfels, R. Kache, and W. Krauter, *J. Prakt. Chem.*, 35, 166 (1967).