



PS5.46 — TH

JOHN H. DAWSON
ELISABETH T. KINTNER
MAUREEN K. GENO
Department of Chemistry
University of South Carolina
Columbia, South Carolina 29208
U.S.A.

BINUCLEAR RUTHENIUM ALKYL DIOXIME COMPLEXES: MODELS FOR ELECTRON TRANSFER THROUGH SATURATED BARRIERS

A question of particular interest to the study of the mechanism of electron transfer in metalloproteins is the nature of the intervening groups and the distance separating redox-active transition metals. We are interested in the distance dependence of intramolecular electron transfer through saturated barriers. The electron density surrounding the metal centers of existing models [1] for electron transfer through saturated barriers is very different from that found in the Fe-Porphyrin or Fe-S prosthetic groups of electron transfer proteins [2]. We have used the (bpy)₂Ru(II) (bpy = 2,2'-bipyridine) moiety instead of (NH₃)₅Ru(II) [3] in order to better mimic the electron density of the protein prosthetic group. Thus we have synthesized a series of binuclear ruthenium alkyl dioxime complexes in which the bridging ligands are the monocyclic 1,4-cyclohexanedione dioxime (cyclodiox), the bicyclic 1,4- and 1,5-substituted *trans* decalindione dioximes (decadiox), and the tetracyclic 5 α -3,17-androstanedione dioxime (androdiox). This provides a series of binuclear metal complexes with the metals separated by a barrier of variable distance. The results of cyclic voltammetric studies of these complexes are shown in Table I. The potential differences for the mono- and bicyclic 1,4-bridged complexes are 471 and 325 mV, respectively with the latter being an irreversible process. The

tetracyclic and 1,5-bicyclic dimers display reversible redox behavior. In the steroid case the two waves nearly coalesce. Overall these data suggest that as the distance between the ruthenium centers increases, the difference in potential decreases.

Table I
Cyclic voltammetry of Ru dimers

| Bridge | E _{1/2} (V vs SCE) | |
|--|-----------------------------|------|
| 1,4-cyclohexanedione dioxime | .685, | .214 |
| 1,4-decalindione dioxime | .950, | .625 |
| 1,5-decalindione dioxime | .960, | .770 |
| 5 α -3,17-androstanedione dioxime | .900, | .827 |

Addition of one equivalent of Ce(IV) to the doubly reduced species generates a mixed-valence Ru^{II}-Ru^{III} dimer which is expected to display near-IR intervalence charge transfer (IT) bands. Results for the mono- and tetracyclic Ru dimers are shown (Table II). The extent of delocalization of the exchanging electron (α^2) can be estimated from the properties of the IT band [5] according to the equation (1) [6]

$$\alpha^2 = \frac{4.2 \times 10^{-4} \epsilon_{\max} \tilde{\nu}_{1/2}}{d^2 \tilde{\nu}_{\max}} \quad (1)$$

where d is the Ru-Ru internuclear separation (in Å, based on crystal structure data of the oximes), ϵ_{\max} is the molar absorptivity at the wavelength maximum and $\tilde{\nu}_{1/2}$ is the bandwidth at half-height. The values of α^2 for the mono- and tetracyclic ruthenium dimers (Table II) differ by three orders of magnitude, suggesting that the mixed-valence state is more delocalized in the monocyclic diruthenium complex than in the ruthenium steroid dimer.

Table II

| Ru dimer | ΔE (Volts) | $\tilde{\nu}_{\max}$ (nm) | ϵ (M cm) ⁻¹ | α^2 (Å ² M cm) ⁻¹ |
|---|-----------------------|------------------------------|------------------------------------|---|
| Ru ₂ (μ 1,4-cyclodiox) | .471 | 910 | 42 | 1.3 \times 10 ⁻³ |
| Ru ₂ (μ 3,17-androdiox) | .073 | 718 | 3.5 | 2.6 \times 10 ⁻⁶ |

These Ru₂(bpy)₂-dioxime dimers represent a new series of ligand complexes with which to study the distance dependence of intramolecular electron transfer through saturated barriers. As the dis-

tance between the ruthenium ions increases, the difference in reduction potential of the two rutheniums decreases as does the degree of delocalization of the mixed valence state. At the same time, the energy of the IT band increases with concomitant decrease in molar absorptivity.

ACKNOWLEDGEMENTS

JHD is the recipient of a Camille and Henry Dreyfus Teacher/Scholar Award, an Alfred P. Sloan Foundation Research Fellowship and a National Institutes of Health Research Career Development Award.

REFERENCES

- [1] a) D.K. LAVALLEE, B. ANDERES, *Inorg. Chim. Acta*, **79**, 213 (1983);
b) B. ANDERES, D.K. LAVALLEE, *Inorg. Chem.*, **22**, 2665 (1983).
- [2] M. ERECINSKA, in B. CHANCE, D. DeVULT, H. FRAUENFELDER, R.A. MARCUS, J.R. SCHREIFFER, N. SUTIN (eds.), «Tunneling in Biological Systems», Academic Press, New York, 1979, p. 453, and references therein.
- [3] S.K.S. ZAWACKY, H. TAUBE, *J. Am. Chem. Soc.*, **103**, 3379 (1981).
- [4] M.K. GENO, J.H. DAWSON, *Inorg. Chem.*, **23**, 1182 (1984).
- [5] a) N.S. HUSH, *Prog. Inorg. Chem.*, **8**, 391 (1967);
b) N.S. HUSH, *Electrochem. Acta*, **13**, 1005 (1968);
c) M.B. ROBIN, P. MAY, *Adv. Inorg. Chem. Radiochem.*, **10**, 247 (1967).
- [6] a) R.W. CALLAHAN, R.F. KEENE, T.J. MEYER, D.J. SALMON, *J. Am. Chem. Soc.*, **99**, 1064 (1977).
b) R.W. CALLAHAN, T.J. MEYER, G.M. BROWN, *J. Am. Chem. Soc.*, **96**, 7829 (1974).



PS5.47 — TH

DONALD W. JACOBSEN

Department of Cardiovascular Research
The Cleveland Clinic Foundation
9500 Euclid Avenue, Cleveland, Ohio 44106
U.S.A.

RALPH GREEN

Department of Laboratory Hematology
The Cleveland Clinic Foundation
9500 Euclid Avenue, Cleveland, Ohio 44106
U.S.A.

SYNTHESIS OF METHYLCOBALAMIN FROM THE GLUTATHIONE-COBALAMIN COMPLEX

Mechanistic details on the conversion of vitamin B12 (cyanocobalamin, CN-Cbl) to its coenzyme forms adenosylcobalamin (Ado-Cbl) and methylcobalamin (Me-Cbl) by mammalian cells are largely unknown. Some information is available on Ado-Cbl formation by prokaryotes (reviewed in [1]), but the origin of Me-Cbl, the principal circulating Cbl in man, is obscure. Twenty years ago WAGNER and BERNHAUER proposed that the glutathione-cobalamin complex GS-Cbl might serve as a precursor for Cbl coenzymes based on its reactivity with alkylating agents [2]. We have recently obtained evidence that GS-Cbl is a naturally occurring intracellular Cbl in murine L1210 cells [3]. This paper concerns the reactivity of synthetic GS-Cbl in model systems for Me-Cbl formation.

GS-Cbl was prepared by reacting a 10-fold molar excess of glutathione (GSH) with hydroxocobalamin (HO-Cbl) in 0.10 M sodium acetate pH 4.5 (Reaction (1)). This complex was purified from excess



GSH by gel filtration on a 2.5 × 50 cm P2 polyacrylamide (Bio-Rad) column, or for smaller levels (<1 μmole) of GS-Cbl, on Sep-Pak C₁₈ cartridges (Waters/Millipore). The isolated complex had principal absorbance bands at 534, 428, 372,