Redox Active Metal-Sulfide Clusters and a Series of Computer Assisted Instructional Lessons on Transition Metal Chemistry

Steven D. Gammon Final Seminar April 6, 1989

The material presented in this seminar represents research work in two areas of chemistry: traditional inorganic synthetic chemistry and computer assisted instructional materials development in the realm of chemical education. This seminar will address projects that were developed in both the synthetic and chemical education areas.

The first phase of my graduate research was involved with the synthesis and characterization of a series of charge transfer salts using metal sulfide clusters and TCNQ. The goal of the research was to design a group of salts to be the organometallic analogs of (TTF)(TCNQ) and demonstrate metallic conductivity.

The metal sulfide clusters were cubanes of the formula $(RCp)_4M_2M'_2S_4$ (R = H, Me; M = Cr,V;M' = Cr, V) and the cluster $(RCp)_4V_5S_6$. The reactions for the formation of these compounds are shown below.

$$(RCp)_2M \quad + \quad H_2S \qquad (RCp)_4M_4S_4$$

$$(RCp)_2V_2S_4 \quad + \quad 2(RCp)_2Cr \qquad (RCp)V_2Cr_2S_4$$

$$(RCp)_2V_2S_5 \quad + \quad 2PBu_3 \qquad (RCp)_5V_5S_6 \ + \ (RCp)_4V_4S_4 \ + \ \cdots$$

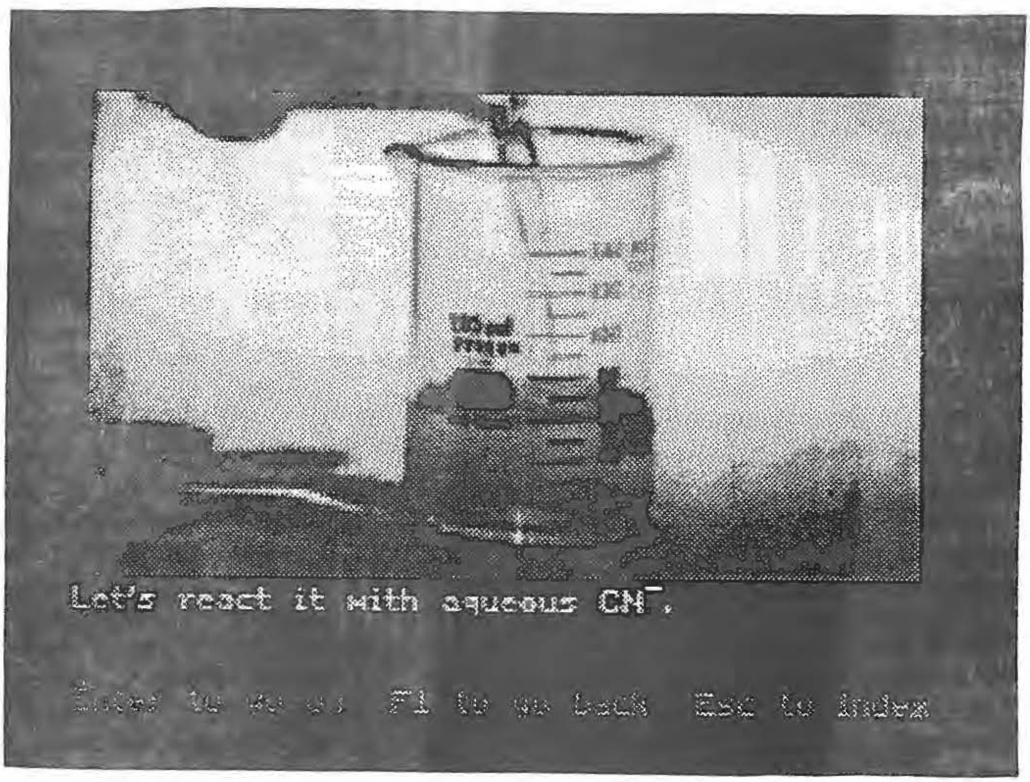
All of the above clusters were examined by cyclic voltammetry and were found to have a 0/+1 oxidation wave at about 0 mV (CH_2Cl_2; Ag/AgCl). This oxidation made them suitable for reaction with TCNQ (0/- reduction at 238 mV). Upon reaction with TCNQ, it was found that these clusters formed both 1:1 (cluster:TCNQ) and 1:2 charge transfer salts with TCNQ. The 1:1 salt can be converted to the 1:2 salt by the addition of one equivalent of TCNQ. Four probe pressed pellet conductivity measurements on 1:2 salts indicated that were semiconductors with band gaps in the range of 0.24 - 0.75 eV. IR and structural studies of both the 1:1 and 1:2 salts indicated that the TCNQ was dimerized. This dimeriztion of the TCNQ was the results of a net charge transfer of 0.5 electrons per TCNQ in both the 1:1 and 1:2 salts.

My most recent research has focused on the design and implementation of a series of interactive videodisc chemistry lessons. The use of interactive videodisc computer assisted instruction (CAI) in chemistry was recently pioneered by Stan Smith and Loretta Jones at the University of Illinois. Smith and Jones have found that the incorporation of video images into traditional CAI can provide a powerful teaching tool in the freshman chemistry curriculum. Because of the success of the interactive videodisc I chose to try developing a series of lessons on transition metal chemistry. Transition metal chemistry is an area that no prior videodisc development work had been done and appeared to be an area that would lend itself to CAI.

The lessons designed in this work are divided into three sub-topics. The first sub-topic is called Orbitals and Electrons. This topic consists of a set of lessons and drills that provide a comprehensive introduction to orbitals, orbital energies and writing electron configurations of s and p block elements. Some innovations in the software from this section included a series of 3-D graphic representations of s, p and d orbitals and an "intelligent" system that allowed students a choice when placing electrons in electron energy diagrams. The next sub-topic is titled Transition Metal Electrons. These lessons are designed to give the student the ability to write the electron configurations of first row transition metals and transition metal ions. In order to write the transition metal electron configurations, the student is introduced to transition metals, 3d orbital energies, transition metal ions and transition metal electron placement in the 3d orbitals.

The last set of lessons are under the sub-topic of Transition Metals. These lessons cover a wide variety of topics ranging from transition metal complex geometries, 3d orbital splitting in an octahedral field, the spectrochemical series, complementary colors and visible spectra. It is in these lessons which there is extensive use of the videodisc. The videodisc is used to show the student transition metal complexes, transition metal chemistry and illustrations of absorbed versus transmitted colors with a visible spectrum. Without the power of the real images provided by the videodisc, most of the Transition Metals lessons would not have been possible; the technology has allowed for a whole new type of instructional approach.

Figure 1 below is a digitized picture from one of the Transition Metals lessons showing CN^- (aq) being added to a solution of $Ni(H_2O)_6^{+2}$.



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