THE FORMATION CONSTANT FOR A COMPLEX ION BY COLORIMETRY (#2.3)

The CCLI Initiative
Computers in Chemistry Laboratory Instruction

Learning Objectives

The objectives of this experiment are to ...

- illustrate how colorimetric measurements are made using the ***MicroLAB*** interface.
- use Beer's Law to measure the equilibrium concentration of a complex ion.
- calculate the equilibrium constant for the formation of a complex ion.

Background

Equilibrium: When substances react, the concentrations of reactants and products change continuously until the system reaches chemical equilibrium. At equilibrium, no changes occur in the concentrations of any reactants or products as a function of time, as long as the system is not disturbed. Equilibrium occurs because chemical reactions are reversible. To illustrate this concept, consider the very important chemical reaction for the synthesis of ammonia from nitrogen and hydrogen:

$$N_{2(g)} + 3\ H_{2(g)} \quad <==> \quad 2\ NH_{3(g)} \qquad (1)$$

When $N_{2(g)}$ and $H_{2(g)}$ react in a closed container, the concentrations of these gases will initially decrease, and the concentration of $NH_{3(g)}$ will increaseAt the same time, the increase in $NH_{3(g)}$ concentration results in more $NH_{3(g)}$ and $NH_{3(g)}$ collisions and the reverse reaction speeds up. Eventually the forward and reverse rates become equal, and no further changes occur in the concentrations of either reactants or products.

The equilibrium constant: The derivation of the equilibrium constant is discussed, along with equations.

In this experiment students will study an equilibrium involving the formation of a complex ion, $FeSCN^{2+}_{(aq)}$, with $SCN^{-}_{(aq)}$ as the ***ligand***, the ion forming the complex with the $Fe^{3+}_{(aq)}$

Procedure: Measured volumes of standard $Fe(NO_3)_3$ and HSCN solutions in 0.50 *M* HNO_3 are combined. Simple dilution calculations are used to determine the *initial* molar concentrations of Fe^{3+} and HSCN in the standard solutions. The complex formation reaction is fast and rapidly reaches chemical equilibrium. Colorimetry and Beer's Law ($A = \epsilon bc$) can be used to determine the molar absorptivity constant of the $FeSCN^{2+}$ complex using the ***MicroLAB*** colorimeter.

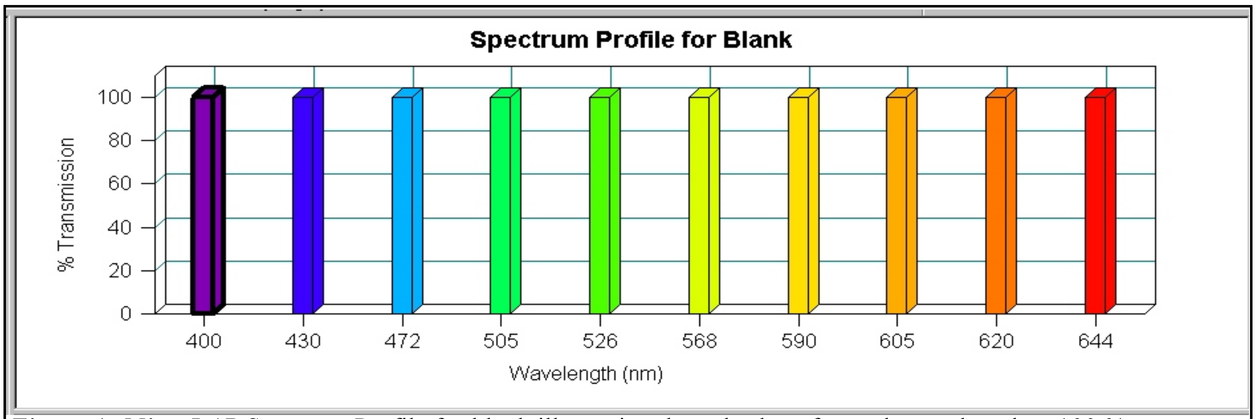

Figure 1. ***MicroLAB*** Spectrum Profile for blank illustrating the color bars for each wavelength at 100 % transmission.

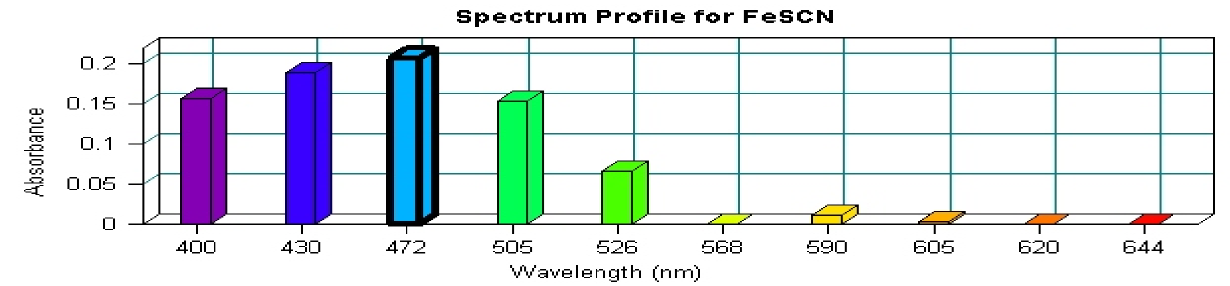

Figure 2. Absorbance Spectrum Profile for the FeSCN2+ ion, with 472 nm as the primary absorbance wavelength.

The ***MicroLAB*** Colorimeter Spectral Profile for the FeSCN at dilute solutions is illustrated in Figure 2, with the maximum absorbance at the 472 nm wavelength.

Preparation of standard solutions

Stock solutions of 0.50 ***M*** HNO_3, 0.200 ***M*** $Fe(NO_3)_3$ in 0.50 ***M*** HNO_3 and 6.0 x 10^{-4} ***M*** HSCN in 0.50 ***M*** HNO_3 should be provided for solution preparation. (**Note** that there are two different $Fe(NO_3)_3$ solutions and two different HSCN solutions in the lab. Be sure students use the right ones in each instance.) Using pipets and volumetric flasks students should *carefully* prepare each required solution. **There are calculations they need to DO BEFORE they come to lab and be entered into the provided table!**

Measurements: Students will first measure the transmission for each of the prepared solutions, then measure the transmission of each of the mixed solutions.

Data Analysis: Guidance is provided for making the measurements and doing the calculations.

Instructor Resources Provided

- Sample Report Sheets providing the format to organize the data collection with sample data.
- Questions to consider, answer and turn-in with suggested answers.
- Tips and Traps section to assist the instructor with potential problems and solutions.
- Sample ***MicroLAB*** screen shots and graphs.
- Laboratory preparation per student station.

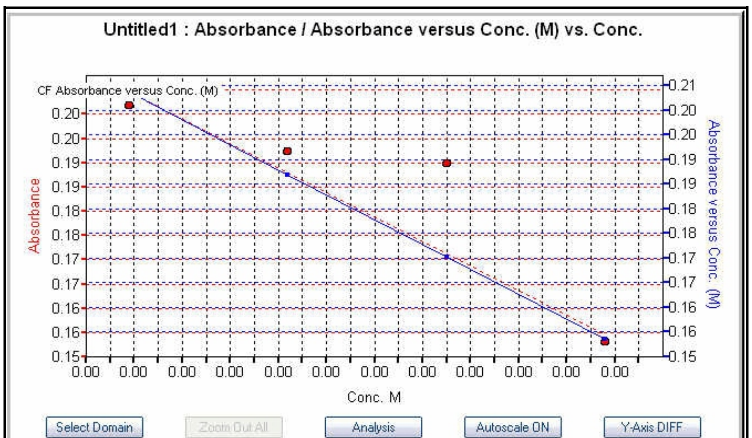

Figure 3. Graph of Absorbance of FeSCN2+ versus concentration, showing the use of the ***MicroLAB*** colorimeter to determine the concentration of the complex ion. This data was taken by Labworks several years ago, so does not have the resolution that the ***MicroLAB*** has.