**Spectrochemical Analysis of Co(III) Complexes via UV-Vis Spectroscopy**

Crystal field splitting theory helps to adequately describe the orbital interactions that contribute to metal-ligand bonding. Electronic effects occurring as a result of ligand to transition metal bonding are evident in the splitting of metal d orbitals in a unique pattern based on the geometry of the complex formed. The quantitative measure of this orbital splitting, termed ΔO, for octahedral complexes, can be deduced from spectroscopic data and is dependent upon the size and charge of the metal and also the π and σ donor or acceptor capabilities of the ligand. The relative position of ligands in the spectrochemical series in terms of their effects on crystal field strength produces both visual effects in the colors of the solutions of the coordination complexes and spectroscopic evidence of d-orbital splitting through the calculation of ΔO using proper Tanabe-Sugano diagrams.

**Safety**

Co(NO3)2•6 H2O and CoCl2•6 H2O will cause skin irritation and can potentially cause respiratory and pulmonary problems with sufficient exposure. Thoroughly wash skin with soap and water if exposed. Hydrogen peroxide, hydrochloric acid, and nitric acid are strong oxidizers and will cause serious skin and eye damage; flush any affected area with water for at least 15 minutes. Glacial acetic acid will cause serious burns and is a lung irritant; use only in the hood. Sodium nitrite and phenanthroline are to be considered toxic. Gloves, lab coat, and goggles should be worn at all times. All final waste products contain metals and should be disposed of in the proper metal waste container.

**Experimental Procedure**

Note: Syntheses must be done in the order specified. Save all solutions, and only use DI H2O.

1. [Co(H2O)6]2+ - Dissolve 0.123 g of Co(NO3)2•6 H2O in 100 mL of H2O to create a 0.0042 M stock solution. You do not need to take the UV-Vis spectrum of this complex.

1. [Co(gly)3]. Add 0.75 g of sodium glycinate to 10 mL of the prepared [Co(H2O)6]2+ solution. Add 5 mL of 3% H2O2 and allow the reaction to proceed for 5 min to completely form the purple complex. Obtain a UV-Vis spectrum.
2. [Co(ox)3]3- Add 1.55g of K2C2O4•H2O to 10 mL of the prepared [Co(H2O)6]2+ solution. Add 10 mL of 3% H2O2 and heat gently to 30 to 40°C with stirring for 10 to 15 min until blue-green color is seen. Obtain a UV-Vis spectrum.
3. [Co(CO3)3]3- - In 50 mL H2O, dissolve 2.99 g of Co(NO3)2•6 H2O and 0.5 mL 30% H2O2. Combine this solution with a solution of 16.9 g NaHCO3 and 0.5 mL 30% H2O2 in 50 mL H2O. Stir solution until bubbling stops. Dilute 1 mL of solution to 25 mL with H2O. Obtain a UV-Vis spectrum.
4. [Co(H2O)6]3+ - Add 20 mL of the [Co(CO3)3]3- solution prepared in synthesis 4 in small increments (to prevent bubbling over) to 80 mL HNO3. Obtain a UV-Vis spectrum.
5. [Co(phen)3]3+ - Add 0.115 g 1,10-phenanthroline to 10 mL of the [Co(H2O)6]3+ prepared in synthesis 5, then add 10 mL of 3% H2O2 and stir for 10 minutes. Obtain a UV-Vis spectrum.
6. [Co(NO2)6]3- - Dissolve 0.38 g of Co(NO3)2•6 H2O in 3 mL H2O. Dissolve 3.07 g NaNO2 in 5 mL H2O. Combine the two solutions and add 1.5 mL glacial acetic acid with caution, as vigorous bubbling will occur. Dilute the solution to 50 mL with H2O and shake vigorously for a few minutes. Dilute 1 mL of the final solution to 50 mL with H2O and obtain a UV-Vis spectrum.
7. [Co(CN)6]3––. Add 2.55 g CoCl2•6 H2O to 75 mL of H2O and boil. With stirring, add a solution of 1.56 g KCN in 30 mL H2O by pipette to the solution. A red/brown colored solution should be produced. Separate the purple solid via vacuum filtration and wash the solid with ice-cold H2O. Add the moist solid to 2.99 g KCN in 50 mL H2O and boil. The solution should turn from green in color to yellow. Record UV-Vis spectrum while the solution is warm.
8. [Co(NH3)6]3+ - Obtain a UV-Vis spectrum in DI water of this previously synthesized compound.
9. [Co(en)3]3+- Obtain a UV-Vis spectrum in DI water of this previously synthesized compound. Any of the isomers of the compound may be used for this analysis.

Note the final color of each of the solutions prepared and the λmax values from the spectra obtained. Use your data to qualitatively and quantitatively rank the ligands from each complex in terms of their place in the spectrochemical series. The longest wavelength λmax for each complex is used to arrange the complexes in order of highest-to-lowest energy (corresponding to the highest-to-lowest value of ΔO). Also, calculate the value of ΔO for each complex using the proper Tanabe-Sugano diagram for Co(III).

**For this report: Abstract, Experimental, Results and Discussion, UV-Vis spectra, Appendix (includes calculations of ΔO)**