Complexes of Nickel

Recommended for Chapter(s): 19

Demo #040

Materials NOT in box

1. Safety goggles.
2. Stir plate (general cabinet).

Procedure

1. (Prep) Make sure that all of the bottles have the correct amount of solution in them.
2. (Prep) Put 150 mL of water into a 500 mL beaker.
3. Place the beaker on a stir plate and set the stirring to low.
4. Pour bottle One (10 mL of 1 M $NiSO_4$) into the beaker.
   a. The solution will turn green.
5. Pour bottle Two (20 mL of 5M NH_3) into the beaker.
   a. The solution will turn blue.
6. Pour bottle Three (10 mL of 25% ethylenediamine) into the beaker
   a. The solution will turn purple.
7. Pour bottle Four (12.5 mL of 1% dimethylglyoxime) into the beaker
   a. The solution will turn red.
8. Pour bottle Five (100 mL of 1M KCN) into the beaker
   a. The solution will turn yellow

Safety

1. Cyanide salts, their solutions, and hydrogen cyanide gas produced by the reaction of cyanides with acids are all extremely poisonous. Hydrogen cyanide is among the most toxic and rapidly acting of all poisons. The solutions and the gas can be absorbed through the skin. Solutions are irritating to the skin, nose, and eyes. Cyanide compounds and acids must not be stored or transported together. An open bottle of potassium cyanide can generate HCN in moist air. Early symptoms of cyanide poisoning are weakness, difficult breathing, headache, dizziness, nausea, and vomiting: these may be followed by unconsciousness cessation of breathing, and death. Anyone exposed to hydrogen cyanide should be removed from the contaminated atmosphere immediately. Amyl nitride should be held under the person's nose for no more than 15 seconds per minute, and oxygen should be administered in the intervals. If the person is not breathing, artificial resuscitation by the Silvester method http://www.ucl.ac.uk/slade/slide/ShortStory/7b.html (not mouth to mouth) should be attempted immediately.

2. Nickel salts and their solutions will irritate the eyes upon contact. Dust from solid nickel salts in harmful, and the compounds are assumed to be poisonous if ingested.

Clean Up

1. Pour the waste into the waste bottle.
    a. If there is not a date on the waste bottle fill out the date.
2. Return the materials to the cart in the demonstration library room.

Stockroom Notes

1. If the waste bottle is full or more than 6 month old put bottle to be picked up by environmental health and safety.
    a. Make another waste bottle with the appropriate tag and put in box.
        i. Faculty Name: Feldwinn
        ii. Department: Chemistry
        iii. Phone: x2127
        iv. Start Date: Leave blank (will fill out when chemical are put in bottle)
        v. Proper chemical name and concentration: nickel (II) sulfate 0.033M, ammonia 0.33M, ethylenediamine 0.12 M, dimethylglyoxime 0.00487 M, potassium cyanide 0.33M
        vi. Physical State; liquid
        vii. Chemical Hazard: Toxic/Poison
2. Refill single use bottle with each of the correct solution to the lines indicated.
3. If needed make up stock solutions:
    a. 1M $NiSO_4$: dissolve 52.6 g $NiSO_4{\cdot}6H_2O$ and dilute to 200 mL
    b. 5 M NH_3: dilute 133 mL of concentrated ammonia solution (15 M) to 400 mL
    c. 25% ethylenediamine: dilute 50 mL of ethlenediamine to 200 mL
    d. 1% dimethyl glyoxime:dissolve 2 g of dimethylglyoxime in 250 mL of ethanol
    e. 1M KCN: dissolve 32.5 g KCN and dilute to 500 mL (see hazard section first)
4. Replace dirty glassware with clean glassware.
5. Return items to demonstration tub.
6. Return tub to the demonstration library.
    a. Return the goggles to the goggle box.

Discussion

This demonstration can be used to show the effects of field ligand strength on the observed color of the complex. The reactions that occur during this demonstration are the following:

rxn 1: $6H_2O + NiSO_4 \rightarrow [Ni(H_2O)_6]^{2+} + SO_4^{2-}$

rxn 2: $[Ni(H_2O)_6]^{2+} + 6NH_3 \rightarrow [Ni(NH_3)_6]^{2+} + 6H_2O$

rxn 3: $[Ni(NH_3)_6]^{2+} + 2en \rightarrow [Ni(en)_3]^{2+} + 6NH_3$

rxn 4: Reaction with dimethylglyoxime (dmg)

rxn 5: $[Ni(dmg)_2] + 4CN^{-} \rightarrow [Ni(CN)_4]^{-2} + 2$ dmg

All of the complexes are Ni^{2+}octahedral except from $[Ni(CN)_4]^{2-}$ which is a Ni^{2+} square planer complex. As the strength of the field ligand increases the field splitting increase. The ligands, used in this demonstration, listed in order of increasing field strength are:

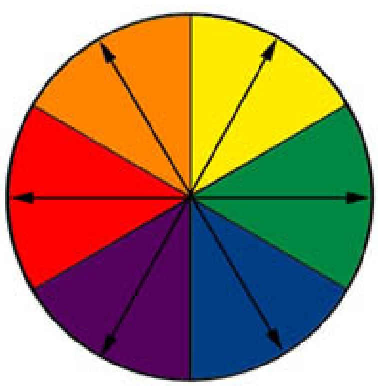
$$H_2O < NH_3 < en < CN^{-}$$

As the strength of the ligand changes, the color of the complex changes. The relationship between the color absorbed by the compound and the size of the field splitting is seen in equation 1.

$$\text{equ 1: } \Delta = \frac{hC}{\lambda}$$

Where Δ is the field splitting, h is planks constant, c is the speed of light, and λ is the wavelength absorbed.

To determine what color each sample absorbs the following chart can be used



Observed	Absorbed
Red	Green
Orange	Blue
Yellow	Violet
Green	Red
Blue	Orange
Violet	Yellow

Therefore, the chart below shows the color absorbed for each of the ligands:

Reaction	**Ligand**	**Color Observed**	**Color Absorbed**
1	H_2O	Green	Red
2	NH_3	Blue	Orange
3	en	Violet	Yellow
4	-	Red	Green
5	CN^-	Yellow	Violet

Equation 1 shows that the strongest field ligand should have the shortest wavelength and the weakest field ligand should have the biggest wavelength. Comparing the color absorbed to the wavelengths of the colors (seen below in table) the demo shows H_2O is the weakest field ligand followed NH_3 and en which leaves CN^- as the strongest field ligand.

Color	**~ Wavelength**
Red	650 nm
Orange	590 nm
Yellow	570 nm
Green	510 nm
Blue	475 nm
violet	445 nm

Materials for demo 040

1. Five single-use bottles filled with the stock solutions to the appropriate levels
2. Gloves
3. 600 ml beaker
4. Stir bar
5. Waste bottle
6. Bottle with DI H_2O
7. Five stock solutions