Copper Transformations

Prelab Assignment

Read the entire experiment. Submit your completed prelab questions on Labflow before you begin the lab, according to the deadline set in the syllabus.

Experimental Overview

During this experiment you are performing a set of reactions that show how copper can be used in different ways. Between Part I and Part II you will be testing 2 methods to determine which method is preferred. Your report will be a full development of your observations and references. See reporting requirements at the end of the lab manual.

Application

Metal ions are critical to the proper functioning of biological systems. Out of the many metals found in the human body, copper in particular facilitates many essential processes.

Copper ions, and enzymes containing copper, enable cellular respiration, certain types of enzyme production, and bone development and maintenance, among many other roles.

The concentrations of metal ions such as Cu are tightly regulated in the human body,[1] which leads to a homeostasis of ion concentrations. As the role of Cu in certain enzymes and functions developed, even the type of tissues it is found in have been highly controlled. When this effective regulation of Cu in the human body is disrupted, various types of human disease can arise.

In certain environments Cu^{2+} ions have been shown to damage DNA and may be a factor in DNA related diseases such as Alzheimer's disease.[1]

While metal ions such as Cu^{2+} may damage DNA, the chemical form and type of metal is critical to what kind of effect occurs. For example, cisplatin (Figure 1) is a molecule centered on a Pt^{2+} ion that also interacts with DNA. Cisplatin can react with DNA and prevent the normal replication of DNA from proceeding, leading to cell death.[2] This interaction may appear to be extremely detrimental but has been exploited in the medical fields to help fight certain types of cancer.[2]

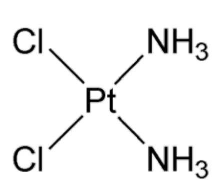

Figure 1 - Structure of cisplatin

There are limitations to cisplatin and new areas of chemical research are investigating the possibility of using molecules with Cu ions as anticancer drugs.[3] Essential to this type of research is an excellent understanding of what kinds of chemical transformations Cu containing molecules can undergo. In this experiment, some of these transformations will be studied.

References

1. Festa, R. A.; Thiele, D. J. Copper: An essential metal in biology. *Curr. Biol.* **2011**, 21, R877-R883.
2. Kelland, L. The resurgence of platinum-based cancer chemotherapy. *Nat. Rev. Cancer.* **2007**, 7, 573-584.
3. Santini, C.; Pellei, M.; Gandin, V.; Porchia, M.; Tisato, F.; Marzano, C. Advances in Copper Complexes as Anticancer Agents. *Chem. Rev.* **2014**, 114, 815-862.

Procedure: Throughout the experiment, make sure to take detailed notes of what you do and how the reactions respond. Focus on making complete observations that you will use when writing your report.

Part I - Obtaining solid copper from a salt solution

1. Prepare for the experiment.
    a. Obtain and wear goggles.
    b. Use the *Chemicals Utilized* Table to help keep track of materials obtained that will be disposed of at the end of the experiment.
    c. Record procedural notes and observations during the experiment.
    d. Obtain any necessary equipment from your instructor.
2. Transform $[Cu(H_2O)_6]^{2+}{}_{(aq)}$ to $Cu(OH)_{2\ (s)}$
    a. Obtain 25 ± 1 mL of hexaaqua copper (II) solution in a 100 mL beaker.
    b. Obtain 8 ± 1 mL of 5 % sodium hydroxide solution.

    Note: Be careful when handling NaOH. It is a strong base and corrosive if it contacts skin.

    c. Add the sodium hydroxide solution dropwise to the copper solution.
    d. After a blue precipitate is formed, periodically test the acidity of the solution by dipping a glass stirring rod into the solution and transferring some liquid to red litmus paper. Try to not transfer the blue precipitate.
3. Transform $Cu(OH)_{2\ (s)}$ to $CuO_{(s)}$
    a. Add 20 ± 2 mL of deionized water to the reaction mixture obtained in the previous step, and one or two boiling stones.
    b. Heat the contents of the beaker, but do not boil the water. Boiling will make a fine powder of CuO that is difficult to filter. Heat the beaker until all of the blue $Cu(OH)_2$ has been converted to black CuO.

c. Filter and wash the CuO using filter paper and a glass funnel. Keep the solid on the filter paper and discard the filtrate.

4. Transform $CuO_{(s)}$ back to $[Cu(H_2O)_6]^{2+}{}_{(aq}$
   a. Obtain 10 ± 0.1 mL of sulfuric acid in a beaker.

   Note: Be careful when handling sulfuric acid. It is a strong acid and corrosive if it contacts skin.

   b. Redissolve the solid on the filter paper by adding sulfuric acid dropwise and collecting the filtrate.
5. Transform $[Cu(H_2O)_6]^{2+}{}_{(aq}$ to $Cu_{(s)}$
   a. Add 1 ± 0.1 g of Zn to the blue solution obtained in the previous step and immediately cover the beaker with a watch glass to contain any corrosive spray which may form. Allow this reaction to proceed and record any observations.
   b. After the solution is no longer blue, some sulfuric acid (maximum 10 mL additional) may need to be added to react with any excess Zn.
   c. Transfer the liquid from the beaker, leaving the copper metal behind. Wash this metal three times with deionized water and also decant this liquid to another beaker.
   d. Transfer the copper metal to a clean and dry watch glass that is labeled. Place this in an oven set at 110 °C for 20 minutes.

   Note: Be sure to carefully handle all hot glassware. Hot glass looks the same as cold glass. Do not weigh items on balances that are too hot to pick up with bare hands.

   e. When the copper metal is dry, measure the mass of the isolated metal.

Part II - Obtaining solid copper from a salt

6. Prepare $[Cu(H_2O)_6]^{2+}{}_{(aq}$ from $CuSO_4 \cdot 5\ H_2O$
   a. Obtain 1 ± 0.2 g of copper (II) sulfate pentahydrate.
   b. Dissolve the copper (II) sulfate pentahydrate in 25 ± 1 mL of deionized water.
   c. Stir with a glass stir rod until completely dissolved.
7. Transform $[Cu(H_2O)_6]^{2+}{}_{(aq}$ to $Cu_{(s)}$
   a. Using the hexaaqua copper (II) solution generated in step 6, perform the following steps with this solution to generate solid copper. Be sure to record the final isolated mass.
   b. Add 1 ± 0.1 g of Zn to the blue solution obtained in the previous step and immediately cover the beaker with a watch glass to contain any corrosive spray which may form. Allow this reaction to proceed and record any observations.

   c. After the solution is no longer blue, some sulfuric acid (maximum 20 mL) may need to be added to react with any excess Zn.
   d. Transfer the liquid from the beaker, leaving the copper metal behind. Wash this metal three times with deionized water and also decant this liquid to another beaker.
   e. Transfer the copper metal to a clean and dry watch glass that is labeled. Place this in an oven set at 110 °C for 20 minutes.

Note: Be sure to carefully handle all hot glassware. Hot glass looks the same as cold glass. Do not weigh items on balances that are too hot to pick up with bare hands.

   f. When the copper metal is dry, measure the mass of the isolated metal.

8. Clean all glassware and equipment. Dispose of all waste properly. Refer to the *Chemicals Utilized Table* to determine the correct quantities of disposed materials and record these values on the waste sheets. Be sure to clean up any materials spilled during the experiment. Please leave the laboratory in better condition than at the start of the experiment.

Observations: (Record observations in Labflow)

Step 2:

Step 3:

Step 4:

Step 5:

Step 6:

Step 7:

Data Analysis: Communicating your Observations

The experimental results are the way a scientist reports the outcomes of their lab work. Each experiment is done in order to address an unknown, therefore the results should clearly relate to the direction of the work. The experimental results are the qualitative and quantitative observations of the work, presented clearly and concisely. The data presented should be complete.

Describe your observations from each step for Method I and Method II, in three to five sentences per step. Make sure to consider both (a) and (b) below.

a. How do your observations relate to what you are trying to find?
b. What molecular-level events are related to your observations?

Discussion Questions:

1. What were the main differences in Method 1 vs. Method 2?

2. Discuss the *safety* and *yield* considerations that would lead to one method being preferred over the other method.

Chemicals Utilized Table

Chemical Name	Amount	Waste Type

Section Development: References

Using references in a lab report can serve multiple purposes. In the introduction of a report, references are commonly used to describe the current work with ideas and concepts in the broader area of relevant research. While in the discussion of a report, references are primarily used to cite specific data and results in other published research. Both of these purposes place the current work in context.

References to research data and results can help validate the results of the current work if the data is consistent. However, the current work may be inconsistent with published results, in which case referencing research to offer alternative ideas or interpretations is equally important.

Consider your experiment.

1. List the observations you have that might have a comparison available in the published literature.
    a. Look up a published value or observation that relates to the observations you made in this experiment.

b. Give examples of values that would be found in a reference source (such as the CRC handbook) and in a journal article.

2. Give 3 correct citations (using the ACS Style Guide) for references that would support the data and analysis of the current experiment. Following each citation, include a complete sentence that explains why the reference is appropriate.

Submit your **Observations, Data Analysis, Discussion and References questions** via Labflow. Include molecular-level explanations where appropriate. Answer discussion questions completely.