Determination of Copper in Brass

Concentration of Solutions

Introduction

Analyze percent copper by preparing a series of dilutions of a known copper solution and comparing their colors. A microscale lab.

Concepts

- Concentration
- Molarity
- Dilution equation
- Absorbance

Background

There are two main objectives for this experiment:

1. To become familiar with two similar colorimetric methods of quantitative analysis.
2. To compare/contrast these two methods as far as ease of use and precision are concerned.

A brass sample is dissolved in nitric acid, producing only one colored species in solution:

$$Cu(s) + 4HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2NO_2(g) + 2H_2O(l)$$

The concentration of copper(II) ion, and hence, the concentration of copper in the brass sample can be measured by evaluating the intensity of the blue color. The color intensity can be measured visually by a comparison of the sample's color with that of a series of copper(II) ion solutions of known concentrations. Alternatively, since the absorbance of the colored solution is directly proportional to its concentration

(A = abc), a Beer's Law plot can be constructed using solutions of known concentration. The copper ion concentration of the brass sample may then be read directly from this plot.

Materials

Copper(II) nitrate solution, $Cu(NO_3)_2$, 1.0 *M*, ~10 mL

Nitric acid solution, HNO_3, 6 *M*, 3–4 mL

Water, distilled, ~20 mL

Cuvets for spectrophotometer (optional)

Pipet, Beral, thin-stem

Pipet, graduated, 10-mL

Reaction plate, 24-well, 2

Screw, brass, ¼ × #2, or other small pure brass object

Spectrophotometer or other device to measure absorbance (optional)

Toothpicks or plastic stirrers

Volumetric flask, 5-mL

Safety Precautions

6 M nitric acid is very corrosive to all body tissue and toxic by ingestion and inhalation. Nitric acid is also a strong oxidizing agent. Copper(II) nitrate is an oxidizing agent, and moderately toxic by ingestion. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please consult Material Safety Data Sheets for further safety, handling, and disposal information.

Procedure

1. Mass the brass screw to the nearest 0.001 g and place it in the 5-mL volumetric flask.
2. Add 3–4 mL of 6 *M* HNO_3. *Note:* This reaction must be performed in a hood, as toxic NO_2 gas is released.
3. Swirl the flask occasionally until the metal has completely dissolved (45–60 min.). Disregard small insoluble flecks, if

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present.

4. Prepare comparison samples of copper(II) nitrate solutions by serial dilution: Using the 24-well plate and a Beral pipet, add 1 drop of the 1.00 *M* $Cu(NO_3)_2$ solution to well A1, 2 drops to well A2, etc., until 20 drops have been added to well D2. Then, add 19 drops of distilled water to well A1, 18 drops to well A2, until 0 drops are added to well D2. *Note:* The total number of drops in ***all*** wells is 20 drops. Use the same Beral pipet for both additions.
5. While waiting for the screw to completely dissolve, the student can still calculate the concentration of Cu(II) ion in each cell using

$$M_i V_i = M_f \times V_f$$

where V = volume in drops and V_f = 20 drops.

6. When the screw has completely dissolved, carefully add distilled water to the 5 mL mark on the volumetric flask and invert several times to mix. Let any solids settle, then draw out the solution with a clean pipet and place it in a cell of the 24-well plate. Stir for one minute to aid in releasing any NO_2 gas remaining in the solution.
7. Using the same thin-stem Beral pipet used for the serial dilutions, add 20 drops of the unknown solution to another well of the 24-well plate. Visually match the color intensity of this well with the closest standard dilution and record the well number (and/or the appropriate Cu(II) ion concentration).

Tips

- This activity can reasonably be completed in one 55 minute class period, along with 45 minutes of preparation time.
- For Honors or AP students, a logical extension would be the spectrophotometric determination of copper(II) ion. The same Cu^{2+} solution used previously can be evaluated here. The wavelength of maximum absorbance of the Cu^{2+} ion can be determined by the students using the standard 1.00 *M* $Cu(NO_3)_2$ solution. Alternatively, the teacher can give this value to the students (650 nm).
- A standard curve of absorbance versus concentration must be prepared by determining the % transmittance of a set of standard solutions. These solutions are prepared as follows:
- A stock solution is prepared by diluting 20.0 mL of 1.00 *M* $Cu(NO_3)_2$ to 100 mL with distilled water. Aliquots of this stock solution (2.0, 3.0, 4.0, 6.0 and 8.0 mL) are then diluted to 10.0 mL, and their % T is determined. A Beer's Law plot is then constructed.
- It is necessary to dilute the unknown copper(II) ion solution so that the % T may be read in the 25%–75% range. The concentration of the unknown solution may then be read directly from the Beer's Law graph, and the same calculation as before will yield the % copper in the brass screw.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory wastes. The excess nitric acid solution may be disposed of according to Flinn Suggested Disposal Method #24b. The copper nitrate solution may be flushed down the drain with excess water according to Flinn Suggested Disposal Method #26b.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Constancy, change, and measurement
Content Standards: Grades 5–8
Content Standard A: Science as Inquiry
Content Standard B: Physical Science, properties and changes of properties in matter, transfer of energy
Content Standards: Grades 9–12

Content Standard A: Science as Inquiry
Content Standard B: Physical Science, structure and properties of matter, chemical reactions, interactions of energy and matter

Sample Data

Microscale Method

Mass Screw = 0.206 g
$[Cu(NO_3)_2]$ = 1.04 M
color match = well B4
$[Cu^{2+}]$ = 1.04 M × 10 drops/20 drops
= 0.520 M
= 0.520 mol/L
= g Cu^{2+} = 0.520 mol/L × 63.5 g Cu/mol × 1 L/1,000 mL × 5.00 mL/sample
= 0.165 g
% Cu = 0.165 g/0.206 g × 100
= 80.1%

Spectrophotometric Method

mass screw = 0.211 g
$[Cu(NO_3)_2$ = 1.04 M
l max = 650 nm

$[Cu_{2+}]$	%T	A
0.0416	74.4	0.128
0.0624	65.2	0.186
0.0832	56.0	0.252
0.125	43.0	0.367
0.166	31.8	0.498
0.208	24.2	0.616

The unknown Cu^{2+} solution is diluted 1:5 with distilled water;
50.0%T = 0.301 Absorbance
For A = 0.301, the Beer's Law plot yields $[Cu^{2+}]$ = 0.102 M
mass Cu = 0.162 g
% Cu = 76.8%
If one does a least-squares calculation on the above data, one gets
y = 2.94x + 0.00427 where y = absorbance, x = $[Cu^{2+}]$
For A = 0.301, $[Cu^{2+}]$ = 0.101 M
% Cu = 76.0%

References

Mills, J. L. and Hampton, M. D. *Microscale Laboratory Manual for General Chemistry*, Random House: New York, 1988, p 51.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Determination of Copper in Brass* activity, presented by Michael Heinz, is available in *Concentration of Solutions*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Determination of Copper in Brass* are available from Flinn Scientific, Inc.

Catalog No.	Description
C0213	Copper(II) Nitrate, Reagent, 25 g
N0048	Nitric Acid, 6 *M*, 500 mL
AP7025	Flinn Scientific Spectrophotometer
AP1447	Reaction Plate, 24-well

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.