Guide: Experiment 1 – Determination of error in Opentrons OT-2 via the automated preparation of copper glycinate.

Aim

In this experiment, you will carry out an automated synthesis of copper (II) acetate monohydrate. As a part of this experiment, you will:

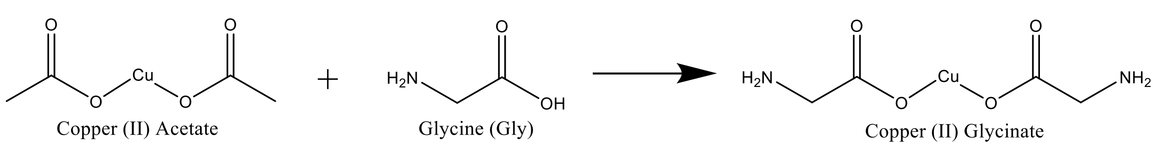
- Practice the preparation of standard solution
- Lean to program Opentrons OT-2
- Learn to operate Opentrons OT-2
- Practice and learn data analysis with spreadsheets

Before you come to the lab

1. Read the experiment, safety information and programming guide.
2. View or review the following techniques
    a. Preparation of standard solutions
    b. Use spreadsheets to analyse data
3. Complete both pre-lab and the pre-lab safety test before the start of the lab.
4. Prepare your lab notebook. Write the experiment title, date, aim and reaction scheme, and write the experiment into the index. Prepare a table of reagents and list the role of each component of the reaction mixture.

Introduction

Robotic automation is becoming increasingly popular in chemistry laboratories and industry for improving the efficiency, cost and reproducibility of chemical experiments. In this experiment, the Opentrons OT-2 liquid-handling robot is used to explore the coordination reaction between copper (II) acetate monohydrate and glycine. The OT-2 allows for precise dispensing of different volume ratios of the two reactants using pre-written Python protocols, making it straightforward to test multiple conditions for comparison.



The experiment focuses on whether a precipitate forms under certain conditions. By systematically varying the volumes of copper (II) acetate and glycine standard solutions, it is possible to compare observations—whether a solid forms or not—with theoretical predictions based on the solubility product constant, K_{sp}. When the product of ion concentrations in solution exceeds K_{sp}, precipitation should occur; if it remains below K_{sp}, the solution should stay clear. Any discrepancies between theoretical and observed outcomes may point to experimental or pipetting errors, providing a practical way to assess both the chemistry in question and the OT-2's liquid handling accuracy.

This experiment demonstrates key concepts in second-year inorganic and analytical chemistry, including coordination complex formation, solubility principles, and equilibrium. By incorporating the OT-2, it also illustrates how automation and precise data collection can enhance modern chemical research workflows.

Chemical Hazards

The following reagents are used in this experiment:

Copper (II) acetate monohydrate	
Hazard statements	H302: Harmful if swallowed H314: Causes severe skin burns and eye damage H410: Very toxic to aquatic life with long lasting effects
Precautionary statements	P260: Do not breathe dust P273: Avoid release to the environment P280: Wear protective gloves/ protective clothing/ eye protection/ face protection P301 + P312: IF SWALLOWED: Call a POISON CENTER/ doctor if you feel unwell P303 + P361 + P353: IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water P305 + P351 + P338: IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
Safe handling	N/A
Disposal	Residues to the copper/metal solvents waste container.

Ethanol	
Hazard statements	H225: Highly flammable liquid and vapour H319: Causes serious eye irritation
Precautionary statements	P210: Keep away from heat/sparks/open flames/hot surfaces - No smoking P233: Keep container tightly closed P240: Ground/bond container and receiving equipment P241: Use explosion-proof electrical/ventilating/light//equipment P242: Use only non-sparking tools P305 + P351: IF IN EYES: Rinse cautiously with water for several minutes P338: Remove contact lenses if present and easy to do. continue rinsing
Safe handling	Boiling point: 78 °C Flash point: 14 °C Autoignition temperature: 363 °C
Disposal	Residues to the non-chlorinated solvents waste container.

Glycine	
Hazard statements	Non-Hazardous
Precautionary statements	Non-Hazardous
Safe handling	Non-Hazardous
Disposal	Residues to the sink.

Pre-lab – Data analysis practice

Using the provided workbook with data (or python for an extra challenge) for each well calculate:

1. Volume fraction
2. Concentration
3. Actual K_{sp} (K_{sp} = [Cu][Gly])

Calculate the theoretical K_{sp} and plot all this data on a concentration space diagram.
Extra challenge: Find the percentage of accurate reaction wells (Hint: Use the excel IF function).

Part 1 – Coding the OT-2

Complete the Jupyter notebook exercise on Coding the OT-2.

Part 2 – Preparation of the stock solutions

Prepare a standard solution of copper (II) acetate monohydrate (0.3 M) (8 ml deionised water + 2 ml ethanol). GENTLE heat may be required. Solution should be a clear dark blue.

In a separate flask, prepare a standard solution of glycine (0.6 M) in deionised water. Solution should be transparent.

Part 3 – Running of the OT-2

Connect to the OT-2 Via the USB adapter and upload your code file to the Opentrons app. Set up the labware according to the OT-2 protocol. Pipette the stock solutions into the reservoir slot according to the protocol. Perform the labware offset checks required in the set up and run the code.

After an hour take note of the precipitation that had occurred and in what wells (looking from below helps).

Part 4 – Data Analysis

Download the Json file off the OT-2 robot post run. Run the provided code to extract the data into excel, copy this data into a copy of your prelab workbook and fill in the flag column with y/n to denote the precipitation. You should have a concentration space graph set up from the pre-lab with an overlaid K_{sp} line, analyse the points that should/shouldn't have precipitated to determine an approximate error in OT-2. You can do this by comparing expected outputs with theoretical.