CHEM 109
Introduction to Chemistry
Revision 1.1

Laboratory Exercise: The Synthesis of Copper (II) Oxide

In this laboratory exercise we will synthesize an Oxide of Copper. In particular, we will generate the Oxide of Copper (II). We will do this by treating the Water soluble salt Copper (II) Sulfate Pentahydrate with Hydroxide Ion. This will generate Copper (II) Hydroxide, which, when heated strongly is converted to Copper (II) Oxide.

As we have discussed, Copper forms an exception to the general Aufbau electron filling scheme in that its 3d orbitals are lower in energy than its 4s orbital, resulting in an electron configuration of:

$$Cu = 1s^2\ 2s^2 2p^6\ 3s^2 3p^6 3d^{10}\ 4s^1$$

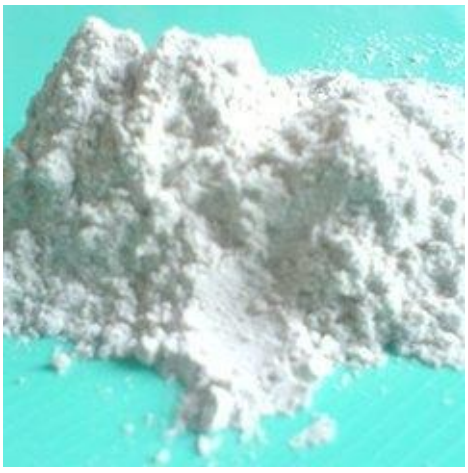
$$= [Ar]\ 3d^{10}\ 4s^1$$

This is consistent with Copper's placement in Group 1B of the Periodic Table of the Elements, suggesting it has but a single valence electron. This electron configuration suggests Ionically Bonded salts of Copper should involve Cu^+ ions, where the outer 4*s* electron is lost:

$$Cu^+ = [Ar]\ 3d^{10}$$

And, this is frequently the case. Salts of Cu^+ are reasonably common, often water insoluble and mostly white in color. However, Cu^+ is readily oxidized to Cu^{2+} in most aqueous solution conditions. So, Cu^{2+} salts are much more common than the Cu^+ salts. Many of these salts are water soluble and blue or green in color.

Copper (II) Sulfate Pentahydrate



Copper (I) Chloride
(http://www.indiamart.com/kantachlorides/copper-chlorides.html)

We will use a water soluble salt of Cu^{2+} as a starting point for our synthesis; Copper Sulfate Pentahydrate.

$$CuSO_4 \bullet 5H_2O(s) \longrightarrow Cu^{2+}(aq) + SO_4^{2-}(aq) + 5\ H_2O(l)$$

Recall from our Solubility Rules, Sulfates tend to be soluble in Water.

Sodium Hydroxide can then be added to precipitate the Hydroxide salt of the Copper (II) Ion; again, recall Hydroxides tend to be insoluble.

$$Cu^{2+}(aq) + 2\ OH^-(aq) \longrightarrow Cu(OH)_2(s)$$

Heavy heating of the Hydroxide will yield the final product; Copper (II) Oxide.

$$Cu(OH)_2(s) \longrightarrow CuO(s) + H_2O(l)$$

This final product can then be filtered from the Water, dried and weighed. The actual yield of this product can then be compare with the expected theoretical yield to judge the quality of this synthetic method.

Procedure

1. Weigh out ~2.0g of Copper (II) Sulfate Pentahydate on an Analytical Balance and place this into a 250 mL beaker. Add 10 mL of Water to the salt. Dissolve the Copper salt with stirring.

2. Add 10 mL of 6M Sodium Hydroxide to the solution with stirring.

3. Place a watch glass over the beaker and heat the mixture to boiling. Avoid spattering. If spattering does occur, use a wash bottle to wash all the solid back down into solution.

4. Heat the mixture until all the blue Hydroxide has been visibly converted into the Oxide. This should only take a few minutes.

5. Quarter a Whatman #1 filter paper. (Your instructor will demonstrate how to do this properly.) Weight the dry filter paper.

6. Set-up a long-stem gravity funnel in a Ring and add your filter paper to the funnel.

7. Filter your mixture in small portions. Use your rubber policeman and some small spurts of Water from your wash bottle to transfer all the solid to the funnel.

8. Once the filtration is complete, carefully remove the filter paper from the funnel. Unfold the filter paper onto a watch glass. Place the sample into a 105^{o}C drying oven. Allow the sample to dry for at least 3 hours; overnight is preferred.

9. Once dry, re-weigh the filter paper and sample.

10. By difference determine the mass of Copper (II) Oxide. Compare this result with the Theoretical Yield to determine the Percentage Yield.

Data Analysis

1. Calculate the Theoretical Yield of Copper (II) Oxide.
2. Calculate the Percentage Yield of Copper (II) Odide.
3. Comment on any sources of loss.