

A simple Environmental-Friendly Method for Disposing Toxic Chemical Wastes

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Abstract – We present two methods of silver reduction from toxic chemical wastes containing silver by-products to make their disposal less complex and more environmental-friendly. We demonstrate the simplicity and advantages of these methods, which could be applied to educational or industrial laboratory facilities.

Keywords – green waste disposal, silver refining process, glucose and copper reduction, argentometry.

Introduction

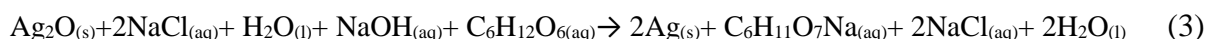
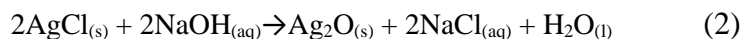
Several argentometry techniques such as the Volhard or Bohr method are commonly used in educational institutions and industrial laboratories. These methods create different types of silver by-products that are considered harmful and must be discarded using specific protocols. Removing silver from such chemical wastes can be beneficial for three reasons. First, the remaining waste will be less toxic and hence, more environmentally friendly. Second, the waste without silver will be less expensive to dispose. Third, the recycled silver can be reused in the laboratory for other experiments.

The objective of this presentation is two-fold. First, we present and compare two methods to extract silver from waste solutions through precipitation, reduction with glucose [1] and reduction with copper [2]. Second, we will show how through further processing (melting and electrolysis) we can extract pure silver, which can be used in other laboratory experiments.

Materials and Methods

We have used three types of chemical waste (samples A, B, C) and two reduction methods (with glucose and copper). Sample A was obtained from the remaining of a chemistry experiment at TAV College and contained chicken broth soup, sodium chloride (NaCl), silver nitrate (AgNO₃), potassium chromate (K₂CrO₄), and water. Sample B consisted of a mixture of silver chloride (AgCl) and sodium chloride in water and was obtained from a different chemistry experiment at TAV, while sample C contained silver nitrate dissolved in water. Due to the nature and composition of the samples, we used the reduction with glucose on samples A and B and reduction with copper on sample C.

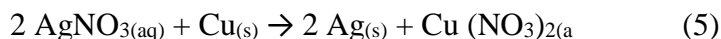
Here, we briefly discuss the two reduction methods. The glucose reduction method started by adding considerable amount of NaCl to ensure the formation of silver chloride (AgCl) precipitate from the waste solutions (Eq. (1)). We then added sodium hydroxide (NaOH) to form silver oxide (Ag₂O) from the precipitate (Eq. (2)). The addition of glucose then reduced the silver oxide to silver powder (Eq. (3)). Further, the powder was washed several times and the liquid was absorbed with a specific pump.



The complete chemical equation which describes this process is:



The copper reduction method consisted of forming silver precipitate directly by submerging copper rods in the silver nitrate solution (sample C) as described by Eq. (5).



To ensure maximum silver recovery we used two indicators, 0.5 M KI and 5%-K₂CrO₄ (according to Mohr method), to detect the presence of unreacted silver. After extraction, we used electrolysis to purify the silver powder after melting it. For electrolysis, a mixture of distilled water and AgNO₃ was added in a stainless-steel bowl. The impure silver was placed in a mesh which was submerged in the electrolytic cell. Finally, the pure silver powder was collected and melted into silver pellets.

Figure 1 presents the extracted dried silver powder collected after reduction with copper (Fig. 1a), the melted silver (Fig. 1b), and purified silver (Fig. 1c). The purity of the silver pellets was confirmed by scraping them into small pieces and then applying a drop of nitric acid followed by a drop of potassium chromate, following [3].

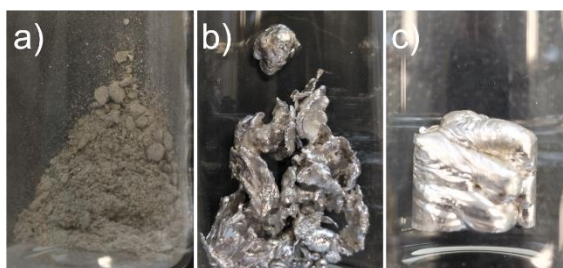


Fig.1 Dried silver powder extracted from copper reduction method (a), melted silver before purification (b), and purified silver (c).

Conclusion

We have shown the possibility of converting a toxic chemical waste into a less harmful solution, while recovering valuable material. The methods we presented can be reproduced in almost any laboratory environment and do not require extensive human or physical resources. The reduction with copper resulted in ~60% of silver recovery, while the glucose reduction yielded only ~15% silver recovery. Although, the reduction with copper seems less complex and more efficient, it is not possible to apply it on chemical wastes such as samples A and B, as the copper can unpredictably react with other chemicals present in the waste which lowers the possibility of silver precipitation.

References

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