

Introduction to Hazardous Waste

Laboratories produce a variety of wastes from aqueous to organic to halogenated to bio-hazardous. Waste is always produced but is not always hazardous to health or the environment. Further, many hazardous wastes can be treated, allowing for harmful compounds to be destroyed or removed and disposed of safely.

Hazardous waste is defined by the BC Environmental Management Act as being dangerous goods if the substances is no longer being used for their original purpose and meet criteria for class 2, 3, 4, 5, 6, 8, or 9 of the federal Transportation of Dangerous Goods Regulation. The BC Hazardous Waste Regulation also defines a variety of wastes directly, including PCB wastes, biomedical wastes, wastes containing dioxin, waste oil and asbestos, waste pest control product containers and wastes containing pest control products, leachable toxic wastes, wastes containing tetrachloroethylene, and waste containing polycyclic aromatic hydrocarbons.

Current waste disposal methods at UNBC include packing up the waste to be shipped off to a disposal company. Expenses for this routinely exceed budgets. Planning for waste before it is produced in research labs appears to be minimal or non-existent and many students are unsure as to what materials actually are hazardous waste.

Bench Top Treatment of Teaching Wastes

Dr. Margaret-Ann Armour of the University of Alberta produced a book, *Hazardous Laboratory Chemicals Disposal Guide*, that contains treatments for many different chemicals that have been tested and proven to deal with harmful substances. Armour's approach is used at the University of Alberta to directly treat at the benchtop chemical wastes produced through teaching. This guide, however, does not address the British Columbia disposal regulations, and

components of it contradict the regulations. Part of this project adapts Margaret-Ann Armour's guide to follow BC waste regulations.

All types of waste that are treated should be examined with an appropriate analytical device to ensure all concentrations are within the proper limits before being disposed of on campus.

Project Goal

The goal of this project is to assess current waste handling procedures and to identify opportunities to reduce the quantity of waste produced through UNBC laboratory teaching activities and to apply Margaret-Ann Armour's approach to wastes produced, within the BC regulatory context. Additional goals of the project include changing the culture of awareness in planning for laboratory and research waste and integrating waste handling into the laboratory curriculum at the undergraduate level.

Project Outcomes

Several areas were identified where waste can be reduced. In first year biology, the wastes produced from three labs were identified as being safe to treat and disposed of on campus. Prior to this it had been handled as hazardous waste with the associated expenses. In first year chemistry, five first semester teaching labs (Chem 120), and two second semester teaching labs (Chem 121) generated waste that could be treated safely on campus. Second year labs for both biology and chemistry were examined to identify possibilities for waste reduction. Although many labs showed opportunities for bench top treatment of waste, only one lab in first semester chemistry (Chem 250) was thoroughly tested. A third year biology class (Biol 321) was also identified as a possibility for further waste reduction.

One of the overall goals of this project was to change the way faculty, staff, and students think about and manage waste on campus. Meetings were held with the senior lab instructors and lab technicians for chemistry labs, biology labs and field schools. These meetings resulted in the implementing of procedures for waste treatment. Brief presentations were given to first year chemistry and biology classes to help raise the awareness of waste for lab classes. A graduate level seminar presentation was given to new grad students in fall 2013 to help plan for waste before any projects began. A second such seminar was held in May 2014 for interested laboratory users. Meetings with Facilities staff revealed that there are no infrastructure issues with disposing of non-hazardous waste to sewer by qualified personnel.

All samples from attempted waste treatments were to be analyzed at the Northern Analytical Laboratory Service (NALS). Due to changes in staffing, NALS is currently not operating and the samples were not analyzed. Dr. Margot Mandy's meeting with Dr. Margaret-Ann Armour revealed that all methods in her manual, *Hazardous Laboratory Chemicals Disposal Guide*, were tested and found to meet Alberta standards. However the methods cannot be used for British Columbia without further testing.

Future investigations include analysis of the products of the benchtop treatment procedures used in this project and determining the end product. Following this analysis, integrating waste handling into curriculum at the undergraduate level should be examined further.

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Cells and Tonicity (Biology 101, 2012)

Overview

The purpose of the lab is to learn how certain molecules move through a semi-permeable membrane when there are different concentrations on either side of the membrane (osmotic potential). The solutions inside and outside of the membrane are tested to determine how many molecules migrated.

Discussion

The waste that is generated can be divided into two components. The first component consists of the solutions that were inside and outside of the membrane. The second component of the waste is generated though all of the various tests that are conducted for this experiment. The first component, which composes the majority of the waste, does not contain anything harmful in it (table salt, egg protein, starch, sugar). The second component contains several hazardous materials that are difficult to treat, and if mixed with the other non-hazardous waste, all of the waste becomes hazardous.

Recommendation

By keeping these two sets of waste separate the non-hazardous can be disposed of directly, and only the small volume of hazardous waste from the testing needs to be disposed of as hazardous waste. Send the labelled waste bottles to Dispensing Chemist or designate for disposal.

Enzymes (Biology 101, 2012)

Overview

The rate at which oxygen is produced by mixing hydrogen peroxide with potato catalase is examined in this lab. The oxygen that is produced in the reaction gets trapped in a fiber glass disk which allows it to stay afloat on the surface of the solution.

Discussion

The waste from this lab is 1% hydrogen peroxide and potato catalase. Hydrogen peroxide above 3% is hazardous however, because it is only 1% and is diluted further in the lab procedure, the solution can be washed down the drain. Before washing the solution down the drain it is important to ensure that all fiber glass disks have been removed.

Recommendations

Place a filter paper in the funnel for the waste container. This will allow for any liquid waste to pass through and prevent any fiber glass disks from falling into the solution. Send the labelled waste bottle to Dispensing Chemist or designate for disposal.

Photosynthetic Algae (Biology 102, 2012)

Overview

Green algae, red algae, brown algae and spinach are provided to the students. Pigments are extracted from the various leaves and separated into different components using thin layer chromatography. The TLC plates are then compared.

Discussion

All forms of algae and plant used in the lab are native to British Columbia. Disposing of the plants into the environment will not cause damage to the ecosystem. All plants used are edible meaning the pigments are not harmful to living creatures. As the algae has been defined as

non-hazardous they can be disposed of in landfills and the solutions containing them can go to sewer after filtering out any solids that are present in solution.

Recommendations

Decant off as much liquid as possible. Filter the sand out of the solution by placing a filter paper in the funnel for the waste bottle. Send the labelled waste bottle to Dispensing Chemist or designate for disposal.

Blood Chemistry (Biology 321, 2012)

Overview

A simulated blood kit is used to determine how many blood cells are present in a single drop of blood. A drop of the simulated blood is placed on a slide and viewed under a microscope.

Discussion

The simulated blood has the same chemical composition of blood. Blood is not chemically a hazard therefore the simulated blood, which is of a similar composition, allows for disposal down the drain.

Recommendation

Send the labelled waste bottle to Dispensing Chemist or designate for disposal.

Stoichiometry: Limiting Reagents (Chemistry 120, 2012)

Overview

Calcium oxalate is synthesized from calcium chloride, potassium oxalate, and ammonium hydroxide. The crystals are then removed from solution and weighed to determine the identity of the limiting reagent.

Discussion

The two concerns with this waste are the oxalate ions in the solution and the ammonium hydroxide. Both can be treated by neutralization with hydrochloric acid. The initial reaction is carried out under basic conditions in order to prevent the oxalate ion from converting to oxalic acid. Oxalate and oxalic acid are compounds that are readily found in nature. The oxalate ion is highly biodegradable and poses no threat to the environment.¹

Recommendation

Neutralize waste solution. Send the labelled waste bottle to Dispensing Chemist or designate for disposal.

References

- 1) Smith, R. L; Oremland, R. S.. Anaerobic Oxalate Degradation: Widespread Natural Occurrence in Aquatic Sediments. *Applied and Environmental Microbiology*. **1983**, **46**, **106-113**.

Thermochemistry: Measurements of Heat Changes in Chemical Reactions

(Chemistry 120, 2012)

Overview

Different inorganic salts are dissolved in water to determine whether the solvation of the salt is exothermic or endothermic. The one that are the most exothermic and endothermic will be tested in a calorimeter.

Discussion

Most hydroxide salts and calcium salts that form are insoluble in water. The solubility of the heavy metal hydroxide salt is dependent on pH.¹ Several of the anions present in solution, such as the sulfate anion, can be precipitated out with the calcium ions that are present. Some of the inorganic salts that are tested in the lab are lithium and barium salts. Both lithium and barium are difficult to treat and are hazardous.

Recommendations

The barium and lithium salts should be removed from the lab since the lab is concerned solely with the thermodynamics of the solvation process. The salts can be replaced with alternative salts that are safer and equally endothermic. Suggested salts for replacement are ammonium nitrate and potassium chloride. With this change, the waste can be safely disposed of down the drain by the dispensing chemist or designate. It will no longer be necessary to ship the waste as hazardous waste.

References

- 1) United States Environmental Protection Agency. *Control and Treatment Technology for the Metal Finishing Industry Sulfide Precipitation*; Industrial Environment Research Laboratory: Cincinnati, OH, 1983: p 6.

Microscale Precipitation (Chemistry 120, 2012)

Overview

A large number of solutions are mixed together in different combinations to determine what physical changes can be observed. The physical changes are identified by colour changes and formation of a precipitate.

Procedure for Waste Treatment

While stirring slowly add a 1 M calcium hydroxide solution. Continue to allow the solution to stir until the precipitate has stopped forming. Filter out any precipitate that has formed using vacuum filtration.

Discussion

By using the properties of hydroxide salts, it is easy to precipitate out most of the metal ions present in solution. Each salt that is formed has a specific pH for which it is most insoluble. Using pH control, the metals can be precipitated out one at a time.¹

It is possible to precipitate out the metal ions so that the concentrations for being non-hazardous are obtained. The concentration of the ions is high and there are a variety of ions present in solution, meaning precise pH control would be required to precipitate out each individual ion. The total volume of this teaching lab is 40 L, meaning it is neither efficient nor cost effective to use this method of treatment. It is better to send this small amount of waste away rather than trying to treat it.

Recommendation

Waste can be shipped out as hazardous, non-reactive waste. Send the labelled waste bottle to the Dispensing Chemist or designate for disposal.

References

- 1) United States Environmental Protection Agency. *Control and Treatment Technology for the Metal Finishing Industry Sulfide Precipitation*; Industrial Environment Research Laboratory: Cincinnati, OH, 1983: p 6.

Purification of Copper Sulfate Ore (Chemistry 120, 2012)

Overview

A mixture of sand, charcoal, and copper sulfate is given to the students to separate the components based on their physical properties. The solution is then separated into its components. The copper sulfate in solution is then recrystallized using 50% ethanol.¹

Procedure for Waste Treatment

Calcium hydroxide is added to the filtrate solution so that pH is maintained at 9. Copper hydroxide forms a blue precipitate that is insoluble in water. The blue precipitate that is formed is then vacuum-filtered out. The solution was analyzed by a UV-Vis spectrometer using quartz cuvettes.

Results

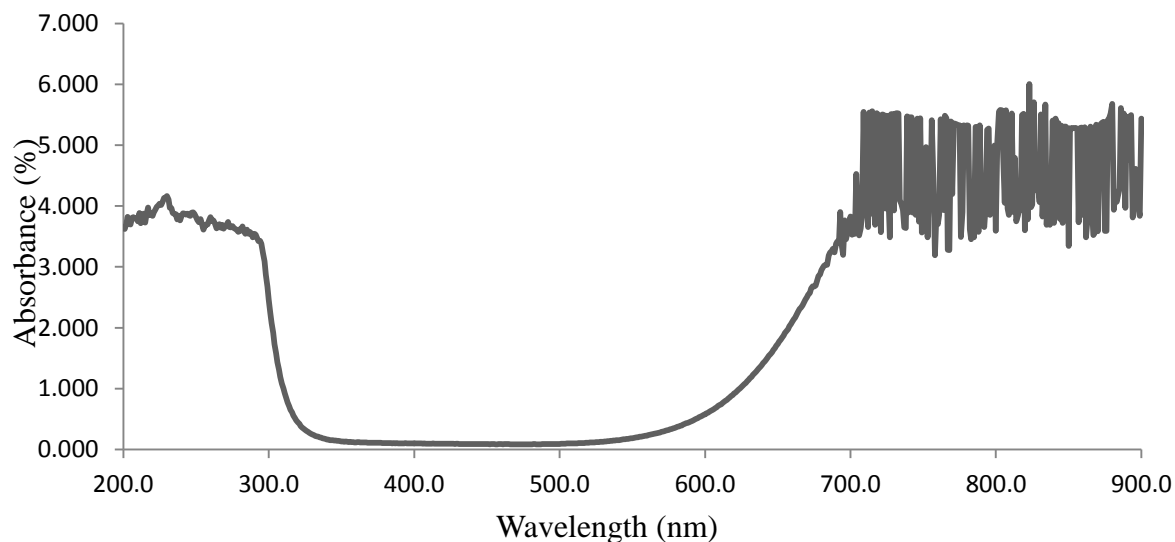


Figure 1: UV-Vis absorbance of a 1 M Copper Sulfate solution

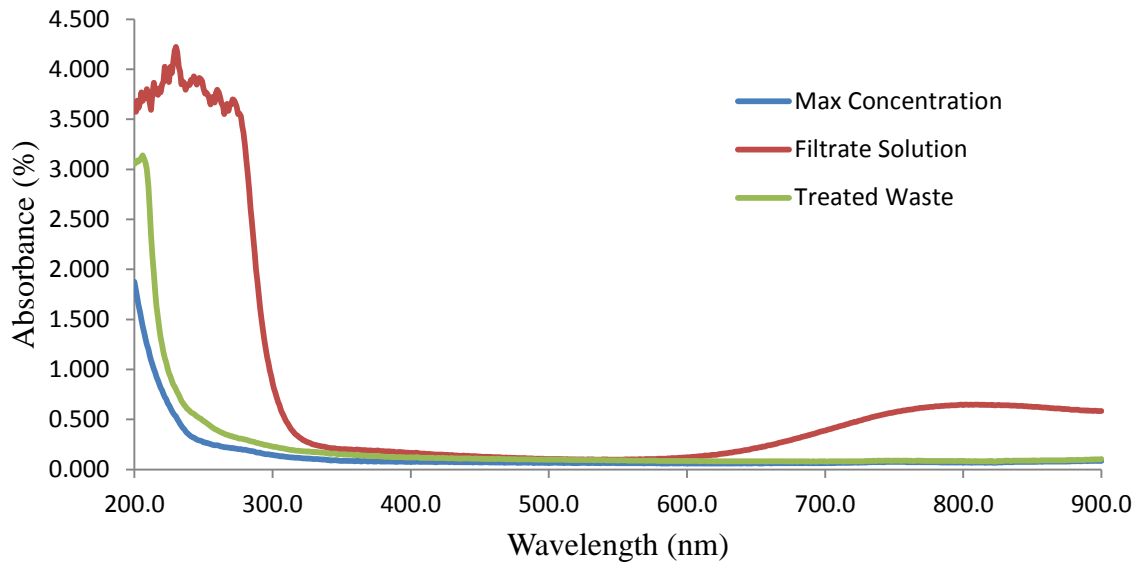


Figure 2: Comparison of UV-spectra of the waste before and after treatment and the maximum concentration of copper allowed in solution

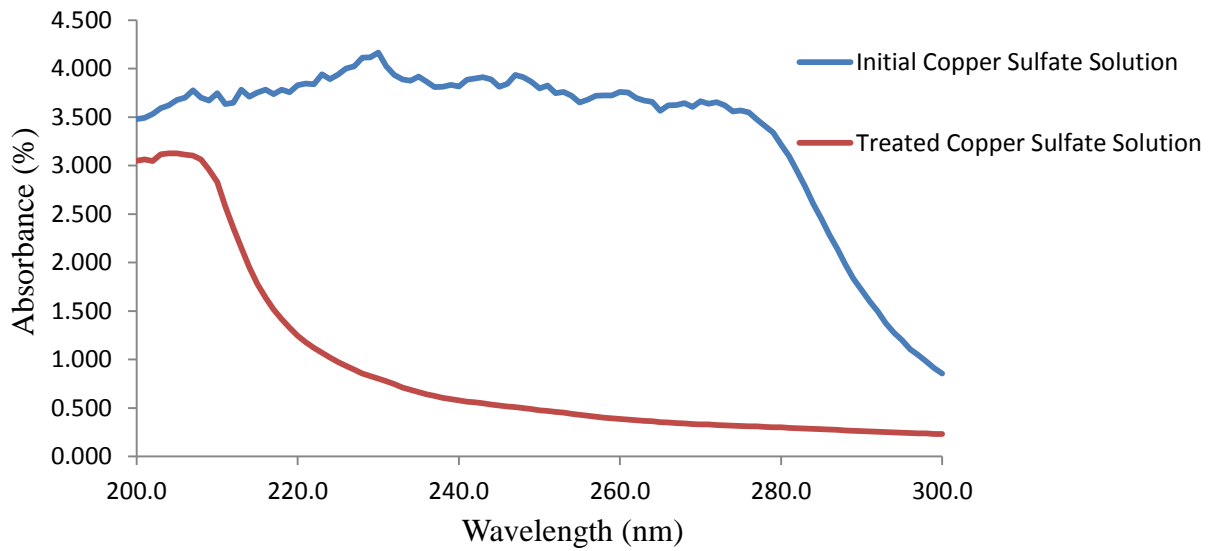


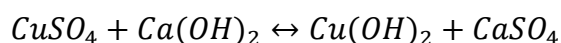
Figure 3: Comparison of the absorbance of the copper sulfate solution before and after treatment

Table 1: Flame Test for the Precipitate Formed When Treating the Copper Sulfate Filtrate

Wire Type	Flame Colour
Steel	Same as Blank
Copper	Same as Blank

Discussion

Copper sulfate can be precipitated out of a solution using calcium hydroxide.



Copper (II) hydroxide is insoluble in water and calcium hydroxide is only slightly soluble (0.205g/100mL).² The solubility of copper (II) sulfate can be controlled using the pH of the solution. Copper (II) sulfate is most insoluble when the pH of the solution is 9.³ The solubility of the copper sulfate becomes 0.001mg/L at this pH. The British Columbia Hazardous Waste Regulations state that the effluent standard for which copper can be poured down the drain is 0.3 mg/L.⁴ The amount of sulfate that can be disposed of by the drain is not mentioned by BC Hazardous Waste Regulations and is not considered a hazardous waste. In the City of Prince George as stated in Bylaw No. 7897, the maximum amount of sulfate waste that can be disposed of is 3 g/L.⁵ Calcium Sulfate, also known as gypsum, is a contributing mineral to the primary sources of calcium in the environment.⁶

In Figure 2, we see the UV-Vis spectra of the copper sulfate solution before and after treatment as well as compared to a solution of the maximum concentration allowed to be disposed of. When comparing the spectrum of the solution before and after the treatment with calcium hydroxide we see that there is a reduction in the absorbance over the range of 600 nm to

900 nm in the IR spectrum. In Figure 3 the ultraviolet region of the before and after treatment spectrums are compared. It can be seen that there is a reduction in the absorbance.

A flame test was used to determine which metals may be present in a solution. Each metal has a distinct flame colour. The flame test results were consistent with the metal ions having been precipitated out of solution.

Calcium hydroxide can be potentially be used to precipitate out many different heavy metal ions. These ions include lead, nickel, zinc, silver, cadmium and copper. Many heavy metal have a specific pH for which they are most insoluble

Suppose there was a mixture of copper and nickel in solution. In order to precipitate out the both metal ions that is present in solution the treatment must be done in two steps. First calcium hydroxide is added until the pH of the solution is around 9. At a pH of 9, copper hydroxide has solubility around 0.001 mg/L while nickel hydroxide has a solubility of 0.1 mg/L. The copper hydroxide can be filtered out removing most of the copper in solution. The pH can then be changed to around 10.5 where nickel hydroxide is the most insoluble. The nickel hydroxide can then be filtered out resulting in a solution with copper and nickel level below the maximum concentration allowed for disposal into the municipal sewage system.³

Recommendation

Add calcium hydroxide to precipitate out many of the ions present in solution. Filter out the precipitate and dispose of waste. Send the labelled waste bottle to Dispensing Chemist or designate for disposal.

References

- 1) Parshotam, U. *General Chemistry I, Chem 120 Fall 2012 Laboratory Manual*. University of Northern British Columbia: Prince George, BC, 2012. p 5.1-5.4.
- 2) CRC Handbook of Chemistry and Physics, 90th ed. Lide, D.R., Ed.; CRC Press: Boca Raton, FL, 2010; Chapter 4, p 56-61.
- 3) United States Environmental Protection Agency. *Control and Treatment Technology for the Metal Finishing Industry Sulfide Precipitation*; Industrial Environment Research Laboratory: Cincinnati, OH, 1983: p 6.
- 4) Effluent Standards for Hazardous Waste Facilities. Environmental Management Act, Hazardous Waste Regulations; Queen's Printer: Victoria, BC, 2004; p 2-4
- 5) City of Prince George Sanitary Sewer Bylaw No. 7897. Prince George, BC, 2006; p 19
- 6) Manahan, S. E. *Water Chemistry: Green Science and Technology of Nature's Most Renewable Resource*; CRC Press: Boca Raton, FL, 2011; p 60-63.

Waters of Hydration (Chemistry 120, 2012)

Overview

The crystals that were produced in the copper sulfate lab are tested to determine the degree of hydration. The crystals are heated to remove any water present. A solution is then made up and tested against a calibration curve.

Procedure for Waste Treatment

While stirring slowly, add a 1 M calcium hydroxide solution until the pH is around 9. Continue stirring until the precipitate has stopped forming. Filter out the precipitate with a vacuum filter system.

Discussion

The waters of hydration waste can be treated the same way as the purification of copper sulfate waste. It is important that the waste be separated into its two components. The first

component consists of all of the copper sulfate containing waste. The copper sulfate is easy to treat. Copper hydroxide is very insoluble at a pH of 9.¹

The second part of the waste is generated from improper technique when heating the crystals. When done incorrectly, sulfur is produced rather than the dehydrated copper sulfate. Although the amount that will be produced is small it is best if it is kept separate from the rest of the waste.

If the waste is mixed by mistake it is still possible to treat. The sulfur waste concentration is not at a level where it will pose a major hazard. The sulfur product appears as a yellow residue when heating the crystals.

Recommendation

Keep sulfur waste separate from other waste from the lab. Treat majority of waste with calcium hydroxide. Send the labelled waste bottle to Dispensing Chemist or designate for disposal.

References

- 1) United States Environmental Protection Agency. *Control and Treatment Technology for the Metal Finishing Industry Sulfide Precipitation*; Industrial Environment Research Laboratory: Cincinnati, OH, 1983: p 6.

Chemical Equilibrium: Iron Thiocyanate Complex (Chemistry 121, 2012)

Overview

Different concentrations of potassium thiocyanate and ferric nitrate are mixed together to form a ferric thiocyanate complex. The resulting solutions are measured by UV-Vis spectroscopy to give a visual representation of equilibrium. This is possible because the complex formed produces a coloured solution.

Discussion

Treating this waste is more difficult than other wastes that are produced in first year labs. In solution one of the by-products that may be produced is hydrogen cyanide. The solution is safe because the hydrogen cyanide should stay in solution; however, when treated with sodium hypochlorite, there is a strong chance that it could escape as hydrogen cyanide gas. In order to treat this waste, a safe and efficient method for trapping the gas is necessary. Hydrogen cyanide gas is used in execution chambers and is extremely poisonous. This safety issue has prevented different methods from being tested due to the uncertainty of the reaction.

Recommendations

Replace this experiment with a different experiment that demonstrates equilibrium. The possibility of hydrogen cyanide gas makes the waste too dangerous to treat.

Vitamin C Drink (Chemistry 121, 2012)

Overview

A back titration of sodium thiosulfate is used to determine the concentration of vitamin C that is present in an unknown soft drink.

Discussion

The only hazardous component of the vitamin C drink waste is the iodine that forms a complex with the starch indicator. The iodine can be treated with sodium thiosulfate which is the titrant in this experiment. In theory the student only need to add the excess sodium thiosulfate from their burette in order to treat this waste. There are several unknowns that come about with the treatment. When treated, an unknown precipitate forms in solution. The precipitate is too fine to be filtered out and analyzed without specific equipment. Different analysis techniques such as mass spectrometry are required to analyze the precipitate that forms. After a certain time the sodium thiosulfate begins to precipitate out and the iodine begins to form again. This reaction is visible as the solution will turn from the treated clear solution back to the dark blue iodine solution with the starch indicator.

Recommendations

This waste treatment technique needs further testing. A different method should be examined so that iodine is not used. The iodine is being constantly generated and as a result is difficult to treat.

Bromination of Phenol (Chemistry 121, 2012)

Overview

Bromic acid is mixed together with phenol and methyl red indicator. The solution is then timed until the solution turns red.

Discussion

The two hazardous products that are present in the waste are phenol and tribromophenol. The phenol can be oxidized with potassium permanganate to make hydroquinone, catechol, and

other oxidation products which are less hazardous. The concern with treating this lab is how the tribromophenol will react upon undergoing oxidation.

Recommendation

It is not clear whether or not the oxidation products are more hazardous than the tribromophenol. Since the waste cannot be treated safely it is better to send the waste away for disposal.

Iodine Clock (Chemistry 121, 2012)

Overview

A solution of potassium iodide, acetic acid buffer, sodium thiosulfate, and starch indicator is prepared. Various amounts of the solution are mixed with a hydrogen peroxide solution. The solution is timed until the starch iodide complex forms producing a dark blue colour.

Discussion

The treatment method that is used is similar to the treatment of the vitamin C drink waste. Iodine is the only waste that is hazardous that is present in solution. The iodine can be treated with sodium thiosulfate. When it is treated the waste turns to a colourless clear solution. It is necessary for the solution to undergo analysis before the solution can be washed down the drain. The recommended analysis tool to use is mass spectrometry.

Recommendation

Ship waste away as hazardous waste until further analysis on the method can be performed. Send the labelled waste bottle to Dispensing Chemist or designate for disposal.

Basic Laboratory Techniques (Chemistry 210, 2012)

Overview

Potassium permanganate is used as a dye for an aqueous solution. The coloured solution is used as an indicator so students can learn proper lab techniques. The dyed solution allows for spills to be identified more readily and to allow student to observe the effects of dilution visibly.

Discussion

The treatment process for the potassium permanganate solution is a prime example of how the “Hazardous Laboratory Chemicals Disposal Guide” does not fit into BC regulations. BC regulations clearly state that no solution can be intentionally diluted for the sake of disposal. The concentration of the manganese waste after rinsing glassware combining the other wastes present in the lab would result in more than 100 times the maximum concentration allowed to go down the sewer for manganese.¹

Recommendation

The potassium permanganate being used in the experiment is solely being used as a dye and not as an analytical tool. With the potassium permanganate acting in such a way, it can be switched with something less hazardous and biodegradable. Some possible substitutions are food dyes, grape juice or other types of chemicals that produce a coloured aqueous solution.

References

- 1) Effluent Standards for Hazardous Waste Facilities. Environmental Management Act, Hazardous Waste Regulations; Queen’s Printer: Victoria, BC, 2004; p 2-4

Statistical Analysis of Acids/Bases (Chemistry 210, 2012)

Overview

Several indicator dyes are tested by titrating TRIS solutions with hydrochloric acid. The indicators that are used consist of phenol red, methyl red, methyl orange, bromothymol blue, bromocresol green, and phenolphthalein.

Discussion

For the waste generated for this lab, the primary concern is the LD₅₀ values for the different indicators present in solution. A substance is classified as toxic by the Transportation of Dangerous Goods Regulations if the oral LD₅₀ is less than or equal to 300 mg/kg. A substance is dermally toxic if the dermal LD₅₀ is less than or equal to 1000 mg/kg. A substance is considered toxic by inhalation if it meets one of two requirements. The first is if the LC₅₀ is less than or equal to 4 mg/L. The second requirement is if vapour LC₅₀ is less than or equal to 5000 mL/m³.

Recommendations

All of the dyes meet the requirements for being non-hazardous. None of the dyes are listed in the Transportation of Dangerous Goods Regulations. With this waste the solutions should be neutralized individually and analyzed before being disposed to sewer by the Dispensing Chemist or designate.

References

- 1) Transportation of Dangerous Goods Regulations; Danatec Educational Services: Calgary, Alberta, 2012; p 67-72.

Synthesis of Acetaminophen (Chemistry 250, 2012)

Overview

Acetaminophen is synthesized from acetic anhydride and 4-aminophenol. The crystals of acetaminophen are then recrystallized in a 50% ethanol solution.

Discussion

The waste that is produced with the synthesis of acetaminophen contains 4-aminophenol and trace amounts of acetaminophen. The waste was treated in two different ways.

The first method is divided into two steps. In the first reaction, the waste reacts with sodium hydroxide. This reaction is left to occur overnight. This method is used to treat the acetic anhydride. The 4-aminophenol was the limiting reagent in the reaction and theoretically should have been completely reacted; however this is not the case. The result of this treatment is the formation of a dark black precipitate. The solution was then treated with potassium permanganate and sulfuric acid solution followed by a sodium bisulfite solution. The result was a slightly yellow solution with precipitate present. Several tests such as flame test, solubility test and melting point were used to help identify the products that formed at each step of the first treatment. The tests proved to be inconclusive and the waste produced still remains unidentified.

The second method of treatment is similar to the first treatment without the sodium hydroxide step. The result is the solution turns a bright orange with no precipitate. The solution was tested with the flame test but the products were not identified.

Recommendation

The unknown substance that resulted in from the treatment has not yet been determined. Further analysis is required before the treated waste can be determined non-hazardous.

Extraction of Caffeine from Tea (Chemistry 250, 2012)

Introduction

Caffeine and other products are extracted from various kinds of tea leaves including green tea, pekoe orange, black tea and china black tea. The Liquid-liquid extraction are then used to remove the caffeine for crystallization and weighing.¹

Procedure for Waste Treatment

The aqueous phase of the liquid-liquid extraction is neutralized using 1 M hydrochloric acid. If the neutralization mark is missed then a 5% sodium carbonate solution can be used.

Results

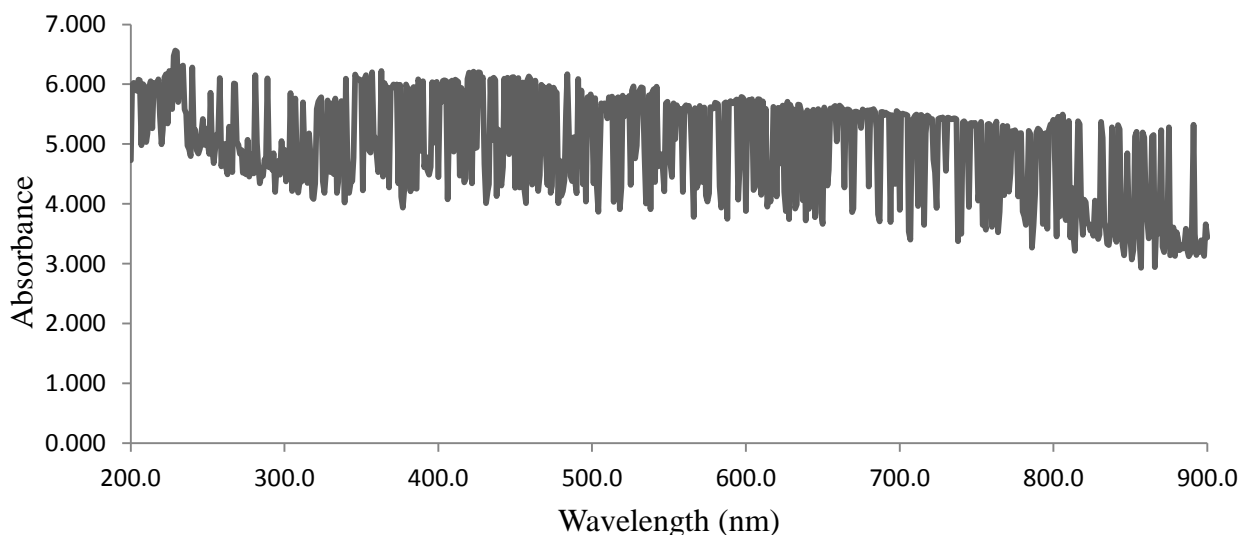


Figure 3: UV-Vis Absorption of caffeine extract waste from tea leaves after neutralization

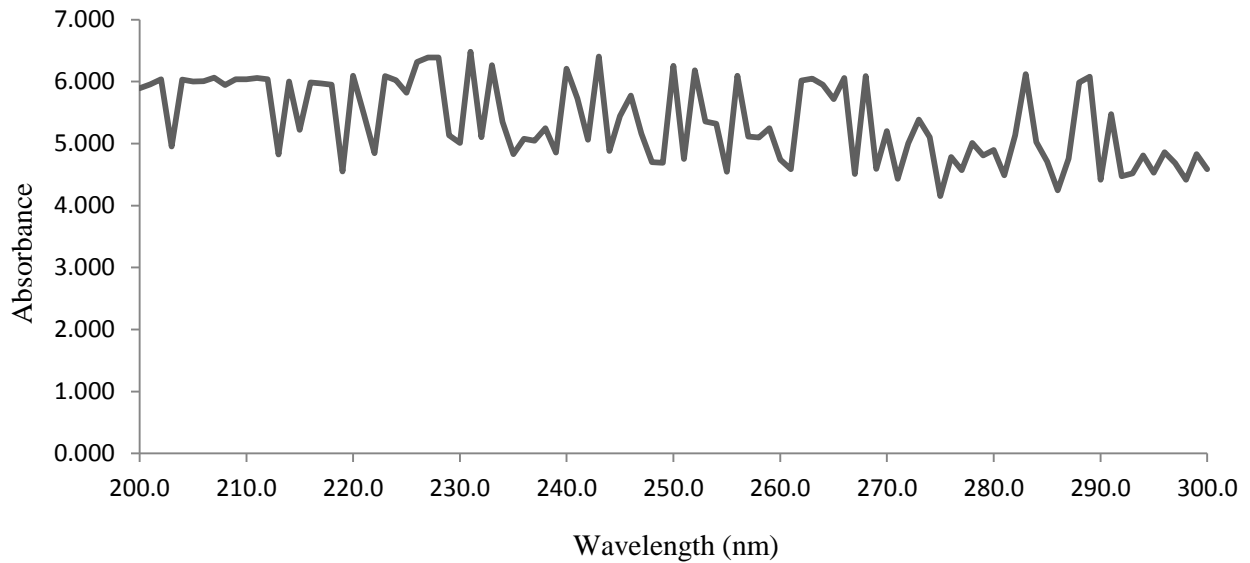


Figure 4: Spectrum of the absorbance of the caffeine filtrate in the ultra-violet region

Discussion

With the aqueous waste that is produced the only hazardous chemical is the caffeine. Of the various types of tea that is used in the experiment the one containing the most caffeine is black tea. The amount of caffeine that is present in a one cup of black tea is 47 mg.² For comparison one cup of Red Bull™ is 77 mg per cup.³ This amount of caffeine is almost double the amount caffeine present in the tea. These concentrations are the caffeine level before extraction and dilution are taken into account. Since Red Bull can be consumed and poured down the drain legally and safely, then the same can be said for the caffeine extraction waste.

In Figure 3 and 4 we see the UV-spectra of the filtrate solution after it has been neutralized. The spectrum reveals that the solution is impure and is composed of chemicals more than just caffeine. The UV-Vis spectrum provides inconclusive data on the amount of caffeine present in solution.

Recommendation

The caffeine solution generated from this experiment must be neutralized before being poured down the drain by Dispensing Chemist or designate.

References

- 1) Hall, A. *Chemistry 250 Lab Manual*. University of Northern British Columbia: Prince George, BC, 2012. p ex4.
- 2) Black Tea, 2011. US Department of Agriculture. Ndb.nal.usda.gov.
<http://ndb.nal.usda.gov/ndb/foods/show/4238?fg=Beverages&man=&lfacet=&format=&count=&max=25&offset=125&sort=&qlookup=>. (accessed July 8, 2013)
- 3) Red Bull, 2011. US Department of Agriculture. Ndb.nal.usda.gov.
<http://ndb.nal.usda.gov/ndb/foods/show/4159?fg=Beverages&man=&lfacet=&format=Abridged&count=&max=25&offset=&sort=&qlookup=red+bull> (accessed July 8, 2013)

S_n1 Reaction (Chemistry 250, 2012)

Overview

2,5-dimethyl-2,5-hexanediol undergoes a reaction with hydrochloric acid. Through this S_n1 reaction the resulting product is 2,5-dichloro-2,5-dimethylhexane.

Discussion

This lab should be replaced with a different experiment. The purpose of the lab is to look at S_N1 reaction and understand how it works. From this standpoint the lab serves as an excellent learning tool for the reaction however it sets a bad example for waste production. The product that is formed is basically an unknown. No company makes it and, as a result, the toxicity of the compound has not been investigated. The MSDS sheet is very difficult to find and most sections on it state “not available”. This results in a safety issue not only for the Dispensing Chemist and Chemical Technician but also the students. If a spill occurs in the lab there is no way to determine how to deal with it safely or if the students will be in danger. The product, 2,5-dichloro-2,5-dimethylhexane, is a halogenated waste.

Recommendation

This teaching lab should not be used as there are safety risks that are associated with the lab. This lab should be replaced with an S_n1 reaction where the final product is well characterized and is either a non-hazardous material or a compound that can be safely treated with established protocols.

Contaminated Lab Debris Disposal

A significant issue is that the university is exporting waste barrels containing low density contaminated materials (e.g., paper towels, gloves, microtubes). As a result some waste barrels are leaving UNBC greatly under the maximum weight permitted per barrel (450lbs). A solution identified for this issue was to compress the bags of gloves using a shop vacuum.

A test packing was performed with for proof of concept using ethidium bromide contaminated materials. Ethidium bromide is a known mutagen, but was selected for its low vapor pressure and high ignition temperature. The vacuum used has a HEPA filter attached to the exhaust as well as an additional exhaust hose to control airborne contaminants. The empty drum mass was 14.2kg and with an initial fill of partially compressed bags weighed 36.2kg. After vacuum packing, the drum weighed 39.4kg, indicating an increase of 12.7% in the mass of the waste contained. Several of the waste packages did not compress appreciably, either due to sharp items poking through the vacuum package or because the package contained large incompressible items. Further packing is possible with additional practice.

Each drum of contaminated debris waste costs \$220, and in 2013 seven of these drums were shipped, two of which contained ethidium bromide contaminated waste. The goal for 2014 is to reduce the total drums sent by one drum by utilizing vacuum packing.