GREEN / SUSTAINABLE CHEMISTRY: CHEMICAL WASTE MANAGEMENT IN HIGH SCHOOL

Zahra Arzani [a]
[a] Beheshty School, Azymeyeh Mehran squre, Bostan, Karaj, Iran
[a] Corresponding author: Zarzani2111@yahoo.com

 ISSN: 1923-6654 (print)
ISSN 1923-6662 (online). Available at http://www.ssrn.com/link/OIDA-Intl-Journal-Sustainable-Dev.html

Abstract: Lab experiments are a way to help students interact with the principles of chemistry and understand how the information from their textbook looks in real-life scenarios. In some places, high school teachers mostly use quick demonstration such as the Ammonium Dichromate self-decomposition, commonly called the " volcano". Another popular high-interest experiment is using different salt solutions to create different chemical reactions and different colored precipitates such as lead iodide, silver chloride, barium sulfate and silver chromate. Most of the chemicals which let over in these experiments are toxic and the way of disposal is very important. The objective of the research was founding the safe way to dispose chemical waste in the study area, with no disposal collecting system, and environment protection. To do this, Questioner form was produced about how teachers deal with chemical waste materials in their laboratories in sample high schools in Albors province of Iran. The results showed all labs in my research statistical population were dump chemical waste in rubbish bin or sink. In terms of keeping environment clean three suggestions were made: (a) Using less chemical in each experiment (b) proposing a set of reactions in each case to convert the waste to starting material (c) Lastly cooperate with companies which are nearby to collect the waste (Companies how need those compound as starting material). The survey was then sent to high school science chairpersons across the state of Alborz. Also a groups of teacher in curriculum center has been formed to write a laboratory manual for high school chemistry courses which explained how to manage chemical waste too. Also I found that virtual laboratory is not as effective as practical laboratories.

Keywords: Chemical Waste, Sustainability; Waste management, High School Chemistry Laboratory, reuse

INTRODUCTION

Because laboratories are accepted by most educators to be a necessary component of any science high school curriculum, the construction and operation of a safe science laboratory is an area that should be researched and given a great deal of consideration. At the high school level, students can move beyond the simplistic chemistry experiments that they did in earlier grades, like those that involved adding food coloring to water or mixing together vinegar and baking soda in order to create a reaction. High school chemistry science projects and activities can explore more deeply the compositions of substances, their properties and how substances interact. By doing these kind of experiments, the main point is how to deal with chemical waste which are sometime toxic to human been. In addition according to the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil, in 1992 also known as Agenda 21 and has been adopted by more than 178 governments for moving the world towards sustainable development there is a need for environmentally sound management of hazardous wastes (United Nations, 1992). Effective control of the generation, storage, treatment, recycling and reuse, transport, recovery and disposal of hazardous wastes is of paramount importance for proper health, environmental protection and natural resource management, and sustainable development (Sales, 2006). Walton suggests designing an experiment which disposal method of a product from a previous experiment (Walton,1987).organic synthesis has been

devised by Stradling and Gage in which Acetophenone is carried through several reactions, the products being used as starting materials until eventually an end product is produced which must be discarded.

Two main experiments have been done in all high school chemistry laboratories in the state of Alborz (in Iran): 1- the Ammonium Dichromate self-decomposition (AD), 2- mixing solution to have different colored precipitates of Cations (DCP). According to ScholAR Laboratory Safety in Chemistry Classroom Workshop Notes all heavy metals: including soluble, insoluble salts, solutions, and residues are Not Suitable for Trash or Drain Disposal (ref: 10). Therefore in this research the way of handling chemical waste of these two experiments were investigated.

METHOD

A hundred high schools were chosen randomly and a questioner was made to found out how many teachers doing AD and DCP experiments and how they deal with the wastes.

QUESTIONS

(1) How many years are you teaching chemistry in high school? (a) more than ten (b) more than fifteen (c) more than twenty (d) more than twenty five (2) Do you do the Ammonium dichromate decomposition (AD) experiment? (3) What are you doing with the waste in that experiment? (a) Collect in a bottle (b) throw in rubbish bin (c) reuse (d) other (4) Do you mix solution to have different colored precipitates of Cations (DCP) for showing reaction types? (5) What are you doing with the waste in that experiment? (a) Collect in a bottle (b) throw in rubbish bin (c) reuse (d) other

RESULTS

The Ammonium Dichromate decomposition becomes self-sustaining at 2250C, and the product raise quietly with the evolution of some sparks and Chromium Trioxide (Cr2O3), a greenish powder which is lifted up in part by the rising hot Nitrogen gas. Within a short time the entire Dichromate sample has decomposed and a volume of Cr2O3 many times larger than the original sample volume is left behind. Teachers believe AD experiment surprise and amuse high school age students. They also eveelib Students generally respond best to experiments that yield immediate and familiar results. In DCP experiments simply the two liquids react together, forming an aqueous solution and insoluble solid such as Silver Chloride or Lead Iodide which drops out of the solution as soon as the two liquids are mixed in a container together. The answers to questioners shows 95% of teachers using these experiments (AD and DCP) but most of them do not have idea about what to do with the wastes of them.

According to Material Safety Data Sheets (MSDS) (ref: 11) for potassium dichromate (VI) 0.02 M. One should cautiously acidify a 3% solution or suspension of the material to pH 2 with sulfuric acid. Gradually add 50% excess of aqueous sodium bisulfite (sodium hydrogen sulfate (III)) with stirring at room temperature. An increase in temperature indicates that a reaction is taking place. If no reaction is observed on the addition of about 10% of the sodium bisulfite solution, initiate it by cautiously adding more acid. If manganese, chromium or molybdenum present adjust the pH of the solution to 7 and treat with sulfide to precipitate for burial as hazardous waste. Destroy excess sulfide, neutralize and flush the solution down the drain.

DISCUSSION

By looking through the answers to questioner, founding the way to reuse of chemical waste produce in AD and DCP experiments will be necessary. Four suggestions were made: (a) Using less chemicals - One way to achieve waste reduction and disposal goals is by eliminating chemical waste at the source. Micro scale chemistry, currently have used for the general, organic, and inorganic chemistry. The process of conducting experiments with minute amounts of chemical to achieve the same results as those requiring large beakers of chemicals. The resulting reduction in disposal problems and safety hazards makes micro scale chemistry an attractive alternative to more traditional methods of educational experimentation (Stell j., 2001).

On the other hand, if using a micro scale experiments as a show, this does not have the visual impact that macro scale experiments have, in the same way that a 6 inch TV screen is less irritant than a 22 inch screen. Except each group of students can do the experiment by themselves. To make it easy, we use simple plastic bags instead of microplate as shown in Figure 1. (b) Proposing a set of reactions in each case to convert the waste to starting material (A): Chromium (III) oxide (A-1): Chromium Trioxide (Cr2O3), a greenish powder which is produced as Ammonium Dichromate decomposition (AD), can be converted to Potassium Dichromate by following reaction: Add sodium hydroxide solution to give first a grey-green precipitate and then the dark green solution containing [Cr(OH)6]3- ions. Oxidase this solution by warming it with hydrogen peroxide solution. The solution turns yellow as potassium chromate (VI) is formed.

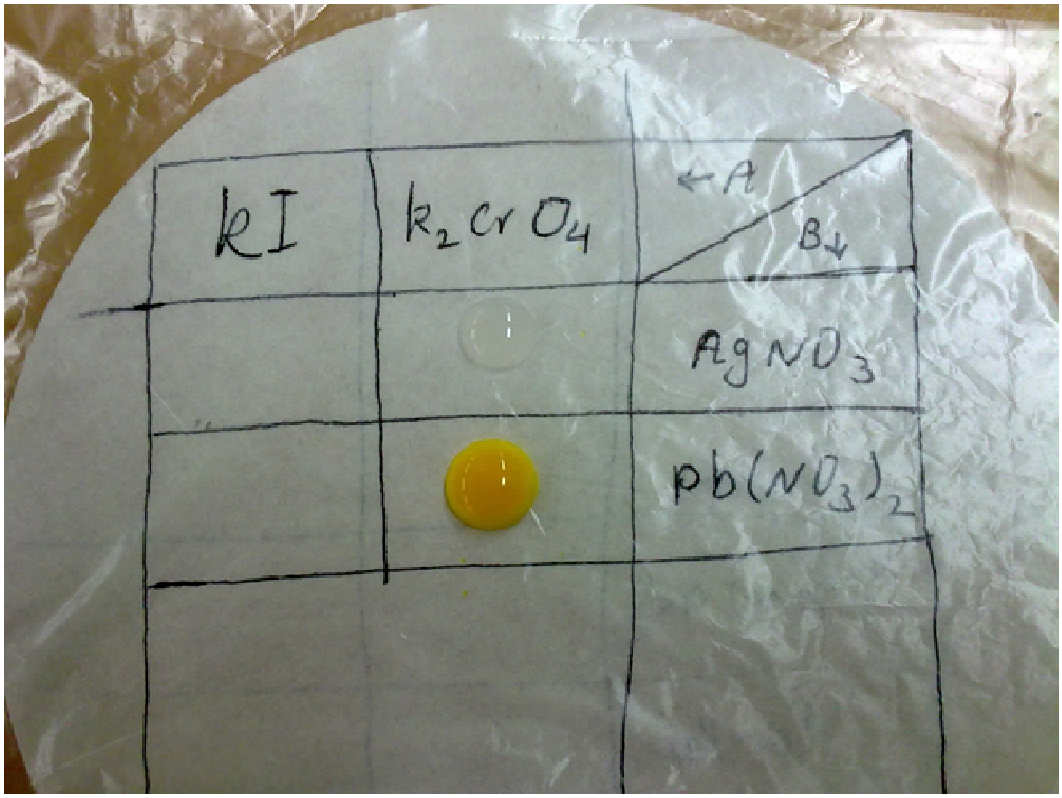


Figure 1: Plastic bags used instead of microplates

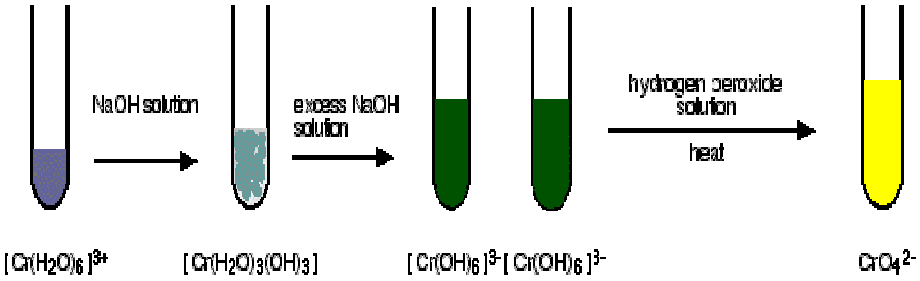
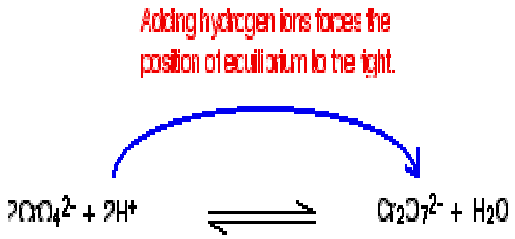


Figure 2: Set of reactions to convert waste to starting material

All that is left is to convert the yellow potassium chromate(VI) solution into orange potassium dichromate(VI) solution. That is done by adding acid



Unfortunately there is a problem here. Potassium dichromate will react with any excess hydrogen peroxide to give initially an unstable deep blue solution and it eventually gives the original chromium (III) ions again! To get around this, one first needs to destroy any excess hydrogen peroxide. This is done by boiling the solution. Hydrogen peroxide decomposes on heating to give water and oxygen. The solution is boiled until no more bubbles of oxygen are produced. The solution is heated further to concentrate it, and then concentrated ethanoic acid is added to acidify it. Orange crystals of potassium dichromate are formed on cooling.(ref 11+ 12)
A-2: Chromium oxide can be converted into elemental chromium metal through a thermite-like reaction: unlike iron oxide thermites, chromium oxide thermites creates few or no sparks, smoke or sound, but glow brightly. Because of the very high melting point of chromium, chromium thermite casting is impractical. However when heated with finely divided aluminium or carbon, it is reduced to chromium metal and aluminum oxide (ref : 19).

$Cr_2O_3 + 2\ Al \rightarrow 2\ Cr + Al_2O_3$

Lead Iodide

In DCP experiments simply the two liquids react together, forming an aqueous solution and insoluble solid such as mixing Lead nitrate with potassium Iodide which yellow precipitate (Lead Iodide) drops out of the solution as soon as the two liquids are mixed in a container together.

$$Pb(NO3)_2(aq) + KI(aq) \rightarrow KNO_3(aq) + PbI_2(s)$$

The lead iodide is a toxic compound and should be handled with care. We need to know that it is poisonous and when mixed with water it might cause instant deaths. Lead Iodide is converted to Lead nitrate and Iodide: Lead iodide is treated with nitric acid in a flask equipped with thistle tube and gas exit tube. The evolving gas is conducted into a flask containing water. The water traps any iodine which escapes the reaction flask as vapor. Heat is applied if necessary to initiate reaction. At first nothing happens, and then the lead iodide begins to disappear, the solution turns brown and violet vapors of iodine are observed as well as brown nitrogen dioxide. The lead nitrate-iodine solution is chilled and filtered to produce a brown solution of lead nitrate and solid iodine. The brown lead nitrate solution is extracted with cyclohexane to yield a colorless nitrate and iodine in cyclohexane.

$$PbI_2(s) + HNO_3(aq) \rightarrow Pb(NO_3)_2(aq) + I_2(s) + NO_2(g)$$

Nitrogen dioxide is carcinogen and the system should be completely closed.

Silver Chloride

$$NaCl(aq) + AgNO_3(aq) \rightarrow NaNO_3(aq) + AgCl(s)$$

Another DCP experiment is mixing silver nitrate with sodium chloride to make a white precipitate. By following reactions silver chloride is converted to silver nitrate again: Adding ammonium hydroxide to precipitate and then iron powder will give silver. Silver metal oxidize very easily and turn to silver oxide. Addition nitric acid will give silver nitrate and water.

$$AgCl(s) + NH_4OH(aq) \rightarrow Ag(NH_4)_2Cl(aq) \xrightarrow{Fe} FeCl_{2(aq)} + NH_4Cl(aq) + Ag(s)$$

.

$$Ag_2O + HNO_3 \rightarrow AgNO_3 + H2O$$

These experiments in which compounds are carried through a series of reactions producing remarkably different products, and then is regenerated, has an obvious educational advantage too.

Cooperate with companies which are nearby to collect the waste (Companies how need those compound as starting material).

Chromium Trioxide (Cr_2O_3) is used in different companies. It was used as a pigment. It dissolves in acid to produce chromium (III) salts, such as chromium(III) chloride. Stainless steel's corrosion resistance is based on this compound. A thin layer of this compound forms on the surface of the stainless steel. It prevents the rest of the steel from oxidizing.

Chromium Trioxide can be used as a catalyst for oxidation of ammoina to form Nitrogen monoxide and thence to produce nitric acide.

4NH3(g) + 5O2(g) ⟶ 6H2O (g) + 4NO(g)

I am working in this part with glass company and ….. the result is not known yet.

virtual lab: Chemistry is an experimental science that is most effectively learned through direct experience. Therefore, while computer simulations may be useful to extend or reinforce chemical concepts, they are not adequate substitutes for direct “hands-on” laboratory experience. The laboratory program that is adopted should challenge every student’s ability to: •think analytically and to reduce problems to identifiable, answerable questions; •understand problems expressed as experimental questions; •design and carry out experiments that answer questions; •manipulate data acquired during an experiment — perhaps even to guide progress; •make conclusions and evaluate the quality and validity of such conclusions; •propose further questions for study; and • communicate accurately and meaningfully about observations and conclusions• communicate accurately and meaningfully about observations and conclusions.

The subject of Exothermic and endothermic was touched by using practical lab and virtual lab. The opinion of student after word was collected: Student a: both methods were good but experiment in virtual lab is the same as driving a car in computer's game. Student b: I enjoy both but I feel much better in practical lab and it was more exciting than virtual one.Student c: For me reading " The see sand is so soft is not enough, my foot would like to feel it".

CONCLUSION

Chemistry, the study of matter and its forms, is a branch of science that is extremely hands-on. For many, it is associated with flashy reactions involving color changes and other observable phenomena. High school chemistry is often the first introduction that students receive to the field, so careful choice of demonstrations is crucial. For this reason, a solid repertoire of experiments and activities is important to increase student interest and learning in high school chemistry. In Alborz’s high school most of the teachers in topic of reaction types using The Ammonium Dichromate decomposition (AD) and different colored precipitates of Cations (DCP). But the problem is these reactions will end of with chemical wastes which are not safe to environment. Since there were no collecting chemical disposal system in our schools, so founding the safe way of handling the waste is very important. The proposed methods were sent to high school science chairpersons across the state of Alborz. Also a group of teachers in curriculum center has been formed to write a laboratory manual for high school chemistry courses which explained how to manage chemical waste too. By considering waste disposal, the pattern of responsibility for waste is implanted in the student mind. They are learning an attitude: One must be responsible for one's actions. They have an environmental awareness and should respond very positively to this program.

REFERENCES

[1] Sales M.G.F. at al, A waste management school approach towards sustainability, Resources, Conservation and Recycling, Volume 48, Issue 2, 15 August 2006, Pages 197-207
[2] Stell, Jeannie Microscale chemistry. Oil & Gas Journal 99. 41 (Oct 8, 2001): 17.
[3] Stradling, S. and Gage, C., J Chem. Educ., 1116 (1985)

[4] Walton, W.A., J Chem Educ., A69 (1987)
[5] Waddell Dave, Local Hazardous Waste Management Program in King County, Publication Number SQG-LABS-1 rev. 8/06 August 2006.
[6] No- Waste Lab Manual for Educational Institutions, Prepared by College of the Redwoods Under a Grant From California Department of Toxic Substances Control
[7] United Nations. Our common future (The Brundtland Report). Report of the World Commission on Environment and Development. Oxford, England; New York: Oxford University Press, 1987. p. 383, UN Library (NY).
[8] United Nations. Department on Economical and Social Affairs, Division for Sustainable Development, Agenda 21, Programmed of action for sustainable development, Rio Declaration on Environment and Development, Statement of Forest Principles: the final text of agreements negotiated by Governments at the United Nations, Conference on Environment and Development (UNCED), 3–14 June 1992, Rio de Janeiro, New York: UN, 1993, p. 294.
[9] United Nations, 2002. Report of the World Summit on Sustainable Development, Johannesburg, South Africa, 26 August–4 September 2002. United Nations, New York, 2002, p. 173. A/CONF.199/20 United Nations, Publication ISBN 92-1-104521-5.
[10] Laboratory Safety in Chemistry Classroom: www.scholarchemistry.com
[11] http://chemistry.slss.ie/resources/downloads/ph_sd_md_potassiumdichromatecrystals.pdf
[12] http://www.chemguide.co.uk/index.html --- Jim Clark 2009 (last modified November 2011
[13] Safety Regulations in High School Chemistry Labs | eHow.com http://www.ehow.com/about_5057331_safety-high-school-chemistry-labs.html 2011/12/22
[14] http://www.nyu.edu/ehs/waste.disposal/lab.waste.html
[15] http://www.nap.edu/openbook.php?record_id=4911&page=139
[16] http://en.wikipedia.org/wiki/Lead%28II%29_iodide
[17] http://www.britannica.com/EBchecked/topic/333615/lead-iodide
[18] www.elmhurst.edu/~chm/demos/colorchangpowder.htm
[19] http://simple.wikipedia.org/wiki/Chromium%28III%29_oxide
[20] CHEMISTRY ,Course Description ,E f f e c t i v e F a l l 2 0 1 0 The College Board
[21] Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards, Updated Version, The National Academies Press at http://www.nap.edu/catalog.php?record_id=12654