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Modifications in Qualitative Analysis to Support Green Lab Practices.

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Abstract: Green Chemistry is an attempt made to minimize the harmful impact of chemicals on the environment by adapting to methods that are inherently non-toxic. The rapid technological development has increased global warming and the chemical industry has a significant contribution to this. We at Bhavan's Vivekananda College, Sanikpuri, Hyderabad, have taken a small step to minimize the usage of hazardous chemicals/procedures in our chemistry practicals for the undergraduate students. The green methods have been implemented in inorganic qualitative and quantitative analysis. Making small changes in our analytical protocol has made an overall impact to make our practicals green while imparting these concepts to students and sustaining the motive of inorganic analysis.
Keywords: Qualitative analysis, hazards, minimize, Green.

I. INTRODUCTION

Anastas and Warner[3,4] father of green chemistry had made efforts at reducing risk to human health from chemicals have focused on reducing the probability and magnitude of exposures. Green chemistry takes a different approach. Green chemistry is based on 12 principles. Our main focus is based on the following three principles.
1) Prevention
2) Real-time analysis for Pollution Prevention
3) Inherently Safer Chemistry for Accident Prevention

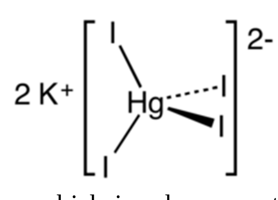
II. SIGNIFICANCE

The inorganic practical session includes semi-micro analysis, where students qualitatively analyze the ions present in the given salt mixture. The analysis involves
1) Identification of certain metals ions that are hazardous
2) Use of certain reagents that are hazardous
3) Certain procedures that are not eco-friendly.

Therefore, we have minimized or stopped the use/identification of such reagents/metal ions.
Following changes were made in our semi-micro analysis to make our lab course more eco-friendly, while imparting the concept.

III. METHODOLOGY

A. Nessler's Reagent replaced by Curcumin Solution
Formula:



1) *Side Effects:* Nessler's reagent contains Mercury, which is a heavy metal and it is hazardous. When in direct contact with humans, it causes certain ill effects on inhaling, contact with skin and eye. An average lethal dose for inorganic mercury salts is about 1 gram. When exposed to high limits, may lead to irritation in the mouth and pharynx and eyes, abdominal pain, vomiting and causes ulcers. Prolonged exposure may lead to vision impairment
2) *Substituted By:* Curcumin is an amber coloured chemical produced by turmeric (Curcuma longa). Chemically, it is a curcuminoid. It is known for its herbal properties. It is widely used as a herbal supplement, cosmetic ingredient, food flavoring, and food colorant. The yellow colour of turmeric is due to curcumin - a diarylheptanoid, belonging to the group of

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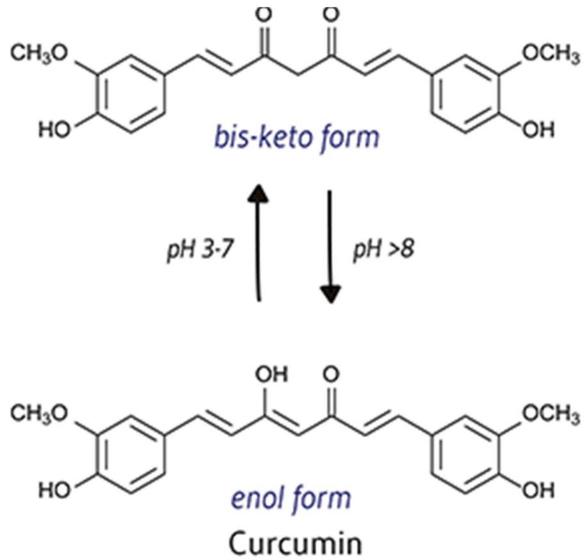
curcuminoids, which are natural phenols. It is a tautomeric compound existing in keto form in acidic medium and enol form in basic medium. This is the concept used in the identification of ammonium ions in qualitative analysis.

3) *The Reaction of Curcumin:*



4) *Conclusion:* Curcumin has no side effects, therefore exposure to curcumin solution is harmless compared to the Nessler's reagent. Not to mention its medicinal properties, as an anti-cancer agent, anti-inflammatory and antioxidant**.**

B. Hydrogen sulphide replaced by Thioacetamide[2]

Formula: H_2S

1) *Side Effects:* Hydrogen sulfide is a colorless, highly flammable and explosive gas. Hydrogen sulfide is absorbed through the lungs. Exposure by any route can cause systemic effects. Fatigue occurs at high concentrations and at continuous low concentrations. Continuous exposure at very low concentration can cause skin allergy and burning eyes. Direct contact with the liquefied gas can cause frostbite.
2) *Substituted by:* Thioacetamide is a thiocarbonyl compound. It is used as a source for H_2S. In qualitative analysis, the ions of Groups II and Groups IV are separated by precipitation of their insoluble sulfides. The sulfide ion is furnished by the weak electrolyte gaseous hydrogen sulfide. Generally, H_2S preparation is a tedious process. An alternate method for using H_2S without fuming the lab is using thioacetamide. In the laboratory, hydrogen sulfide is prepared by hydrolyzing thioacetamide. This method of generating the hydrogen sulfide is very convenient and is used to minimize the presence of the highly toxic and the rotten egg smelling gas in the environment. It promotes the formation of more easily handled sulfide precipitates

$$\underset{\textit{thioacetamide}}{CH_3\overset{S}{\overset{\|}{C}}NH_2} + H_2O \rightleftharpoons \underset{\textit{acetamide}}{CH_3\overset{O}{\overset{\|}{C}}NH_2} + H_2S$$

3) *Conclusion:* Use of Thioacetamide minimizes the exposure to H_2S.

C. Analysis of heavy metals[1]:

The qualitative analysis also involves the identification of cations from various groups. The cationic analysis includes heavy metals as a part of the analysis. Heavy metals like lead, tin, mercury, antimony, cadmium were usually analysed. But due to the ill effects of these heavy metals, we at Bhavan's Vivekananda College, Sanikpuri, have avoided their analysis in the undergraduate chemistry practicals.

1) *Effects of Heavy metals is as Follows:* Lead has major effects on different parts of the body. Lead distribution in the body initially depends on the blood flow into various tissues and almost 95% of lead is deposited in the form of insoluble phosphate in skeletal bones.

When the test solutions containing lead are disposed of, lead and its compounds can contaminate the water.

Mercury is considered the most toxic heavy metal in the environment. Mercury has the ability to combine with other elements and form various amalgams. Exposure to elevated levels of mercury and its amalgams can damage the brain, kidneys and the developing fetus.

Cadmium is highly toxic and it affects the kidney. Cadmium can cause bone mineralization. When compared to other metals, cadmium and its compounds are highly water soluble. They are readily absorbed and so tends to bioaccumulate. Ineffective disposal of cadmium solutions causes environmental pollution.

Tin is a soft, pliable, silvery-white metal. It is not easily oxidized and resists corrosion because it is protected by an oxide film. The exposure to tin residues can cause eye and skin irritations, headaches, stomachaches, sickness and dizziness, severe sweating, breathlessness.

2) *Conclusion:* Avoided the identification of heavy metals to make our practicals greener.

D. Analysis of Nitrates and Halides Have Been Modified

The analysis of nitrates & halides has been modified to avoid fuming of the lab with harmful gases.

1) *Nitrates*

a) *Actual Test:* The nitrate ion can be analysed by heating copper turnings in presence of concentrated sulphuric acid. Brown, pungent gas is evolved. The reaction is as follows: Sulphuric acid reacts with the nitrate ion to form nitric acid. Nitric acid then reacts with the copper turnings to form nitric oxide. Nitric oxide is thus oxidised to nitrogen dioxide. This nitrogen dioxide is the brown gas that is liberated.

$Cu + 4\ HNO_3 \rightarrow Cu(NO_3)_2 + 2\ NO_2 + 2H_2O$

Nitrogen dioxide is a common pollutant and can irritate the skin, eyes, nose and throat. Breathing nitrogen dioxide can irritate the lungs causing coughing and shortness of breath.

b) *Modified test:* Salt mixture + copper pieces + conc. H_2SO_4 are reacted and the gas obtained is passed through a test tube having NH_4OH. By doing this we are converting the nitrogen dioxide to nitrate salts and water. This prevents the fuming of the lab and direct inhaling of the gas.

$2NO_2 + 2NH_4OH \rightarrow NH_4NO_2 + NH_4NO_3 + H_2O$

c) *Conclusion:* Thus by a small modification in the procedure, we have reduced the exposure of the students and the staff to a harmful gas.

2) *Halides*

a) *Actual Test*: Halides were identified by heating the salt mixture with manganese dioxide and concentrated sulphuric acid.

The reaction is:

$MnO_2 + 2NaCl + 2H_2SO_4 \xrightarrow{t°C} MnSO_4 + Cl_2 + Na_2SO_4 + 2H_2O$

There is liberation of halogen gas which fumes the lab and unwanted exposure to manganese sulphate.

To control the exposure to the halogen gas and manganese sulphate the test was modified a little.

b) *Modified test:* Salt mixture is reacted with conc. H_2SO_4 and the gas obtained is passed through a test tube having NH_4OH. By doing this we are converting the chlorine to ammonium chloride and it is less harmful. This also prevents the fuming of the lab and direct inhaling of the gas.

E. Discarding the test solutions: The qualitative analysis involves the use of concentrated acids like sulphuric acid and nitric acid. Initially, we used to dispose of the test solutions into the sink. Disposing these acids into the sink causes corrosion of sanitary ware, pollutes the drainage and ultimately enters the soil.

To prevent this contamination, we modified the disposal procedure. We now collect all the test solutions into a bucket of 10 liters of water and then we check the pH and neutralize it with a base accordingly.

For e.g.: If the collected waste has a pH of 5, then we need to neutralize it with base (10% NaOH).

F. Fume hood: Most of these tests are done in the fume hood to keep our lab green.

G. Wastewater from distill water plant: All the semi-micro analysis requires distill water to minimize the effect of interference of ions present in the water.

In the process of distillation, a lot of water is wasted. This wastewater is collected, cooled and used to water our plants.

IV. SUMMARY & CONCLUSION

The revised lab procedures is an attempt to continuously strive to make our lab practices more green. By avoiding harmful chemicals, we are creating a safer environment in the lab and surroundings.

These green practices help us to maintain a better lab quality.

Beyond serving as a tool for chemists, this paper highlights the need for a transformation in setting up guidelines for general lab practices.

It is our hope that such efforts, which lie at the interface of green chemistry, will help lead to a new generation of inherently safer lab methods.

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