• Учебни опити и демонстрации •
• Teaching Chemical Experiment •

COST EFFECTIVE MICROSCALE GAS GENERATION APPARATUS

Metodija NAJDOSKI, Sasho STOJKOVIKJ
Sts. Cyril and Methodius University, MACEDONIA

Abstract. A new method for microscale gas generation is described. The best way of performing this method is as a hands-on experiment. The microscale gas generation apparatus consists of a plastic test tube closed with half-cut pipette bulb and a syringe with a needle. In order to observe the reaction of the generated gas with some reagent, the pipette tubing can be introduced into a second test tube. Using this method, many gases such as carbon dioxide, chlorine, oxygen, hydrogen, ammonia, sulfur dioxide, hydrogen chalogenides, hydrogen cyanide, some hydrides and acetylene can be generated. The proposed method for microscale gas generation is safe, simple, cheap and attractive.

Keywords: gas generation, hands-on experiments, teaching chemical experiment, microscale experimentation

Introduction

From the XVIIth century up today many ideas and apparatuses for gas generation were proposed and some are still used. Most famous is the traditional Kipp's apparatus which is still in practical use in many school laboratories.

Microscale chemistry has many advantages:[1)] saves time for preparation, clears away and reduces waste, is safer, and lowers the cost of the experiment. Due to this fact contemporary gas chemistry experimentation is done at a microscale level. Microscale apparatuses are simpler and easier for construction and even have higher efficiency in student's motivation in learning chemistry than the traditional. Many eminent chemists have contributed to the development of new methods for microscale gas generation. Professor Hubert Alyea introduced gas generation with syringes [1], Obendrauf et al. proposed numerous methods for gas generation in a test tube with a syringe for reactant introduction and with another syringe for gas collection [2-5]. Mattson et al. who were also using syringes contributed with their ideas [6-8]. An important part of microscale experimentation is essentially based on the: construction of a small-scale and low-cost gas apparatus [9] and a microscale gas generator [10]. Such ideas are easily amenable to new experiments.

Laboratory work, which is a part of the education in chemistry in every primary and secondary school, is formally divided in experiments to be demonstrated by the teacher and hands-on experiments by the students. In our experience, the latter are not abounded enough. The gas generation experiments are now, mainly, demonstration experiments, for one class or group of students. Due to the high cost and fragile nature of the traditional apparatuses only the teacher can handle with them. In order to change this experimental method, a novel method is proposed in this article.

Experimental

Materials and equipment

The needed materials for the experiment for gas generation are: two test tubes (12 mm/75 mm) (**a**), gypsum stand (**b**), plastic pipette (**c**), small spoon (**d**), 2 mL syringe (**e**), syringe needle (1.2 mm/40 mm) (**f**), scissors (**g**), sticky tape (**h**), cutting pliers (**i**) and they are shown on Fig. 1.

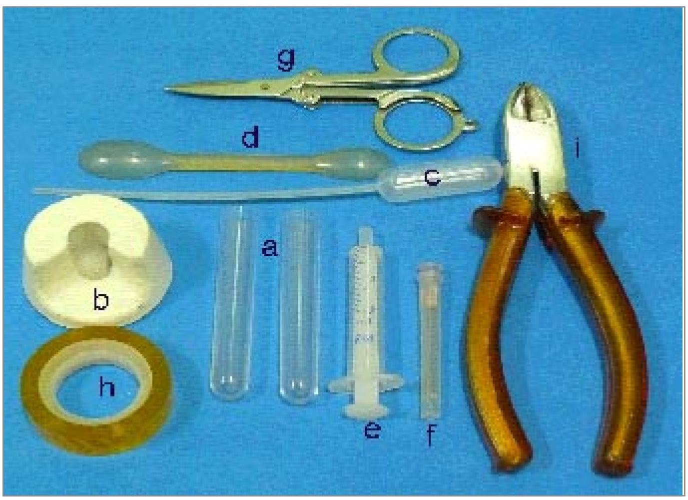

Fig. 1. Materials needed for apparatus assembling

The needed chemicals for this experiment are: ~ 2 g calcium carbonate, ~ 2 mL of 2 mol/dm^3 hydrochloric acid and ~ 3 mL fresh lime water.

Performing the experiment

The microscale gas generation apparatus assembling starts by inserting the calcium carbonate in a test tube using small spoon. Pipette bulb is half cut with scissors and than is pierced through with a syringe needle as shown on Fig. 2.

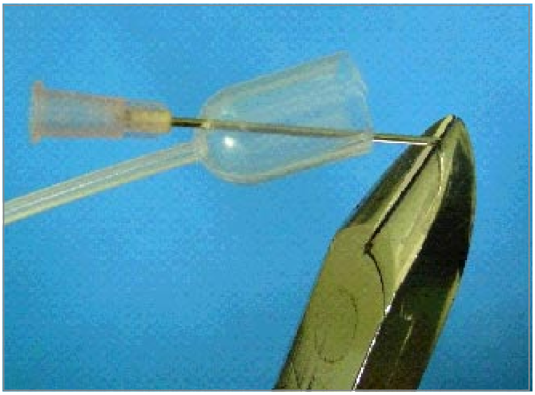

Fig. 2. Cutting needle's tip

For safety reasons syringe needle's tip must be cut off with cutting pliers (cf. Fig. 2). Then, the first test tube is inserted into the cut pipette bulb as it is shown on Fig. 3. The first and the second test tube are held together with a sticky tape. The second test tube is filled with lime water up to 1/2 of its volume. Pipette's tubing is bent and inserted inside the second test tube. The syringe is filled with 2 mL of hydrochloric acid and it is connected with its lure connector with the needle (not to be removed from the pipette bulb). The apparatus is ready for carbon dioxide generation. Assembled apparatus can be placed on a stand (Fig. 3) or it can be held in student's hands (Fig. 4).

The hydrochloric acid should be added drop by drop into the test tube. The evolved gas is introduced into the second test tube with lime water which soon is getting turbid. A key fact that should be mentioned here, for the reader who will perform the experiment for the first time, is that the test tube diameter should tightly fit inside the cut pipette bulb. If they don't match, the gas will leak at this joint.

Fig. 3. Assembled apparatus placed on a stand

Fig. 4. Assembled apparatus held in hands

Results and discussion

The apparatus can be used for generation of significant number of gases as the following: oxygen (H_2O_2 in the syringe, MnO_2 in the test tube), hydrogen (HCl in the syringe, Zn in the test tube), ammonia ($NH_4Cl(aq)$ in the syringe, NaOH in the test tube), sulfur dioxide (H_2SO4 in the syringe, Na_2SO_3 in the test tube), acetylene (H_2O in the syringe, CaC_2 in the test tube), chlorine (conc. HCl in the syringe, $KMnO_4$ in the test tube), hydrogen chalogenides, hydrogen chalcogenides, hydrogen cyanide, some hydrides and etc.

Microscale gas generation apparatus was tested in the university laboratory, in one primary and one secondary school. This microscale method was introduced to students, had a positive impact on their knowledge, and improved their attention and curiosity. The results showed that the practical use of this method during chemistry classes in schools is very effective.

Safety tips

Syringe needle tip is sharp! The students must be careful while piercing the pipette's bulb and the tip must be cut off.

Always use syringe needles with wide diameter of the hole (0.8 mm -1.2 mm) in order to avoid case of clogging when there is possible reaction of reagent with the needle metal. Due to the corrosive nature of concentrated acids and solid hydroxides a special care should be taken (wear rubber gloves and safety goggles).

In case of generating gases which are toxic, corrosive or flammable such as chlorine, hydrogen chalcogenides, hydrogen cyanide, some hydrides, standard ways of protection (work in a fume hood) and safety are in the first place. Fume hood can be avoided if one works with less than 20 mg of reactants and if the gas is not extremely toxic.

Conclusion

The proposed novel gas generation apparatus provides conditions for hands-on experimentation. This idea involves students in the process of experimentation and makes them active participants in the educational process. This should produce creative students with increased inspiration for chemistry. The described method has all advantages that come with the microscale chemistry. The idea for microscale gas generation described in this article provides more productive and vivid method of experimentation which should substitute the demonstration experiments to a certain extend.

Acknowledgments. The authors thank one of the referees for his/her valuable remarks and corrections to the manuscript of this paper.

NOTES

1. http://en.wikipedia.org/wiki/Microscale_chemistry

REFERENCES

1. **Alyea, H.N**. Syringe Gas Generators. *J. Chem Educ*. **69**, 65 (1992).
2. **Obendrauf, V.K**. *Lectures in Summer School*. Salzburg, 2005, pp. 22-26.
3. **Obendrauf, V.K., A.M.C. Koehler-Kruetzfelddt**. Teaching the Chemistry of Gases with Hands-on Experiments. *Chemical Education J*. **7**(2), reg. no. 7-14 (2004).
4. **Obendrauf, V**. Experimente mit Gasen im Minimastab. *Chemie in unserer Zeit*. **30**(3), 118 (1996).
5. **Obendrauf, V.K**. Low-Cost-versuche mit SO_2 und H_2S. *Chemie & Schule* **4**, 8 (1994).
6. **Mattson, B.M**. Microscale Gas Chemistry: Generating Gases in Large Syringes. *Chem 13 News* no. 251 (1996).
7. **Mattson, B.M, M.P. Anderson, J. Nguyen, J. Lannan**. Microscale Gas Chemistry. Part. 8: Experiments with Hydrogen Sulfide. *Chem 13 News* no. 258 (1997).
8. **Mattson, B.M., M.P. Anderson, J. Nguyen, J. Lannan**. Microscale Gas Chemistry. Part. 9: Experiments with Sulfur Dioxide. *Chem 13 News* no. 259 (1997).
9. **Wang, J., Z. Lu, C. Zhao**. A Novel Microscale Gas Generator *J. Chem. Educ*. **80**, 181-182 (2003).
10. **Kvittingen, L., R. Verley**. Construction of a Small-Scale and Low-Cost Gas Apparatus. *J. Chem. Educ*. **81**, 1339-1340 (2004).

МИКРОЕКСПЕРИМЕНТЪТ В УЧЕБНАТА ПРАКТИКА: ПОРТАТИВЕН ГАЗ-ГЕНЕРАТОР

Резюме. Киповият апарат за генериране и съхранение на газове все по-рядко се използва в учебната практика. В настоящата работа е предложен и проверен в практиката прост и безопасен за работа газ-генераторен апарат.

✉ **Dr. Metodija Najdoski** (corresponding author)
Institute of Chemistry,
Faculty of Natural Sciences and Mathematics,
Sts. Cyril and Methodius University,
Arhimedova 5, PO Box 162, 1000 Skopje,
MACEDONIA
E-Mail: metonajd@yahoo.com