Microscale chemistry experiments

ZHOU NING HUAI*,
GOH NGOH KHANG
& CHIA LIAN SAI

Introduction

With increased concern about the problems of environmental pollution as well as rising laboratory costs, the strategy in teaching/ learning chemistry through laboratory work requires certain modifications. Complete removal of laboratory work is not practical, because laboratory work will help students build up their process skills and experience, as well as appreciate real life in chemistry. Suggestions for replacing laboratory programs with videotapes, computer simulations or demonstrations, are useful but address only part of the problem. So as not to sacrifice valuable laboratory learning experience in chemistry, and at the same time, maintain the importance of laboratory investigations for the learning of chemistry, what modifications can be made?

A Possible Solution

One possible solution is the change from the traditional, large-scale glass and metal-ware to the non-traditional microscale plastic or glass equipment. Figure 1 shows a set of microscale glassware developed by Zhou N.H. (1992).

Similar microscale equipmen: had also been developed elsewhere in America and Germany. Figure 2 shows a set of microscale plastic apparatus, comprising a series of well plates and a multi-purpose plastic pipette, also developed by Zhou N.H. (1992).

* **A NOTE ON ZHOU NING HUAI**
Zhou Ning Huai is professor & chairman of the Department of Chemistry, Hangzhou Teachers College, China. He is one of the pioneers of microscale chemistry and has contributed a great deal in this area.

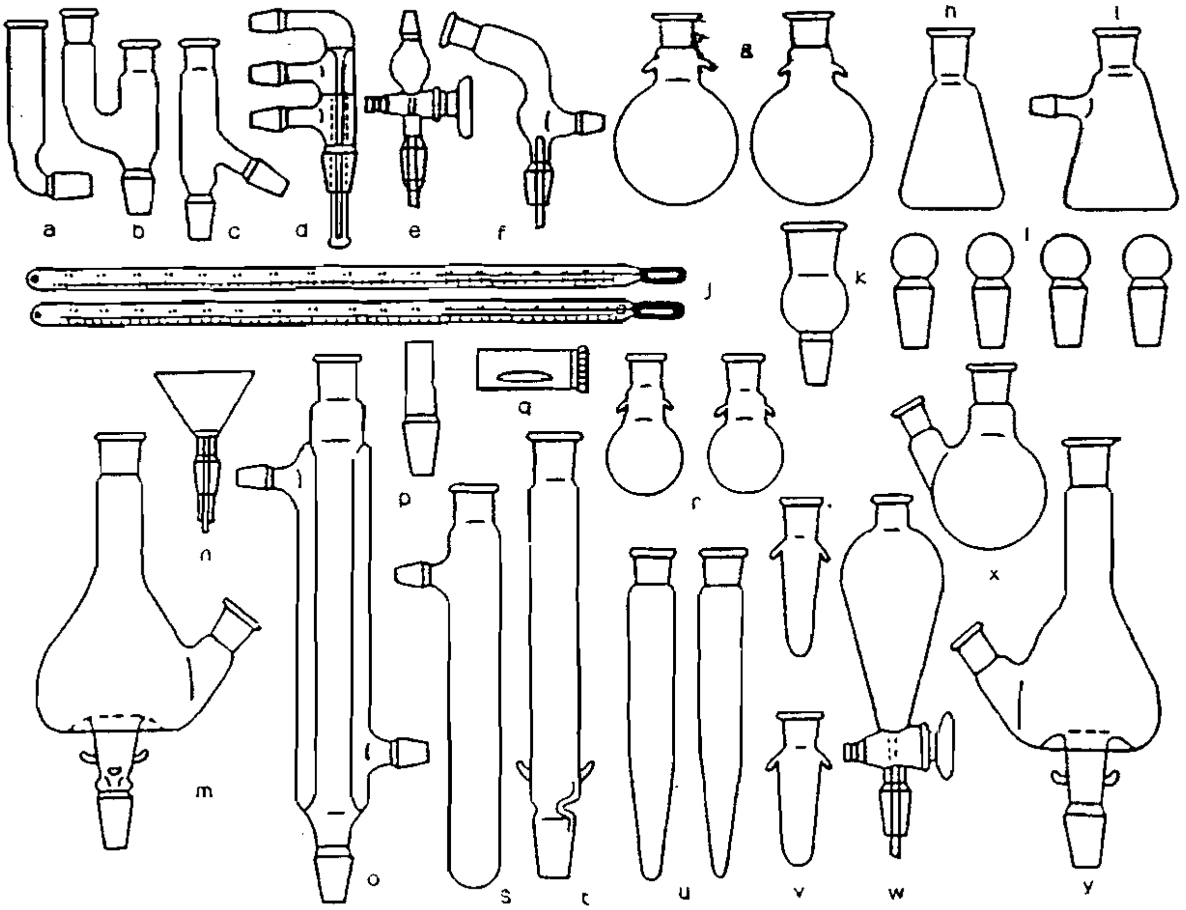

Figure 1 : A Set of Microscale Glassware

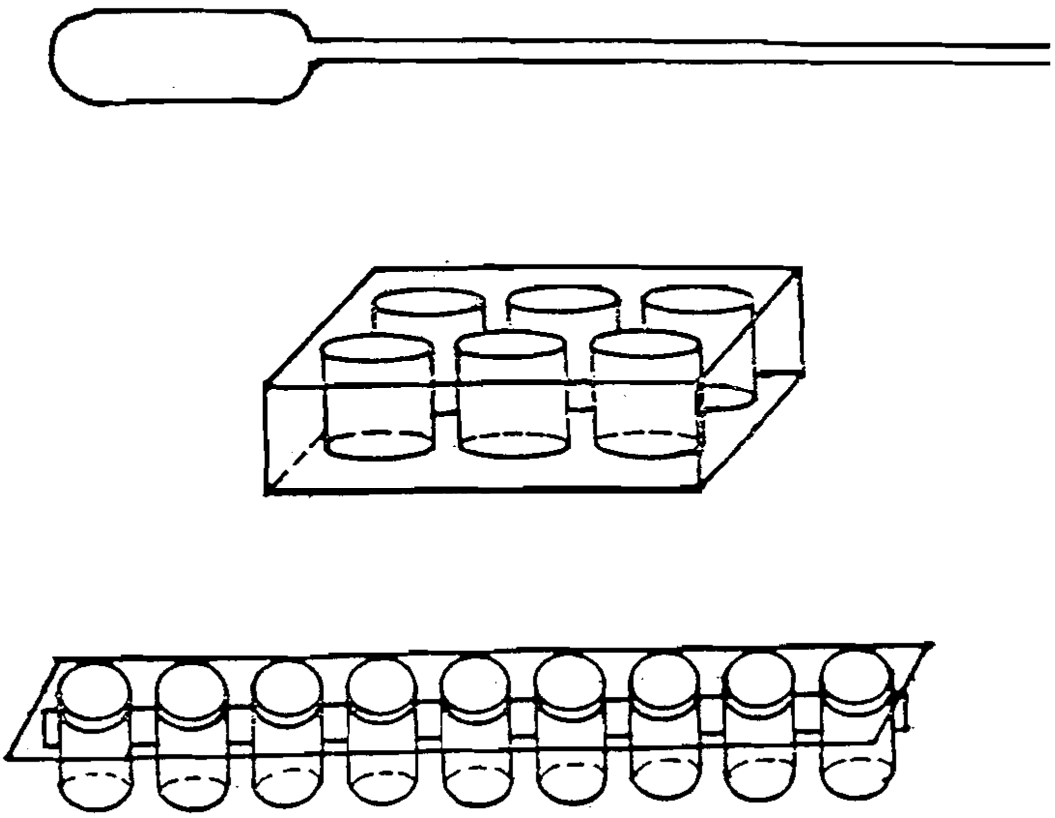

Figure 2 : A Set of Microscale Plastic Apparatus

Two Sample Experiments

In order to demonstrate how such microscale chemistry can be incorporated into the teaching of chemistry in school, we will describe the following two experiments.

Experiment 1 : Electrolysis of Dilute Sodium Hydroxide

Aim To demonstrate the formation of an explosive mixture after electrolysis of dilute sodium hydroxide solution.

1. Squeeze a piece of multi-purpose plastic pipette provided, and then immerse it into a small beaker containing some dilute sodium hydroxide solution.

2. Set up the apparatus as shown in Figure 3.

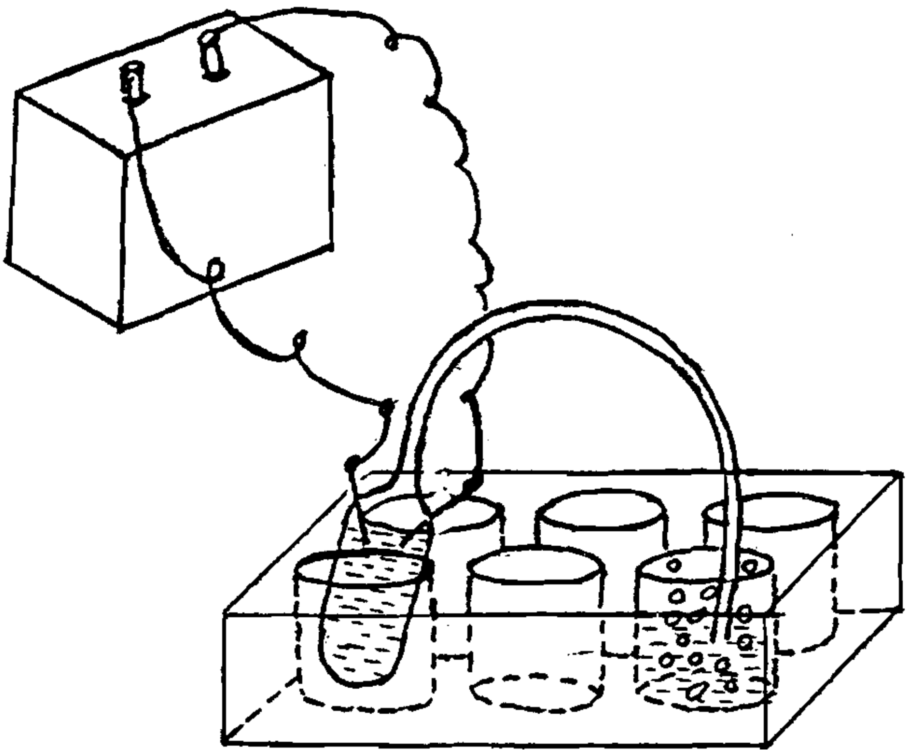

Figure 3 : Electrolysis of Dilute Sodium Hydroxide Using Microscale Plastic Apparatus

3. Use two pieces of stainless steel pins and fit them at the two sides of the plastic pipette.

4. Use two sets of crocodile clips to join these pins to a 6-V battery.

5. After a short while, a mixture of hydrogen and oxygen gases will produced.

6. Lead the mixture of hydrogen and oxygen, via the tubing of the multi-purpose plastic pipette, into a solution containing some shampoo in Well 3. The gaseous mixture will be trapped in the bubbles formed at the top of the shampoo solution.

7. Test for the gaseous mixture produced by using a lighted splinter or match. It will explode with a loud sound (pop sound). This indicates that the hydrogen and oxygen formed have reacted.

The pop sound experiment is simple in design and operation, and is very safe. All students are able to perform this experiment by themselves. Furthermore, while this experiment is being conducted, students can see very clearly that electrolysis is still in progress.

Experiment 2 : Precipitation Reactions

Aim To determine the stoichiometry of a precipitation reaction.

1. Use two pieces of equal volume (about 5 cm^3) multi-purpose plastic pipettes (volume of each drop is about 0.05 cm^3) to transfer 0.5M $Pb(NO_3)_2$ solution and 0.5M Na_2CO_3 solution, respectively.

2. Follow the amounts given in the table below, add in $Pb(NO_3)_2$ solution and Na_2CO_3 solution separately to the various wells of the 0.7 cm^3 well plate.

Well No.	Drops of 0.5M $Pb(NO_3)_2$	Amount of $Pb(NO_3)_2$ (m mol.)	Drops of 0.5M Na_2CO_3	Amount of Na_2CO_3 (m mol.)	Predicted amount of $PbCO_3$ (m mol.)
1	1		9		
2	2		8		
3	3		7		
4	4		6		
5	5		5		
6	6		4		
7	7		3		
8	8		2		
9	9		1		

3. Use a small stick or rod to stir the mixture in each well. Put aside for a few minutes for the reaction to complete.

4. Observe the results of the experiment. Which well has the largest amount of precipitate? Write an equation for the reaction between $Pb(NO_3)_2$ solution and Na_2CO_3 solution. Determine the stoichiometry of the reaction.

5. Use 0.5M KI solution instead of 0.5M Na_2CO_3 solution, and repeat the reaction using another 0.7 cm^3 well plate. Predict which well has the largest amount of precipitate. Use your experiment to check your prediction and write an equation for the reaction between $Pb(NO_3)_2$ solution and KI solution.

It is clear that there is a difference in terms of the amount of precipitates present in each well for the two plates. The distribution of the precipitates is found to be trapezium. In plate 1, the fifth well comprises the largest amount of white precipitates of $PbCO_3$, whereas in plate 2, the third and fourth wells contain the largest amount of yellow precipitates of PbI_2. By calculating the amounts of reagents and products in these three wells, the stoichiometric coefficients of the respective reactions can be obtained.

The results of this experiment can be obtained within a few minutes and can be clearly seen by the students. This experiment, which used 90 drops of solutions, provides opportunity for students to concretise their feelings about what is meant by stoichiometry.

The above two experiments were introduced recently to the participants of the in-service course on Effective Approaches To Chemistry Teaching, conducted by National Institute of Education. Some of the participants had also demonstrated this experiment to their students. The feedback is that the students were excited about the experiment and fascinating about the set-up.

Advantages of Using Microscale Chemistry

The above described two experiments, carried out on a microscale plastic apparatus, deliver results which are as good as, if not better than, those produced by the large-scale ones. In addition, it also has the following advantages over the same experiments being conducted in the traditional ways:

- The reaction time is shortened. The curriculum time saved can be used more meaningfuily, either to perform more experiments or for other purposes.

- Since the amount of chemicals used is small and the apparatus is made of plastic, the potential danger of certain hazardous reactions will be cut to a very minimum. Hence, it allows more experiments to be conducted safely by students themselves under any conditions. Consequently, students will have more opportunity to practice their process skills.

- Such microscale approach will also help us to cut cost, to reduce the storage space and to resolve some pollution problems.

Resources for Microscale Chemistry Experiments

Sources for microscale chemistry experiments can be obtained from books published by some authors, such as Russo (1986), Mills & Hampton (1988), Thompson (1990), and Zhou et al. (1992), listed below in the References.

Conclusion

Through the use of two concrete examples, this article illustrates how microscale approach can be adopted for the teaching and learning of chemistry. There are many advantages arising from such an approach. Hence, we would like to promote it in our schools.

Reference

Mills, J. and Hampton, M. (1988). *Microscale Laboratory Manual for General Chemistry.* New York: Random House.

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