Introduction

One of the easiest ways to reduce the amount of chemicals that need to be disposed is to reduce the amount of chemicals used in laboratory experiments. Reduced-scale chemistry practices use smaller chemical quantities, miniature or modified labware, and modified processes to demonstrate common scientific concepts. Often chemical use is reduced to 1/100 or 1/1000 of a traditional experiment, while still demonstrating the same scientific concepts. There are two types of reduced-scale chemistry, “small” and “micro”. The terms are sometimes used interchangeably.

Small-scale chemistry uses inexpensive plastic and polymer materials in place of glassware, reuses single-use equipment, and uses very low concentration solutions. It is commonly used in secondary school classrooms.

Microscale chemistry uses smaller-sized glassware and therefore reduces the amount of chemical per experiment. Microscale chemistry is more common at university level labs, though the methods can be used by secondary schools.

Benefits of reduced-scale chemistry

The benefits of reduced-scale chemistry are far reaching. Reduced-scale chemistry:

- ✓ Reduces preparation time. A single teacher can prepare for class in a matter of minutes.
- ✓ Reduces cleanup time.
- ✓ Allows teachers to repeat experiments. Since reactions are taking place at such a small scale, there is often time to repeat the experiment.
- ✓ Increases lecture and laboratory time. The shorter length experiments allow the teacher to lecture and perform laboratory activities for the concepts covered in the same class period.
- ✓ Allows more variety in experiments. More experiments become time- and cost-effective when performed on a small scale.
- ✓ Lowers cost of labware. Most of small-scale labware is affordable and hard-to-break plastic. Microscale kits can be costly upfront, but can be used for many years. The equipment used in small- and microscale chemistry is also less attractive to thieves for use in clandestine narcotics labs.
- ✓ Reduces liabilities and hazards. Small quantities of chemicals mean less chance for spills and less waste.
- ✓ Improves indoor air quality.
- ✓ Reduces storage area needed. Both the chemicals and labware used in reduced-scale chemistry take up a vastly smaller amount of space as compared to traditional experiments.
- ✓ Saves money. The economic benefits of reduced-scale chemistry are significant. The cost of running a small-scale lab for chemistry students at Colorado State University was 25 times less than a traditional lab.
- ✓ Teaches important lab procedures. Reduced-scale chemistry requires students to be somewhat more precise while performing experiments, a very important skill in industrial and university-level laboratories. In addition, many industrial labs have adopted reduced-scale chemistry.
- ✓ Allows for individual experiments. Macroscale laboratories are often so costly as to prohibit individual lab work. While working as a group is beneficial, individual experiments give everyone an opportunity to test each concept. This also can help the instructor to determine who might need additional assistance for each concept covered.

Considerations in switching to reduced-scale chemistry

- ✓ Initial start-up costs for equipment. The switch to reduced-scale chemistry requires an outlay of money for some large equipment and the classroom sets of labware. In general, the plastic alternatives used in small-scale may be less expensive than the microscale kits. However, many materials can be reused for many years. Savings from reduced chemical purchase and disposal costs can be used to purchase this equipment.

- ✓ Smaller experiments. Admittedly, chemistry can be much more impressive when it is performed on a grand scale. However, with more dilute chemicals in small amounts, reduced-scale chemistry allows students to conduct some of these "wow" type experiments safely on their own.

How to switch to reduced-scale chemistry

- ✓ Many vendors offer small-scale and microscale chemistry kits and equipment. Both require a number of items, including reaction plates, small pipets and thermometers, and other equipment.

- ✓ Phase in the switch gradually to reduce some costs.

- ✓ Experience the benefits of reduced-scale chemistry by using less concentrated chemicals in small amounts in your current experiments. For many experiments, a 50% reduction in chemicals can produce the same result.

For more information

National Small-Scale Chemistry Center (www.smallscalechemistry.colostate.edu/)

National Microscale Chemistry Center (www.microscale.org/default.asp)

Scaling Down Experiments, NC Pollution Prevention Program (www.p2pays.org/ref/01/text/00779/ch08.htm)

Pollution Prevention Resource Exchange, School Topic Hub (www.p2rx.org/P2InfoNexpert/schools.cfm)

Microscale experiments, University of Nebraska (dwb.unl.edu/Chemistry/MicroScale/MScale00.html)

Microscale experiments, Rehab the Lab, (www.govlink.org/hazwaste/schoolyouth/rehab/labs.htm)

Titration of strong acid and base: example of a microscale experiment

Source and full text available from: Microscale Experiments, University of Nebraska, dwb.unl.edu/Chemistry/MicroScale/MScale00.html

<u>Supplies</u>

micropipet (pulled Beral pipet)
24-well plate or 3, 13 x 100-mm test tubes
toothpicks
1% phenolphthalein indicator (dissolve 1g phenolphthalein in 60 mL of 95% ethanol; add enough distilled water to bring the total volume to 100 mL.)
0.1 M NaOH (made by dissolving 4 g of NaOH in 1 L of distilled water)
0.1 M HCl (made by dissolving 9 mL of concentrated HCl in 1 L of solution)

<u>Overview</u>

A titration is done with a strong acid and a strong base of equal concentrations using microscale techniques. The chemicals used in this experiment were chosen because they react in a one-to-one stoichiometric mole ratio. Since you know precisely the concentration of base used, you can calculate the number of moles of base used. Because of the mole ratio, this is also the number of moles of acid used. Furthermore, from the volume of acid used, you can calculate the concentration or strength of the acid.

Since the same pipet was used for both acid and base, calibration of this pipet is unnecessary.

<u>Procedure</u>

Select a Beral pipet to use for the reagents. Fill the pipet with distilled water and then squeeze dry. Fill the pipet with a small portion of acid. Expel in the sink. Fill again with acid and expel in the sink. Fill the pipet with acid.

Select a 24-well plate for the experiment. Carefully transfer 50 drops of acid to each of 3 wells. Add 1 or 2 drops of phenolphthalein indicator to each of the wells.

Squeeze the pipet dry. Rinse the pipet 3 times with small portions of distilled water. Discard the rinse at the sink. Fill the pipet with a small portion of base. Rinse. Expel. Repeat the rinsing procedure. Fill the pipet.

Select one of the wells. Add base to this well, drop wise, while stirring, until a faint pink color is observed that remains for 30 seconds on standing. Record the number of drops required to reach this endpoint.

Repeat this procedure for the other 2 portions of acid.

Check your data. All three titrations should agree within 1 drop of one another. If they do not, repeat the titration.