# **E12B - ANALYSIS OF COMMERCIAL VINEGARS**

Vinegar is a solution of acetic acid (HC2H3O2). The strength or concentration of the vinegar is usually given on the label of the bottle in percent by weight or “percent acidity.” The United States Food and Drug Administration regulations require that the product called simply “vinegar” be made from apples and contain not less than 4 g of acetic acid in 100 mL of vinegar (4%). One way to produce a cheap vinegar is to keep the concentration at this allowable minimum. However, vinegar may gradually lose strength on the shelf so the manufacturer may wish to make the product stronger than necessary to guarantee a good shelf life. Vinegars that are **not** made from apples are available, including malt vinegar made from barley and corn, wine vinegar and rice vinegar. Whatever the source, acetic acid is the “sour”, or acid, ingredient.

Here, we will determine the acetic acid concentration of a commercial vinegar by titration with sodium hydroxide solution. We previously standardized the sodium hydroxide and now know its concentration to 5 parts per thousand. The sodium hydroxide is about 0.1 M and is too dilute to provide a satisfactory titration with commercial vinegar. (Too large a volume would be needed even for a small vinegar sample.) Therefore, we **dilute** the vinegar using accurate volumetric glassware before performing the titrations. The instructions below are for typically available vinegars with 4-6% acetic acid; if your vinegar is much stronger than 6%, consult the instructor.

Different vinegars have different subtle flavoring agents; nevertheless, vinegar acts as a source of water-soluble acid in many foods. (Other acid sources that are sometimes used are lemons and sour milk.) One way to evaluate the vinegar is on a **real cost** basis, where you determine the cost in dollars per gram of acetic acid. Another way to evaluate vinegars, if your instructor allows, is to come up with your own analysis. For example, compare white vinegar to rice vinegar to apple cider vinegar or perhaps compare different brands of the same type of vinegar.

## **PROCEDURE**

Bring from home a bottle of clear or pale-colored vinegar. First determine the density of the vinegar using a graduated cylinder and the balance. Record your value in your lab notebook.

Obtain a 250 mL **volumetric flask**, a **buret**, a 25 mL **volumetric** **pipet**, and a **pipet bulb** from the stockroom. The pipet bulb is used to fill and empty the pipet; the instructor will demonstrate its use.

Rinse the volumetric flask and the pipet with tap water and with deionized water. Pour 50 to 100 mL of commercial vinegar into a clean, dry beaker. Now rinse the pipet at least three times with small portions of vinegar, discarding each rinsing. Fill the pipet carefully to the mark with vinegar and allow the 25 mL sample of vinegar to flow into the volumetric flask. (Do not “blow out” the remaining solution in the tip from these “TD”, or “to deliver”, pipets. Properly used, they dispense 25.0 mL.) Fill the volumetric flask **carefully** to the mark with deionized water and mix well by **inverting** the stoppered flask at least twenty times. Pour your diluted vinegar, which we will call the “acetic acid solution”, into a suitable clean, dry, stoppered container. Clean the volumetric flask and return it to the stockroom.

If you are doing this section on the same day as Expt 12A, refill your NaOH buret and proceed to titrate the acetic solution. If working on a later day, you need to obtain a buret, clean it, and fill with your standardized base from part 12A. First rinse the buret well with tap water, then deionized water and then with several small portions of your (standardized) sodium hydroxide solution. Rinse the pipet 3 times with small portions of acetic acid solution. Fill the buret with the sodium hydroxide solution and record the initial reading.

Carry out the following procedure for each titration:

1. Pipet 25.0 mL of solution into a clean Erlenmeyer flask. (It need not be dry.) Add 2 drops of phenolphthalein.
2. Titrate the acetic acid solution with sodium hydroxide to a phenolphthalein end point. Record the final volume on the buret.
3. Repeat the titration until 3 values for the volume of sodium hydroxide used agree within 1% (about 0.1-0.2 mL).

Use the Q test to reject any suspect values.

## **CALCULATIONS**

1. Calculate the molarity of the acetic acid solution/aliquot. The reaction is:

NaOH(aq) + HC2H3O2(aq) 🡪 NaC2H3O2(aq) + H2O(l)

1. Then calculate the molarity of the commercial vinegar; note it is exactly 10 times as strong since we diluted 25.0 mL to 250. mL.
2. Use the experimentally determined density of the commercial vinegar and calculate the concentration of the vinegar in percent acetic acid by mass.
3. If you are doing a cost analysis of your vinegar, calculate the mass of acetic acid per dollar, taking the following into account:
4. Cost of the bottle of vinegar.
5. Total amount in the bottle (usually given in fluid ounces).
6. Mass of a fluid ounce of vinegar (32 fluid ounces per quart, 946 mL per quart).
7. If you are doing a different analysis, devise a way to exhibit your findings.

## **CONCLUSION**

Write a formal conclusion (ie. typed if requested by your instructor). What have you “discovered”? Compare your analysis of the vinegar with the concentration given on the bottle. Also, collect information from other students to compare the vinegars on a cost basis or carry out the analysis of your pre-determined hypothesis. Evaluate your vinegar as to truthful labeling, purpose/role of acetic acid in vinegar, and economical analysis.**E12B - ANALYSIS OF COMMERCIAL VINEGARS**

**REPORT SHEET**

Section\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

For each titration, you will report the following. Repeat the data table and calculations for each titration. On this report sheet only give one sample trial

Initial buret reading \_\_\_\_\_\_\_\_

Final buret reading \_\_\_\_\_\_\_\_

Volume of NaOH used \_\_\_\_\_\_\_\_

Average volume of NaOH \_\_\_\_\_\_\_\_

Q test results (if used):

## **Calculations:**

Include an example of all of your calculations with your report.

Experimental density of your commercial vinegar \_\_\_\_\_\_\_\_\_\_\_

Molarity of NaOH \_\_\_\_\_\_\_\_

Molarity of acetic acid solution \_\_\_\_\_\_\_\_

Molarity of commercial vinegar \_\_\_\_\_\_\_\_

% acetic acid by mass in vinegar \_\_\_\_\_\_\_\_

Real cost of vinegar: $/g \_\_\_\_\_\_\_\_

**EXAMPLE TABLE for Comparison with other students' results:**

Create your own table based on what you decided to analyze.

| Students | Brand (s) | Cost: $/bottle (or whatever your analysis was) | Cost: $/g acetic acid  (or whatever your analysis was) |
| --- | --- | --- | --- |
| 1 |  |  |  |
| 2 |  |  |  |
| 3 |  |  |  |
| 4 |  |  |  |

## **Conclusion:**

# **EXPERIMENT 12B ANALYSIS OF COMMERCIAL VINEGARS**

**POST-LABORATORY QUESTIONS**

1. A generic vinegar, 4.5% acetic acid, costs 95 cents for an 8 oz bottle and $2.79 for a quart bottle. Which is cheaper? Calculate the cost of each bottle in $/g acetic acid.

1. Lemon juice contains citric acid, H3C6H5O7.
2. Write the balanced equation for the reaction of NaOH(aq) with citric acid.

1. Calculate the volume of 0.1205 M NaOH that will neutralize 10.0 mL of 3.8% (by mass) citric acid solution. Assume the density of the citric acid solution is 1.00 g/mL.

# **E12B - ANALYSIS OF COMMERCIAL VINEGARS**

PRE-LABORATORY ASSIGNMENT

Section\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Write below the following information from your bottle of commercial vinegar:
2. Brand & type of vinegar:
3. Ingredients:
4. Cost (or today’s equivalent cost by searching your favorite retail store’s online price):

1. Size of container (usually given in fluid ounces):
2. Labeled % acetic acid (or acidity):
3. Calculate the molarity of a 5.1% acetic acid solution, assuming that the density of the solution is 1.00 g/mL.