

Analyzing the Acid in Vinegar

Purpose:

This experiment will analyze the percentage of acetic acid in store bought vinegar using titration.

Introduction:

Vinegar can be found in almost any home. It can be used on salads and to season other dishes. Vinegar is made up of mostly water plus acetic acid ($\text{HC}_2\text{H}_3\text{O}_2$) and maybe some herbs and spices. It is the acetic acid that gives vinegar its characteristic taste and odor. The optimum amount of acetic acid in vinegar is between 4 and 5 percent by weight. Any percentage of acetic acid greater than 5 results in very bad tasting vinegar.

In order to analyze vinegar bought at a local market, you will use a method called **titration**. Titration is a common analytical method used to measure the amounts of compounds in solution. The glassware you will be using is called a **buret**. The buret holds one of the reactants, called the **titrant**, and conveniently adds it into a reaction vessel which contains the second reactant. The titrant in this experiment will be a sodium hydroxide (NaOH) solution. The vinegar will be in the reaction vessel and follow the reaction given below:



Equation 1 is an acid-base reaction; also known as a **neutralization** reaction. The acetic acid ($\text{HC}_2\text{H}_3\text{O}_2$) found in the vinegar will react with the NaOH until all of the acetic acid is neutralized. When an acid, such as acetic acid reacts with a base like NaOH , the products are a salt ($\text{NaC}_2\text{H}_3\text{O}_2$, sodium acetate) and water (H_2O). If you know the concentration of the sodium hydroxide solution and the volume that you need to add to the acid, then you can figure out how much acetic acid is in the vinegar.

As an example, let's say you measure out 25.00 mL of vinegar using a buret. You are going to assume that the density of vinegar is 1 g/mL. This means you have 25.00 g of vinegar in your flask. After properly cleaning out your buret with sodium hydroxide solution (see proper cleaning instructions in the procedure), you fill the buret and start at an initial volume 0.10 mL. After the reaction is complete, you find your final volume at 12.70 mL. Subtracting this value from the initial volume you obtain a value of 12.60 mL of base added into the flask. You can calculate the number of moles of base you have added to the flask by taking the given molarity of the base, which we will say is 1.5 M (M means moles of substance/L) and multiplying it with the volume of base added once it is converted to L.

$$0.01260 \text{ L of NaOH solution added} \times \frac{1.5 \text{ moles of NaOH}}{1 \text{ L of NaOH solution}} = 0.0189 \text{ moles of NaOH}$$

If you look at equation 1, you will see that the acetic acid in vinegar combines with sodium hydroxide in a 1:1 ratio. This means that the number of moles of NaOH will be the same as the moles of acetic acid, which means that the number of moles of acetic acid in the 25.00 mL of vinegar is also 0.0189 moles. Since you are trying to calculate the percentage of acetic acid in vinegar by weight, you need to convert the moles of acetic acid to a mass of acetic acid. You will do this by multiplying the moles of acetic acid with the molecular weight of acetic acid which is 60.0 g of acetic acid in one mole of acetic acid.

$$0.0189 \text{ moles of acetic acid} \times \frac{60.0 \text{ g of acetic acid}}{1 \text{ mole of acetic acid}} = 1.13 \text{ g of acetic acid}$$

To calculate the weight percentage of acetic acid in vinegar:

$$\frac{1.13 \text{ g of acetic acid}}{25.00 \text{ g of vinegar}} \times 100\% = 4.52\% \text{ acetic acid in vinegar}$$

This final answer is what you are trying to determine in this experiment. Remember this is **JUST AN EXAMPLE!!!!** Your overall answer will probably not be the same, but the steps and calculations you use to determine your answer will be the same.

In order for you to use this mathematical method, you must have a signal to indicate that the reaction has come to completion. To monitor the reaction, a few drops of an **indicator** must be added to the solution at the start of the titration. An indicator is a dye that changes color when the reaction used for analysis is complete. The indicator you will be using in this experiment will be phenolphthalein, this indicator stays colorless until the reaction is complete and then it turns a faint pink. At some point in your titration, you will have added the same amount of base as there is acid (present in the vinegar) in the reaction vessel. This point in the reaction is called the **equivalence** or **endpoint**. At this point, the indicator will change color when the slightest amount of titrant is added. It is at this point you want to stop, record the final volume and calculate the percent acetic acid in the store bought vinegar.

Procedure:

Be sure to record all data in the table on your results sheet.

1. To properly clean your buret, first rinse the buret with distilled water. Then rinse the buret with 3 x 5 mL sample of the titrant (NaOH). Allow this solution to drain from the bottom by opening the stopcock. Make sure the whole interior of the buret has been sufficiently rinsed with distilled water and the titrant solution. Discard the titrant used to rinse the buret and close the stopcock. Fill the buret with titrant as close as you can to the top of the buret. Now open the stopcock and allow some of the titrant to be released. (This eliminates any bubbles at the tip which can cause error in your data.) Try to start your titration with the titrant level near the 0.00 mL mark. However, it does not have to be exactly 0.00 mL, so please do not waste time. Always record this initial volume. The technique for reading the values from a buret are the same as those for the graduated cylinder, read the bottom of the meniscus.
2. Using the buret provided for you, carefully measure and pour 25.00 mL of vinegar into a 250.0 mL Erlenmeyer flask. Calculate the mass assuming the density is 1 g/mL.
3. Add 3-5 drops of phenolphthalein indicator to the flask.
4. After properly cleaning your buret, fill the buret with sodium hydroxide solution and record the initial volume.
5. Titrate your vinegar sample with the sodium hydroxide solution, making sure to gently swirl your flask as you are adding the sodium hydroxide. Add the sodium hydroxide until you have a very slight pink color that remains for more than thirty seconds. You will see a pink color as you add the sodium hydroxide to the flask but will notice when you swirl the flask it disappears. This means that you have not reached the equivalence point yet and need to add more base. Once the color remains for more than thirty seconds, you can be confident that you have reached the equivalence point for your titration.

On your first attempt at performing the titration, you may find you have passed the equivalence point and now have a deep pink color instead of slightly pink. This is okay since you will not count this trial run when you work on calculations with your data. This trial run is to give you a good idea as to the number of milliliters of base that need to be added to reach the equivalence point. Since you are measuring the same amount of vinegar each time, you now will know when you are getting relatively close to the equivalence point and then you can add more carefully as you get closer to the volume of base that you need.

6. Repeat steps 1-5 three more times.
7. Using the data from step 5, calculate the average percentage of acetic acid in vinegar. Provide a sample calculation for each calculation you perform in the space provided under calculations.

Results:

Record your data in the table below and provide your sample calculations in the space provided under calculations.

Titration	Trial Run	1	2	3
Mass of vinegar (g)	_____	_____	_____	_____
Final buret reading of sodium hydroxide (mL)	_____	_____	_____	_____
Initial buret reading of sodium hydroxide (mL)	_____	_____	_____	_____
Volume of sodium hydroxide added (mL)	_____	_____	_____	_____
Volume of sodium hydroxide added (L)	_____	_____	_____	_____
Molarity of sodium hydroxide solution	_____	_____	_____	_____
Moles of sodium hydroxide	_____	_____	_____	_____
Moles of acetic acid (same as sodium hydroxide)	_____	_____	_____	_____
Grams of acetic acid	_____	_____	_____	_____
% acetic acid in vinegar	_____	_____	_____	_____
Average % acetic acid in vinegar (Do not include trial run)			_____	

Calculations

Questions

1. If there were any other acids other than acetic acid present in vinegar, how would this affect your results? Explain.
2. How could you determine the amount of sodium hydroxide found in the commercial cleaner Drano?