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Title: the analysis of aspirin tablet

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Objective: to determine the maximum amount of the active ingredient (acetylsalicylic acid) present in each aspirin tablet.

Introduction

In all pharmaceutical preparation, the manufacturer is required by law to state on the packaging the maximum amount of each active ingredient present. In many preparations the active ingredient will only form a small percentage of the pill or table as whole. For example, in the case of many tablets, the tablets would simply disintegrate into a powder unless additives were put in to assist in making the ingredients cohere into tablet form.

In this experiment, you will have the opportunity to carry out a consumer survey on the aspirin content of a number of commercial preparations, to see whether the manufacturer's claim is justified or not.

Acetylsalicylic acid (aspitin) can be readily hydrolysed by sodium hydroxide into the sodium salts of two week acids, acetic acid and salicylic acid. In this experiment, the hydrolysis is effected using an excess of sodium hydroxide, the excess being later found by titration with standard sulphuric acid. The equation for the hydrolysis reaction is:

$$CH_3.COOC_6H_4.COOH + 2NaOH \rightarrow CH_3.COONa + HO.C_6H_4.COONa + H_2O$$

We are now going to find out the amount of acetylsalicylic acid present in each aspirin tablet. As acetylsalicylic acid can be readily hydrolyzed by sodium hydroxide into the sodium salts of two weak acids, acetic acid and salicylic acid, so we can first add excess sodium hydroxide to acetylsalicylic acid and heat the mixture to hydrolyze the acetylsalicylic acid as hydrolysis reaction occurs at a very slow rate at room temperature and increase the temperature can increase the rate of reaction. After that, the resulting solution contained acetic acid, salicylic acid water and excess sodium hydroxide which was unreacted. Then we can titrate sulphuric acid with the resulting solution to find out the amount of excess sodium hydroxide and therefore the amount of sodium hydroxide used to hydrolyze the acetylsalicylic acid. When the number of mole of sodium hydroxide used to hydrolyze the acetylsalicylic acid is calculated, the number of mole of acetylsalicylic acid and the mass of acetylsalicylic acid present in each aspirin tablet can be also calculated.

Procedures

Part I – Standardization of sodium hydroxide

1) 25 cm^3 of sodium hydroxide was transferred to a 250 cm^3 volumetric flask by a pipette.
2) Distilled water was added to the volumetric flask until reaching the graduation mark.
3) The volumetric flask was inverted for 10 times to mix the solution well.
4) The burette was filled with standard sulphuric acid.
5) The initial reading on the burette was recorded.
6) 25 cm^3 of diluted sodium hydroxide was transferred to a 250 cm^3 conical flask by a pipette.
7) 2-3 drops of phenol red was added to the solution inside the conical flask.
   Standard sulphuric acid was run out from the burette to the solution inside the conical flask until the solution change from purple to yellow.
8) The final reading on the burette was recorded.
9) Titrations were repeated until the normal degree of consistency is obtained.

Part II – Analysis of aspirin tablets

1) A definite number of aspirin tablets (2 or 3 tablets; not weighting more than 1.5 g) were weighted into a 250 cm^3 conical flask.
2) 25 cm^3 of 1.0M sodium hydroxide was added to the aspirin by a pipette.
3) About 25 cm^3 of distilled water was added to the aspirin to dilute the sodium hydroxide.
4) The conical flask was warmed over a heating machine for ten minutes to complete the hydrolysis.
5) The reaction mixture was cooled to room temperature.
6) The reaction mixture and washing were transferred to a 250 cm^3 volumetric flask.
7) The reaction mixture was diluted by adding distilled water to the graduation mark of the volumetric flask.
8) The volumetric flask was inverted to make sure that the solutions inside were well mixed.
9) 25 cm^3 of the diluted reaction mixture was transferred to a 250 cm^3 conical flask by a pipette.
10) The burette was filled with standard sulphuric acid.
11) The initial reading on the burette was recorded
12) 2-3 drops of phenol red was added to the solution inside the conical flask.
13) Standard sulphuric acid was run out from the burette to the solution inside the conical flask until the solution change from purple to yellow.
14) The final reading on the burette was recorded.

15) Titrations were repeated until the normal degree of consistency is obtained.

Data of results

Titration table of sodium hydroxide with standard 0.08572M sulphuric acid

	Trial	1st titration	2nd titration	3rd titration
Initial reading on the burette	7.0 cm^3	7.9 cm^3	10.8 cm^3	3.8 cm^3
Final reading on the burette	22.0 cm^3	22.7 cm^3	25.6 cm^3	18.6 cm^3
Volume of H_2SO_4 used	15.0 cm^3	14.8 cm^3	14.8 cm^3	14.8 cm^3

Average volume of sulphuric acid used
= (14.8 + 14.8 + 14.8) ÷ 3
= 14.8 cm^3
15.0 cm^3 is rejected because this is just a trial.

Titration table of the diluted reaction mixture with standard 0.08572M sulphuric acid

	Trial	1st titration	2nd titration	3rd titration
Initial reading on the burette	3.1 cm^3	14.7 cm^3	9.9 cm^3	22.0 cm^3
Final reading on the burette	15.3 cm^3	27.2 cm^3	22.5 cm^3	34.4 cm^3
Volume of H_2SO_4 used	12.2 cm^3	12.5 cm^3	12.6 cm^3	12.4 cm^3

Average volume of sulphuric acid used
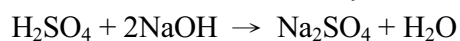= (12.5 + 12.6 + 12.4) ÷ 3
= 12.5cm^3
12.2 cm^3 is rejected because this is just a trial.

Calculation
Standardization of sodium hydroxide
$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + H_2O$
Volume of H_2SO_4 used: 14.8 cm^3
Volume of NaOH used: 25.0 cm^3
Mole ratio of H_2SO_4 to NaOH = 1:2

Number of mole of H_2SO_4 = 0.08572M x 0.0148 dm^3

$\qquad$ = 0.001268656 mol.

Number of mole of NaOH = 0.001268656 mol. x 2

$\qquad$ = 0.002537312 mol.

Molarity of diluted NaOH = 0.00253712 mol. $\div$ 0.025 dm^3

$\qquad$ = 0.10149248M

Molarity of original NaOH = 0.10149248 M x 10

$\qquad$ = 1.0149248M

Determination of amount of acetylsalicylic acid present in one aspirin tablet

Total number of mole of NaOH = 1.0149248M x 0.025 dm^3 = 0.02537312 mol.

$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + H_2O$
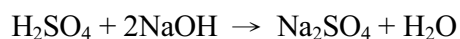
Volume of H_2SO_4 used: 12.5 cm^3

Volume of NaOH used: 25.0 cm^3

Mole ratio of H_2SO_4 to NaOH = 1:2

Number of mole of H_2SO_4 = 0.08572M x 0.0125 dm^3

$\qquad$ = 0.0010715 mol.

Number of mole of NaOH in 25.0 cm^3 = 0.0010715 mol. x 2

$\qquad$ = 0.002143 mol.

Molarity of NaOH = 0.002143 mol. $\div$ 0.025 dm^3

$\qquad$ = 0.0857212M

Number of mole of NaOH in 250 cm^3 = 0.02143

Therefore, number of mole of excess NaOH is 0.02143 mol.

Number of mole of NaOH used to hydrolyse the acetylsalicylic acid:

= 0.02537312 mol. - 0.02143 mol.

= 0.00394312 mol.

$CH_3.COOC_6H_4.COOH + 2NaOH \rightarrow CH_3.COONa + HO.C_6H_4.COONa + H_2O$

Mole ratio of $CH_3.COOC_6H_4.COOH$ to NaOH = 1:2

Number of mole of NaOH = 0.00394312 mol.

Number of mole of $CH_3.COOC_6H_4.COOH$ = 0.00394312 mol. $\div$ 2

$\qquad$ = 0.00197156 mol.

Number of mole of $CH_3.COOC_6H_4.COOH$ in each aspirin tablet:

= 0.00197156 mol. $\div$ 3

= 0.0006571867 mol.

Molar mass of $CH_3.COOC_6H_4.COOH$:

= 12 + 1x3 + 12 + 16 + 16 + 12x6 + 1x4 + 12 + 16 + 16 + 1

= 180

Mass of acetylsalicylic acid in each aspirin tablet:

= 0.0006571867 mol. x 180

= 0.1182936 g

As the mass of each aspirin tablet is 0.18333g,

the percentage by mass of acetylsalicylic acid present in each aspirin tablet:

= (0.1182936 ÷ 0.18333) x 100%

= 64.5%

Conclusion

The percentage by mass of the active ingredient (acetylsalicylic acid) present in each aspirin tablet is 64.5%.

Discussion

The percentage by mass of acetylsalicylic acid in each aspirin tablet we found is much greater than the value that the producer claimed. Here are some possible reasons.

Acetic acid and salicylic acid in the resulting solution may neutralize some of the sodium hydroxide in the solution. This may make the result greater.

Some ingredients in the aspirin tablet are microcrystalline cellulose, croscamellose sodium, titanium dioxide, hydroxyl-methylcellulose, talc, iron oxide, polyvinyl acetate phthalate.

Microcrystalline cellulose is an excipient used in the formulation of tablets. It can be used as a binding agent due to its excellent compression properties, a disintegrant, in order to increase the biological availability of a medicine and as a lubricant to aid in the tableting procedure. But it may not react with the sodium hydroxide.

Croscarmellose sodium is an excipient in medical formulations. It is highly absorbent and insoluble. Croscarmellose sodium is the sodium salt of a cross-linked, partly O-(carboxymethylated) cellulose. But it may not react with the sodium hydroxide.

Titanium dioxide acts as a pigment to provide whiteness and opacity to tablets and may react with sodium hydroxide.

Talc is a mineral composed of hydrated magnesium silicate. Talc is not soluble in water, but it is slightly soluble in dilute mineral acids. In medicine talc is used as a pleurodesis agent to prevent recurrent pneumothorax. Talc may react with sodium hydroxide to form metal hydroxide.

Study Questions

1) Why is 'back titration' instead of 'direct titration' used in this experiment?

We cannot titrate standard sodium hydroxide with the aspirin tablets directly because aspirin tablets are insoluble in water and we cannot take an aqueous solution of it. And also the reaction between the aspirin tablets and sodium hydroxide is slow as the acetylsalicylic acid in aspirin tablet is a weak acid, the reaction between

acetylsalicylic acid and sodium hydroxide is slow and the end point is difficult to identify. Oppositely, the reaction rate of reaction between the sodium hydroxide which is excess in the hydrolysis of aspirin and sulphuric acid is much faster. Therefore the end point is much easier to identify.

2) If phenol red is not available, what other indicator would you choose?
Methyl orange and phenolphthalein can also be used in this titration. As this titration is a strong acid-strong base titration. When we study the titration curve of this titration (fig. a), we can see that the vertical portion of the curve is large. So almost all the indicators are suitable for detecting the end point of this titration.

strong acid - strong base

pH

7

volume of acid added
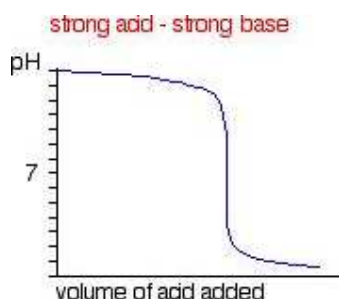
(fig. a)

3) Why must the heated mixture be cooled before transferred to volumetric flask?
Volume of liquid will expend under high temperature. The volume of liquid inside the volumetric flask is exactly 250 cm^3 when the liquid reach the graduation mark only when the liquid is in the room temperature. If we do not cool down the heated mixture before transferred to volumetric flask, then the volume of solution inside the volumetric flask is less than 250 cm^3 when the solution reached the graduation mark.

4) Why do people consider aspirin as an equivalence to dibasic acid?
The basicity of an acid is the number of ionizable hydrogen atom in each acid molecule. As the acetylsalicylic acid can be hydrolysed by sodium hydroxide into two week acids, which one mole of acetylsalicylic acid required two moles of sodium hydroxide to hydrolyse it, therefore aspirin as an equivalence to dibasic acid.

End of Report