

ANALYSIS OF ASPIRIN TABLETS

A class of compounds called *salicylates* are naturally and artificially derived from the compound *salicylic acid*. Salicylic acid is found in products such as toothpaste, wart remover, acne cream, and dandruff shampoo. As shown in Figure 1, when salicylic acid reacts with acetic anhydride, the active ingredient in aspirin is formed - acetylsalicylic acid, or ASA. As with any drug, both salicylic acid and ASA increase in toxicity as dose increases.

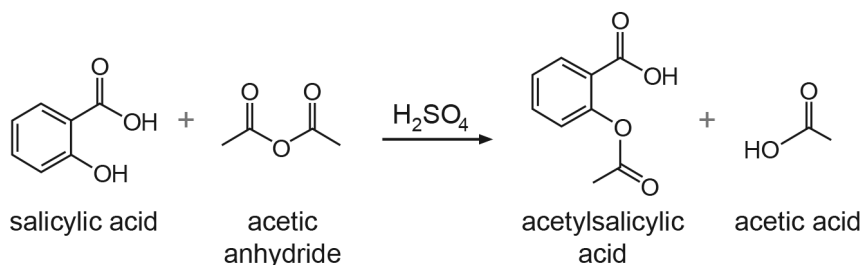


Figure 1. Salicylic acid is a precursor to acetylsalicylic acid

In the late 19th century, salicylates were routinely used as food preservatives due to their antiseptic properties. Salicylates could extend the shelf life of fresh food products like meat and eggs, but overuse of this additive caused illness and sometimes death in consumers. Salicylates were one of a number of food, drug, and cosmetic additives regulated by the Pure Food and Drug Act passed in 1906. The law banned the use of some substances as food additives altogether and limited the amount of other potentially harmful substances. Food and drug manufacturers were also required to identify the active ingredient(s) on product packaging, and the law established purity levels for those ingredients. Consumers can see the ASA content clearly written on a bottle of aspirin. The United States Pharmacopeia (USP) together with the National Formulary (NF) have established the standard ASA content for aspirin tablets. According to USP-NF guidelines, an aspirin tablet must contain $\pm 10\%$ of the amount of ASA indicated on the label. For example, a 325-mg aspirin tablet must contain between 292.5 mg and 357.5 mg of ASA.

An Ultraviolet-Visible (UV-Vis) spectrometer can be used to analyze solutions that absorb light from the near-infrared region, through the visible spectrum, and into ultraviolet wavelengths. UV-Vis spectrometry allows scientists to determine the purity and concentration of substances that form colorless as well as colored solutions. Spectrometry is routinely used in quality and process control in many industries including pharmaceuticals, food and beverage, environmental testing, chemical manufacturing, and biotechnology. In this investigation, spectrometry is used to determine the amount of ASA in an individual aspirin tablet by comparing the absorbance of several colorless ASA solutions of varied concentrations against the absorbance of solution made from an individual tablet sample. This is an application of Beer's law.

Beer's law states light absorbance and solution concentration are directly proportional when absorbance values do not exceed 1.0. A highly concentrated solution has more solute particles available to absorb light than a less concentrated solution. As solution concentration goes up, the amount of light absorbed by solute particles also increases. Higher solution concentrations result in a higher absorbance reading on a spectrometer. The direct absorbance-concentration relationship can be used to construct a calibration curve for product analysis. In this investigation, the linear equation derived from an ASA standard curve will be used to determine the concentration of a solution made from a crushed aspirin tablet.

Objectives

- Determine the mass of acetylsalicylic acid in an aspirin tablet.
- Evaluate the experimentally determined acetylsalicylic acid content of an over-the-counter aspirin tablet against USP-NF standards.

Materials and Equipment

- Data collection system
- UV-Vis Spectrometer
- Quartz cuvettes with caps (7)
- Analytical balance (readability: 0.0001 g)
- Test tube, 2-cm x 15-cm
- Beaker, 50-mL (2)
- Beaker, 250-mL or larger
- Volumetric flask and cap, 100-mL
- Funnel to fit volumetric flask
- Graduated pipet, 1-mL (readability: 0.01 mL)
- Graduated pipet, 10-mL (readability: 0.1 mL)
- Bulb or pump to fit both graduated pipets
- Disposable pipets (7)
- Filtration apparatus and filter paper
- Mortar and pestle
- Scoopula
- Small weighing boat
- Permanent marker
- Lint-free lens wipes
- Acetylsalicylic acid (ASA) solutions A through E
- Aspirin tablet in bottle, 325-mg
- Isopropyl alcohol (IPA), 91%, ~120 mL

Safety

Follow these important safety precautions in addition to your regular classroom procedures:

- Wear safety goggles at all times and use gloves if available.
- Work in a fume hood or in a well-ventilated area. No open flames are permitted during this investigation.
- Follow your instructor's disposal directions.

Procedure

Part 1 – Spectrometer Warmup and Cuvette Preparation

1. Turn on the UV-Vis Spectrometer and connect it to your device. Open the Spectrometry app.
2. Add just enough 91% isopropyl alcohol (IPA) to a small beaker to fill the disposable pipet.
3. Use the disposable pipet to fill a cuvette with IPA. This is the blank, or calibration solution. Label the cap and set the cuvette aside, and set the pipet in the beaker for future use.

NOTE: Fill cuvettes $\frac{3}{4}$ full. Do not overfill. Handle by the sides that are not clear. If bubbles are present, gently tap the cuvette to dislodge the bubbles.

4. Acetylsalicylic acid (ASA) solutions A, B, C, D, and E were prepared from an IPA-based stock solution with a concentration of 2.22×10^{-3} M. Each solution was diluted with 91% IPA and brought to volume in a 100-mL volumetric flask. Stock solution volumes used for each solution are listed in Table 1. Use the dilution equation ($M_1V_1 = M_2V_2$) to calculate the solution molarities for solutions A, B, C, D, and E and enter your answers in Table 1. Show one sample calculation in the space provided below Table 1.
5. Convert the solution molarities to millimolar (mM) by multiplying each by 1,000. Record answers in Table 1.
6. Prepare 5 cuvettes with ASA solutions A, B, C, D, and E. Use a new disposable pipet for each. Label the caps.

Part 2 – Prepare the Aspirin Solution

1. Obtain one 325-mg tablet from a bottle of aspirin; check the label to verify the aspirin or ASA content and expiration date. Record the mass of the tablet in the space provided below Table 1.
2. Crush the tablet to a fine powder with a mortar and pestle.
3. Measure about 0.0400 g of the tablet powder; record the exact mass in the space provided below Table 1.
4. Place the funnel in the volumetric flask. Carefully add the powder to the flask through the funnel, then use the disposable pipet to rinse the weighing boat with IPA into the funnel.
5. Slowly add IPA to the funnel until you approach the calibration line. Rinse the inner surface as you work.

6. Remove the funnel. Use the disposable pipet to fill the flask with enough IPA for the bottom of the meniscus to reach the calibration line.
7. Seal the flask and invert it as many times as needed until only a small amount of insoluble material remains.
8. Filter the solution according to your instructor's directions. A sample filtration apparatus is shown in Figure 2. Pour the solution into a Büchner funnel that contains a quantitative disc filter. The tube leading out of the empty flask is connected to a hand-operated vacuum pump or water aspirator.

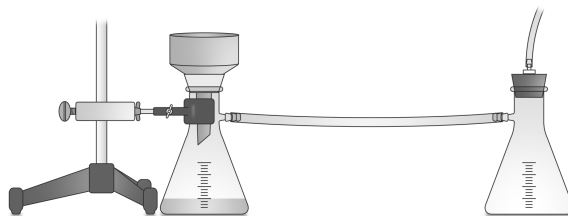



Figure 2. Sample filtration setup

9. Use the 50-mL beaker with 91% IPA to rinse the 10-mL graduated pipet, then transfer 9.40 mL of IPA to the bottom of the test tube and set it in the larger beaker.
10. Add about 10 mL of filtered solution into a clean 50-mL beaker. Rinse the 1-mL graduated pipet with this solution.
11. Use the 1-mL graduated pipet to transfer 0.600 mL of filtered solution to the test tube. Swirl the test tube to mix.
12. Use a clean disposable pipet to transfer the aspirin solution from the test tube to a clean cuvette. Label the cap.



Part 3 – Spectrophotometric Analysis

1. Calibrate the spectrometer with the calibration solution.

NOTE: Wipe the clear sides of the cuvette with a lint-free lens wipe. Insert the cuvette with the clear sides in line with the light and spectrum icons on the device.



2. Place Solution D in the spectrometer and start recording data.
3. Move the **Coordinates** tool  to the most distinguishable peak in the UV region.

NOTE: Experiment with **Number of Scans to Average** and **Smoothing** tools (left) to improve peak stability.

4. Stop collecting data. To fine-tune the wavelength, select the wavelength and absorbance display box and use the arrows to nudge the coordinates box to the highest absorbance.
5. Click the check mark  to accept and set the analysis wavelength; record this wavelength below Table 1.
6. Choose the **Concentration** tab  at the top to navigate to a table and graph display.
7. Change the units in the **Concentration** column from mol/L to mmol/L. Add your calculated mM concentration values for solutions A, B, C, D, and E to the table.
8. Click the first cell in the **Absorbance** column. Place the solution A cuvette in the spectrometer and start recording data. Select the check mark next to the absorbance value to record it.
9. Repeat the previous step to record the absorbance values for solutions B through E; do not stop recording data between solutions.

10. Place the aspirin solution cuvette in the spectrometer.
11. Locate the **Unknown Concentration** table at the bottom-left corner and select the box for **Absorbance**. Click the check mark to keep the absorbance value.

NOTE: To check your calculated concentration, return to the Unknown Concentration table after completing Question 1 and enter the value where indicated. Check your accuracy by noting the proximity of your calculated concentration to the best fit line.

12. Stop recording data. Copy the absorbance values for all solutions into Table 1.
13. **Scale** the data in the graph  and apply a **Linear Fit** . Record the slope (m), y-intercept (b), and value for goodness of fit (r) in the space provided below Table 1. Comment on whether your results will be affected by the linearity of the data based on the r-value closeness to 1, and whether your data indicates a direct relationship based on the proximity of the best-fit line to the origin.
14. Sketch the graph in Graph 1. Include a title, best fit line, and label both axes including units when appropriate.

Data Collection

Table 1. ASA solution concentrations and absorbance values

Solution	Volume stock added (mL)	Concentration (M)	Concentration (mM)	Absorbance
A	2.0			
B	4.0			
C	6.0			
D	8.0			
E	10.0			
Aspirin tablet	N/A	N/A		

Sample calculation for solution concentrations:

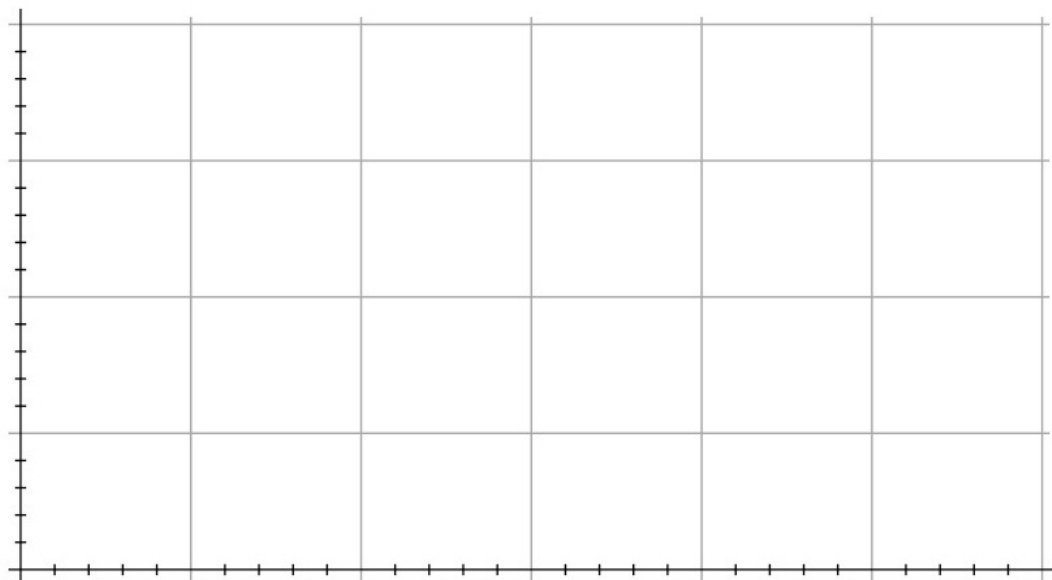
Mass of whole aspirin tablet:

Mass of powdered aspirin sample:

Analysis wavelength:

Linear fit values and linearity comments:

Graph 1:



Questions and Analysis

1. Arrange the absorbance value of the aspirin sample (y) and the linear fit parameters into the line equation ($y = mx + b$) to solve for the concentration of ASA in the dilute aspirin solution (x) in mmol/L, or mM. Show work in the space below. Return to Spectrometry and check your answer by entering your calculated concentration in the Unknown Concentration table. If the data point is not located on or very close to the best fit line, review your calculation and revise your answer if necessary. Then, enter the concentration for the aspirin tablet in Table 1.
2. Use the calculated concentration above to determine the concentration of ASA in the first aspirin solution made in the volumetric flask (in mM). Show work. *Hint: $M_1V_1 = M_2V_2$*

3. Convert the ASA concentration in the original solution to grams ASA in solution. The molecular weight of ASA equals 180.16 g/mol. Show work.

4. What percent ASA (by mass) was in the aspirin powder used to make the solution in the volumetric flask? Show work.

5. Based on the mass percentage calculated above, how many grams of ASA were in the whole aspirin tablet? Show work. How does this mass of ASA compare to the advertised 325 mg of ASA content? Does the ASA content meet the USP-NF standard of $\pm 10\%$?