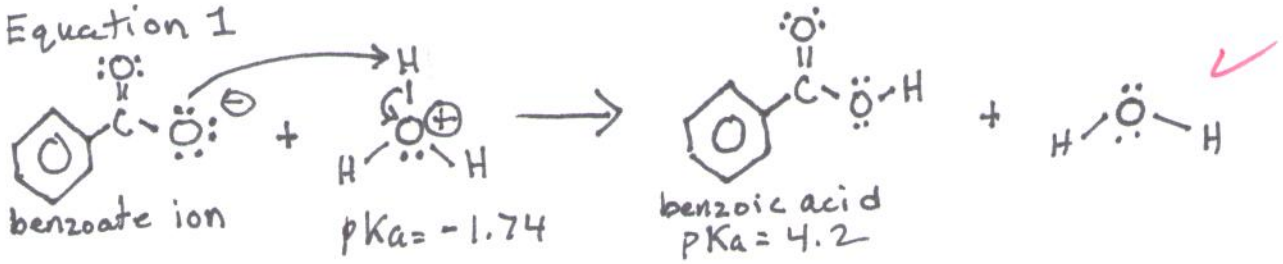
primary objective: to determine if benzoate is converted to a new substance in a simulated stomach environment

Introduction

The objectives of this lab are as follows: One, to demonstrate that sodium benzoate, a common food preservative, can react with stomach acid to form benzoic acid. Two, to collect the benzoic acid formed and determine the percent yield based on the theoretical yield. And three, to practice basic laboratory procedures, namely, cleaning and drying glassware, weighing, washing, and drying solids, measuring volumes, making transfers, and performing vacuum filtration.

To show how sodium benzoate can be converted to benzoic acid in the stomach, approximately 2.00 grams of sodium benzoate is combined with 10 mL of DI water and sufficient 3*M* HCl to reach a pH of approximately 2. The HCl and the pH value of 2 are appropriate since HCl is a major component of stomach acid and the pH of the stomach environment is approximately 2. The reaction is driven by protonation of the benzoate ion as follows:

Equation 1



Because the hydronium ion is a much stronger acid (pKa = -1.74) than benzoic acid (pKa = 4.2), the reaction strongly favors the products rapidly progresses toward completion.

The second objective, the collection of and yield analysis of the benzoic acid product, is achieved, first, by precipitating the benzoic acid product. For the most part, the precipitation occurs upon mixture of the HCl and aqueous sodium benzoate at room temperature since the solubility of benzoic acid (0.34g/100mL) is much lower than the solubility of sodium benzoate (61.2g/100mL). The mixture is then cooled in an ice bath to 10° C, or below, to further reduce the solubility of the benzoic acid product and maximize its recovery. Next, the mixture is transferred to filter paper within a Buchner funnel apparatus. Residual solid adhering to the transfer vessel and stir rod is rinsed onto the filter paper with ice cold water. The strained solid is, then, vacuum filtered by alternating 10 second bursts of suction and rinsing with ice cold water. After this process is repeated two or three times, continuous suction is applied for approximately five minutes. Finally, the solid is transferred to a tarred watch glass and dried in a ~50°C oven to constant mass. The mass of the solid product is determined by allowing the watchglass/product to cool to approximately room temperature, weighing the watchglass/product on an electronic balance, and subtracting out the watchglass's tare mass.

good

Chem. Equation!
pKa values for a/b reaction!
solubility + precipitation!
constant mass!

The theoretical yield is determined using the reaction equation (shown above), the literature values for molecular weight, and the related stoichiometry as follows: (stoichiometric)

$$\text{Theoretical Yield} = \text{grams of reactant} \times \frac{1}{FW_{reactant}} \times (\text{equivalency ratio}) \times FW_{product}$$

Percent yield is calculated as follows:

$$\text{Percent Yield} = \frac{\text{Actual Yield}}{\text{Theoretical Yield}} \times 100\%.$$

Most of the third objective, practicing basic lab operations, is covered in the procedure to isolate and weigh the benzoic acid, with the exception of cleaning and drying glassware. For this experiment, all equipment was washed and rinsed with soap and tap water and final-rinsed with DI water. Beakers and less contamination-sensitive equipment were dried with paper towel inside and out, while the Buchner funnel and graduated cylinders were towel dried on the outside only and air dried.

good intro

! theoretical yld (IMPORTANT TO SHOW HOW THIS IS DETERMINED)

! percent yld

Results — Good & concise

The mass of sodium benzoate reacted was 1.7203g. The theoretical yield of the benzoic acid product, then, was 1.4577g.

$$1.7203\text{ g sodium benzoate} \times \frac{1\text{ mol sodium benzoate}}{144.1\text{ g}} \times \frac{1}{1} \times \frac{122.1\text{ g benzoic acid}}{1\text{ mol}}$$

$$\text{Theoretical Yield} = \boxed{1.4577\text{ g benzoic Acid}}$$

The mass of the benzoic acid product recovered was determined to be 1.3110g. The resulting percent yield is 89.9362%.

$$\text{percent yield} = \frac{1.3110\text{ g}}{1.4577\text{ g}} \times 100\% = \boxed{89.9362\%}$$

Discussion

In terms of the first objective, to show that sodium benzoate can react with stomach acid to form benzoic acid, the results clearly show that sodium benzoate does react- under stomach-like conditions- to form another substance, a white precipitate. We can presume, because the sodium benzoate and HCl are *virtually* the only reactants (barring insignificant contamination) and because the strong tendency for a reaction between the reactants, sodium benzoate and HCl (H_3O^+ when dissociated) to proceed toward the products, benzoic acid and water, that the solid product formed is, indeed, benzoic acid (refer to page 1, Equation 1).

For the second objective of collecting the benzoic acid formed and determining the theoretical and percent yields, I was able to recover roughly 90% or approximately 1.3g of product. Much of the loss of product probably occurred during vacuum filtration, as the filtrate became slightly cloudy upon suction, especially during the initial application of suction (see D&O, pg 04, step3). I reasoned that this could be solid product because of its white appearance. I also lost product when checking pH. I performed at least 10-12 litmus tests and added ~8 mL of HCl (the instructions recommend up to 5mL) before the paper turned the desired orange color. With each test I observed product being transferred to the litmus paper (see D&O, pg. 03, step 8), the result of there being too thin of a supernatant layer to draw from. Other loss of product was observed in transferring the wet cake to the watch glass (residue in the Buchner funnel) and from the filter paper to the watch glass. I would, however, estimate the loss of product from the litmus tests and the transfers to be much less than 1% of the total product recovered and therefore, insignificant.

Ultimately, because a white precipitate did form from a mixture of sodium benzoate and HCl, the production of benzoic acid was demonstrated. Furthermore, since roughly 90% of product was recovered, the methods employed in collecting the product (see paragraph 3) appear to be appropriate as well as sufficiently executed.