The melting point analysis of crude and recrystallized acetaminophen synthesized ...

Acetic Anhydride and p-Aminophenol were heated in a vial attached to an air condenser to synthesize crude acetaminophen, resulting in 0. 097 grams (47. 48% yield). The crude acetaminophen was then recrystallized in a solvent of water and methanol over heat resulting in 0. 082 grams (39. 61% yield) of pure acetaminophen. Melting points of both crude and pure acetaminophen were taken, and found to be 165. 9 – 170. 9°C and 168. 2 – 171. 5°C, respectively. The literature melting point of acetaminophen is 169. 5 – 171. 0°C, indicating that our final product was pure.

Introduction

The synthesis of acetaminophen involves the attraction of the electrophilic carbonyl group of acetic anhydride to the nucleophilic NH2 of the p-aminophenol. This occurs because the NH2 group is a better nucleophile than the OH group attached on the opposite side of the p-aminophenol. A new nitrogen-carbon bond is formed, producing acetaminophen with acetic acid as a byproduct. During the synthesis of acetaminophen, it is necessary to dissolve all solid material, and heat the reaction at a high enough temperature and for a long enough time period to ensure completion. Cooling the mixture in an ice bath ensures that all crystals have formed, and drying removes any remaining solvent.

The synthesis of acetaminophen does not result in a pure product, so recrystallization is necessary to purify the substance. During recrystallization, it is important to dissolve all of the solid in order to remove all the impurities. Acetaminophen crystallizes slowly, so cooling the mixture adequately is necessary. Leaving the mixture in an ice bath for ten minutes

ensures that the process is complete. Drying the crystals removes any remaining solvent. Once recrystallization has occured, comparison by melting point confirms the purification. The recrystallized product should have a melting point close to the literature value, with a narrow range, whereas the impure crystals will melt at a lower temperature with a broader range. Procedure

Reaction Mixture:
0. 150g of p-aminophenol was weighed and put into a 5-mL conical vial. An automatic pipet was used to measure 0. 450 mL water and 0. 165 mL acetic anhydride and was added to the conical vial. A spin vane was placed into the vial and an air condenser was attached. Heating:

The mixture was heated at 120°C using an aluminum block and was stirred gently. After all of the solid dissolved, it was heated for 20 additional minutes to ensure the reaction was complete. Isolation of Crude Acetaminophen:

The vial was removed from the heat and cooled to room temperature. The spin vane was rinsed with 2-3 drops of warm water over the conical vial. The vial was cooled to room temperature then placed in an ice bath for 15 minutes. The liquid was decanted from the mixture and the resulting crystals were dried on filter paper. The crystals were then placed on a watch glass for further drying. The crystals were weighed and a small sample was placed into a capillary tube for melting point determination. Crystallization of Acetaminophen:

The product was placed in a Craig tube and several drops of hot (100°C) solvent (50% water, 50% methanol, by volume) was added and heated until

all of the crystals dissolved. The Craig tube was plugged and set in an Erlenmeyer flask to cool. Crystallization was induced once the mixture was at room temperature by scratching the inner wall of the tube. It was then placed into an ice bath for ten minutes until crystallization was complete. The tube was then centrifuged for 3 minutes to remove the liquid. The crystals were collected on a watch glass and allowed to air dry. The resulting crystals (o. o82g) were pale brown in color. Melting points were taken for both the crude (165. 9 – 179. 9°C) and the pure (168. 2 – 171. 5°C) acetaminophen. Results and Calculations

Moles p-aminophenol :

0. 150 g x (1 mol)/(109. 1 g)= 0. 00137 mol ← p-aminophenol is the limiting reagent

Moles of acetic anhydride:

0. 165 mL x (1. 08 g)/(1 mL) x (1 mol)/(102. 1 g)= 0. 00174 mol Theoretical Yield:

0. 00137 mol x (151. 2 g)/(1 mol)= 0. 207 g

Percent yield of crude acetaminophen:

Crude crystal weight = 0. 089 g

(0. 089 g)/(0. 207 g) x 100%= 46. 48 %

Percent yield of pure acetaminophen:

Pure acetaminophen weight = 0. 082 g

(0. 082 g)/(0. 207 g) x 100%= 39. 61 %

Literature value of acetaminophen melting point = 169. 5 – 171. 0°C Crude acetaminophen melting point = 165. 9 – 170. 9°C
Recrystallized acetaminophen melting point = 168. 2 – 171. 5°C Discussion and Conclusions
Crude acetaminophen was successfully synthesized, forming light brown crystals. All of the solid was allowed to dissolve, and the mixture was adequately heated. The crystals were allowed plenty of time to fully cool. A percent yield of 46. 48% was achieved, with a total of 0. 089 g being formed.

Recrystallization was done on the crude product, resulting once again in light brown crystals. All of the solid was dissolved in the hot solvent, and crystallization occurred once induced by scratching the inside of the tube. The crystals were properly cooled, and a percent yield of 39. 61% was achieved (0. 082 g were formed).

The melting point of the crude acetaminophen (165. 9 – 170. 9°C) was lower and broader than that of the recrystallized acetaminophen (168. 2 – 171. 5°C), showing that initially there were impurities present. The recrystallized acetaminophen melting point was very close to the literature value (169°C), indicating that the final product was quite pure.

The low percent yields of both the crude product and the recrystallized product could have been caused by several factors. Some of both products could have been lost when transferred to the watch glass to be weighed. The hot plate that the reactions occurred on was also very unstable, and the temperature fluctuated throughout the reaction. This may have effected how much product was formed, as more side products would have resulted from

a higher temperature. The crude crystals were also not allowed enough time to adequately dry before recrystallization occurred. Had they been allowed more time to dry, the percent yield of pure acetaminophen may have increased.

Overall, however, the experiment was successful, as pure acetaminophen was synthesized. The melting point of the product confirmed the high level of purity, and the difference between the crude and recrystallized products could be easily observed.