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Organic Chemistry Lab Report IV

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Experiment VIII: The Bromination of Cholesterol ³²

An Electrophilic Addition Reaction (Ad_E) to a Natural Product

Abstract

The main focus of this experiment is to perform an electrophilic addition reaction to a natural product. This product is cholesterol which undergoes a specific halogenation process called bromination. This process causes cholesterol to form cholesterol dibromide. I began with 100 mg of cholesterol which was dissolved by the addition of methyl *tert*-butyl ether (MTBE) then a bromine solution (Br_2 dissolved in acetic acid HOAc with NaOAc). The molecules of cholesterol became cholesterol dibromide and crystallized. This solution went through vacuum filtration and was left to dry for one week before the final mass and melting point were obtained. 88 mg of cholesterol dibromide was collected from initial 100 mg of cholesterol and its melting point ranged from 109.3°C-110.8°C. The percent yield calculated is 56% which is normal considering many other students' yield averaged 51%.

Procedure

The procedure adaptation is from Poulos, Z.J., Organic Chemistry I- "A Laboratory Manual for the Health Science Major," Fall 2019; Hayden-McNeil; Plymouth, MI, 2018. pp 125-136. There were some minor changes to this experiment, by our instructor's directions we were told to not worry about the sizes of beakers for ice water baths. In addition, the wash

solution of 30% MTBE in glacial acetic acid was transferred from the 10 mL graduated cylinder into a culture tube for our convenience when chilled in the ice bath and for when we used it to rinse the flask during vacuum filtration. Another change was the addition of the red-brown solution of bromine which was added slowly by 3-5 drops then placed to chill in an ice bath, this process was repeated until the solution stayed a light yellow color. Instead of using the micropipette and adding 110 uL of the bromine solution, we used a regular Pasteur pipette.

Data and Calculation

Cholesterol mass (initial)	Aluminum dish mass	Cholesterol mass (final)	Actual yield (final cholesterol mass-aluminum dish mass)	Theoretical yield	% yield ($\frac{\text{actual yield}}{\text{theoretical yield}} \times 100$)	Melting point observed (Celcius) °C
100 mg	412 mg	500 mg	500 mg- 412 mg = 88 mg	158 mg	$\frac{88 \text{ mg}}{158 \text{ mg}} \times 100 = 55.69 \approx 56\%$	109.3°C -110.8°C

The theoretical yield is calculated by:

$$(100 \text{ mg of cholesterol}) \times \left(\frac{1 \text{ mmol}}{386.66 \text{ mg}} \right) = 0.26 \text{ mmol}$$

Then, the theoretical yield in moles is used to calculate the theoretical yield in mass:

$$(0.26 \text{ mmol}) \times \left(\frac{606.52 \text{ mg}}{1 \text{ mmol}} \right) = 158 \text{ mg}$$

Classmates % yield:

33%	42%	56%	35%	62%	67%
67%	67%	29%	53%	55%	

Average of classmates % yield:

$$\frac{33+42+56+35+62+67+67+29+53+55}{11} = 51.45 \approx 51\%$$

Discussion and Conclusion

The purpose of the experiment was to perform an electrophilic addition reaction to a natural product. An electrophilic addition reaction is the breaking of a π bond to form two σ bonds. The bromination of cholesterol begins with the breaking of a π bond. However, this π bond is an alkene double bond linked between carbon 5 and carbon 6 in the cholesterol's four membered ring. So when the bond breaks it forms two σ bonds in their place. It gives its electron to one of the two bromine molecules resulting in a bridged bromonium ion then a negatively charged bromide. This is negatively charged because it receives all the electrons that were shared between it and the other bromine atom. The two bromides add anti to the cholesterol intermediate. The breaking of double bonds to form single bonds are exergonic which means this reaction occurs spontaneously.

I measured 100 mg of cholesterol which was in a white powder form. This was mixed with MTBE to fully dissolve the cholesterol in an erlenmeyer flask. Then, drops from the solution of bromine was added into the flask. I observed a change in color going from milky white to a yellow color when bromine was added. This color change did not stay until multiple drops of bromine were added. Once the yellow color was consistent while in the ice bath, I vacuum filtrated the solution. The yellow color indicates an excess of bromine and precipitate indicates crystallization. To get all the solid cholesterol dibromide from the flask, glacial acetic acid wash was prepared to rinse the glassware of any leftover cholesterol dibromide. The solid was placed into a tared aluminum dish and left to dry for a week. Once a week passed, the cholesterol dibromide was massed. I massed 88 mg and the observed melting point at 109.3°C-110.8°C.

This is different from the expected melting point which was given by the lab instructor as 112°C-115°C. My melting point was lower which means my cholesterol dibromide was not extremely pure.

When comparing my percent yield to my classmates, I found the average to be 51%. Compared to my 56% I do not believe my % yield is absurdly high or low. Despite this, my % yield is different from my classmates this is due to human error. When I initially transferred the cholesterol from my measuring tool into the erlenmeyer flask I lost some product. During vacuum filtration, I did not properly scrape out the cholesterol dibromide from the Hirsh funnel and filter paper. Even with the wash solution, I did not collect all the cholesterol dibromide in the flask.

The IR for cholesterol shows a C-O bond at the peak in 1052. Activity between 2850 and 2928 represents the C-H stretch. There is an O-H stretch seen in 3302 and CH₂ at 1464. The IR for cholesterol dibromide we see the same O-H bond in 3418. There are C-H bonds in 2948. We have a C=O bond stretch at 1706 and a C-Br stretch on the right of 667.

Reactions