Oxidization of Benzyl Alcohol to Benzaldehyde

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Abstract

The objective of this experiment was to successfully oxidize benzyl alcohol using benzaldehyde with hydrogen peroxide as the catalyst instead of using less traditional, more hazardous catalysts that are harmful to the environment. Our results indicate that when benzyl triethyl ammonium chloride (BTEAC) is heated to reflux with sodium molybdate and water, the catalyst that is produced can be mixed with benzyl alcohol and hydrogen peroxide, then distilled to create benzaldehyde.

Materials/Methods

First, a Tetrakis (benzyltriethylammonium) Octamolybdate catalyst was prepared. The catalyst, composed of sodium molybdate dihydrate, hydrochloric acid, and water was prepared in the first vial. Into a second vial, benzyl triethyl ammonium chloride and water were combined and heated until completely dissolved. Next, the sodium molybdate solution was added into the second vial and stirred. After removing the solution from the heat, the solid product was collected and left to dry. In order to prepare the benzaldehyde, benzyl alcohol was added to the dry catalyst, along with hydrogen peroxide. The mixture was heated to reflux for 60 minutes. The final products were obtained by distillation (Figure 2). The three batches of distillates, all obtained at different temperatures, were placed onto polyethylene infrared examination cards (Figure 3), and analyzed by Fourier-transform infrared spectroscopy (FTIR) to determine what compounds had been obtained by the distillation process.

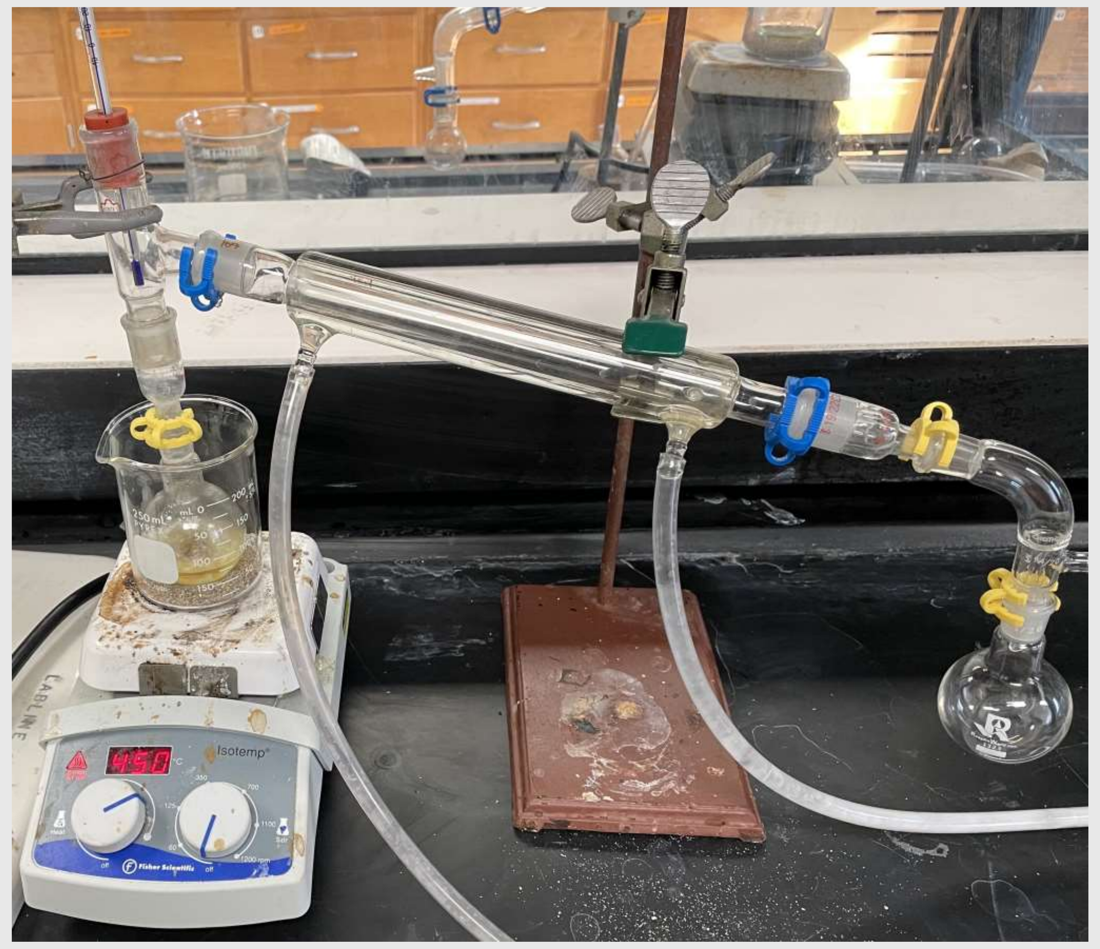

Figure 2, displaying the distillation process of benzyltriethylammonium, hydrogen peroxide, and benzyl alcohol into a benzaldehyde.

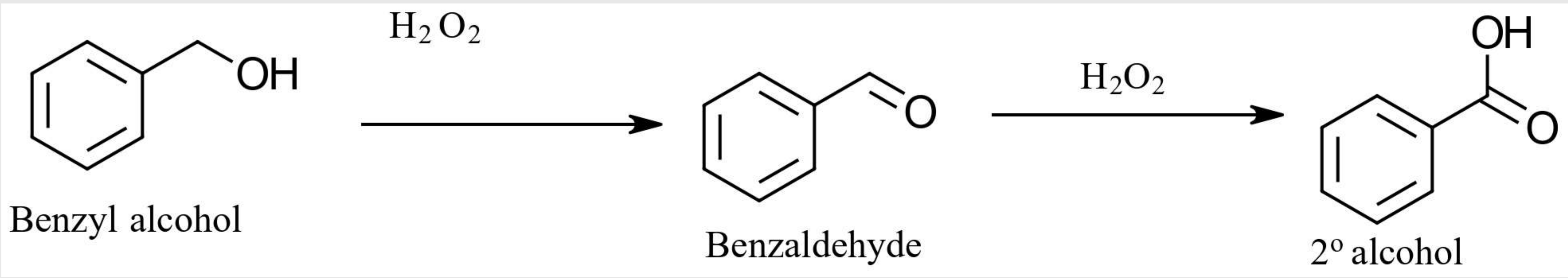

Figure 1 displays the reaction that occurs through distillation as Benzyl alcohol oxidizes into an aldehyde and a second- degree alcohol

Background

The oxidation of alcohol is used in green and organic chemistry to create a carbonyl group, which can be utilized in other chemical reactions (Smith, 2017). Oxidation of primary and secondary alcohols can create corresponding aldehydes and ketones. (Figure 1) The benefit of using hydrogen peroxide in oxidation reactions is that it is an inexpensive and readily available chemical, but more importantly is a greener (more eco-friendly) alternative for the environment due to its by-product being water. According to a study done by Heravi et. al (2020), different chemical environments (such as aqueous mediums, solvent-free systems, and various organic solvents, indicate good selectivity and, in most cases, no overoxidation to acids are observed in the presence of a hydrogen peroxide oxidant.

Results

After analyzing the product of the reflux and three batches of distillation in the FTIR and comparing it with a known negative control sample of benzaldehyde, it was determined that the product that final product was an aldehyde based on its wavelength and absorbency in the FTIR machine. The product of the third distillation also produced an odor that smelled very strong of cherry/almond scent. According to the National Center for Biotechnology Information (2021), benzaldehyde is a compound that smells like cherry/almond reinforcing that the final product was benzaldehyde.

Conclusions

In conclusion for this lab, when the Benzyl Alcohol and a catalyst composed of benzyl triethyl ammonium chloride, hydrochloric acid, and sodium molybdate are combined and distilled, the product is benzaldehyde. This technique of the oxidation of benzyl alcohol and the production of benzaldehyde is much better for the environment because it utilizes hydrogen peroxide, which has a byproduct of water, as an oxidizing agent. This is significant because using other chemicals for oxidation can result in harmful byproducts, and other oxidizing agents are less readily available as opposed to hydrogen peroxide. One source of potential error in this lab may have occurred when obtaining the dried-out catalyst. The reaction only produced about half of the desired amount of dry catalyst, which can affect the outcome of the distillation reaction and temperatures in which distillation occurred.

Figure 3 displays the three polyethylene FTIR cards that contained samples of the three batches of distillate. These cards were then placed into the FTIR machine to examine the wavenumber and absorbance of distillates/

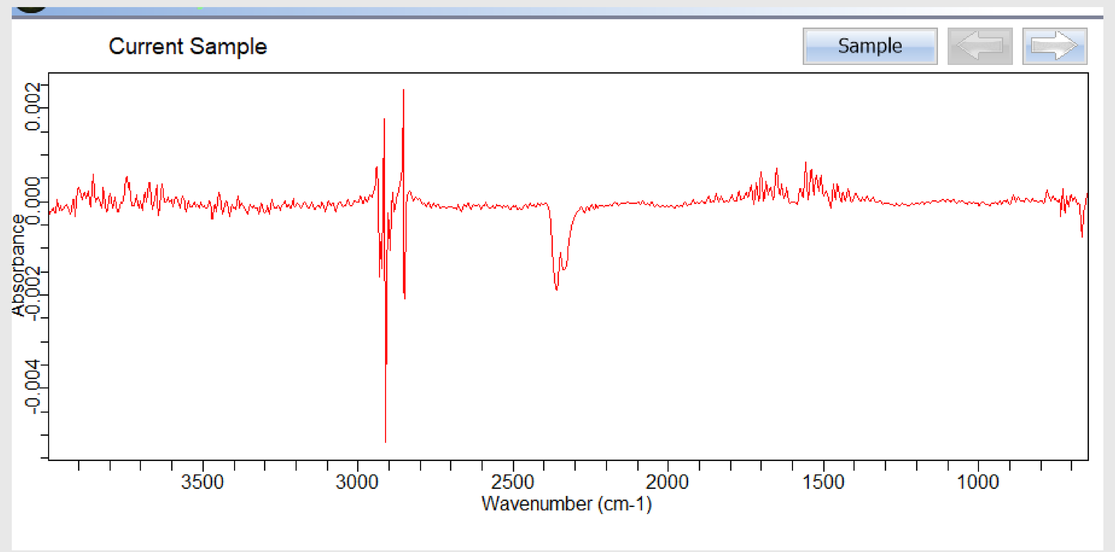

Figure 4 displays the FTIR reading for the third distillation sample. This sample reading from the FTIR machine displayed that the sample was a benzaldehyde, based upon its comparison to a positive control sample of a known benzaldehyde.

References

M. Heravi, M., Ghalavand, N., & Hashemi, E. (2020). Hydrogen Peroxide as a Green Oxidant for the Selective Catalytic Oxidation of Benzylic and Heterocyclic Alcohols in Different Media: An Overview. *Chemistry*, *2*(1), 101–178. doi:10.3390/chemistry2010010

Smith, J. G. (2017). *Organic chemistry (5th ed.)*. New York, NY: McGraw-Hill Education.

National Center for Biotechnology Information (2021). PubChem Compound Summary for CID 240, Benzaldehyde. Retrieved February 14, 2021 from https://pubchem.ncbi.nlm.nih.gov/compound/Benzaldehyde.