Fractional Distillation of an Ethanol- water Mixture

Abstract

The purpose of this experiment is to understand the process of distilling a solution. The solution of 50/50 ethanol-water was used in the experiment. Using fractional distillation apparatus ethanol-water mixture was separated. The fractional use of copper sponge was used in distillation process which created the heat exchange area between the vapor of ethanol and liquid water. The fractional distillation process yield 9.5 ml of ethanol in collecting flask, thus the hypothesis was accepted.

The purpose of this experiment is to understand the process of distilling a solution. Distillation deals with a mixture, a solution composed of two or more elements, that when boiled, will cause each element to vaporized at different temperatures [1]. Distillation is only effective if there is a significant difference between the boiling of the

two elements. Every element had a unique boiling point specific to the amount of bonds and structure of that element.

With that said, in this distillation lab the solution used was 50/50 ethanol-water. The normal boiling point of ethanol is 78°C while the normal boiling point of water is 100 °C. Theoretically, as the solution heated in a distillation apparatus, the temperature begins to rise. The ethanol in 50/50 ethanol-water solution would initially vaporize due to its lower boiling point if compared to water. This separates the ethanol from the water in this solution, channeling the vapors through the condenser. There, the vapor condenses into a liquid and collects into a collecting flask. In this specific solution, 50 percent of the solution leaves the heated flask to the collecting flask. Theoretically, at the end of the experiment, the collecting flask collects 50 percent of the originally volume. This type of distillation is known as simple distillation [1].

Fractional distillation is more effective form of distillation because it more accurately separates the ethanol from the water in 50/50 ethanol-water solution. This type of distillation differs from simple distillation because of the use of copper in the vaporizing process. Copper sponge is used to create a heat exchange area between the vapors of ethanol to the liquid water. As the vapor begins to form, it comes into contact with the copper wires thus cooling the vapor and condensing it to liquid.

As the water heats, the liquid water releases energy in form of heat, which acts as a catalyst in heating lower boiling point liquid ethanol. As the ethanol is exposed the copper wires, the heat from the water moves the ethanol gas upwards towards the condensing flask and the water drips back towards the heated flask. As the liquid moves down the tubing towards the heated flask, it comes into contact with the very hot vapor

once again. This continues many times and after multiple cooling and reheating sessions the vapor is collected in the collecting flask in a theoretic pure form. Because of this repetitive phase change, fractional distillation is the preferred method. It is hypothesized that using the fractional distillation process in a solution of 50-50 ethanol-water, will yield equal portions of ethanol and water.

Method/ procedure:

The procedure to perform this experiment can be found in the book "Macroscale And Microscale Organic Experiments by Kenneth L. Williamson"[1]. Deviation that occurred while performing the experiment was that A deviation that occurred while performing the experiment was that 20mL of Ethanol-Water mixture was used instead of 30 mL. Also, the data for the temperature versus drops of ethanol was not collected.

Results:

Figure 1: *Fractional Distillation Apparatus*

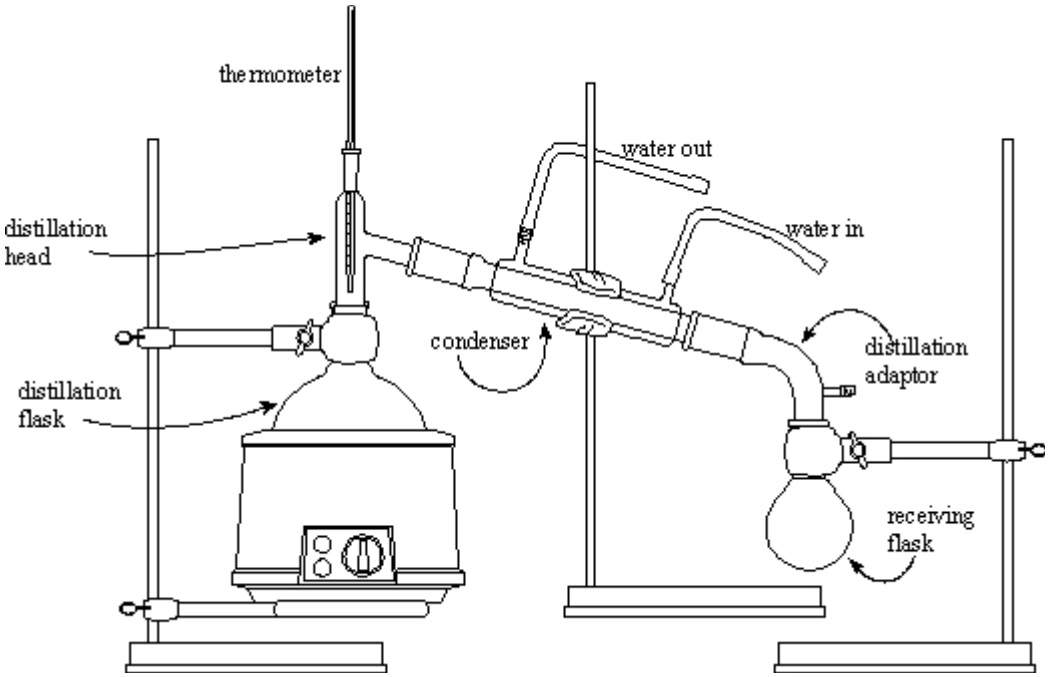

Figure 2: *Simple and Fractional Distillation curves* [1]

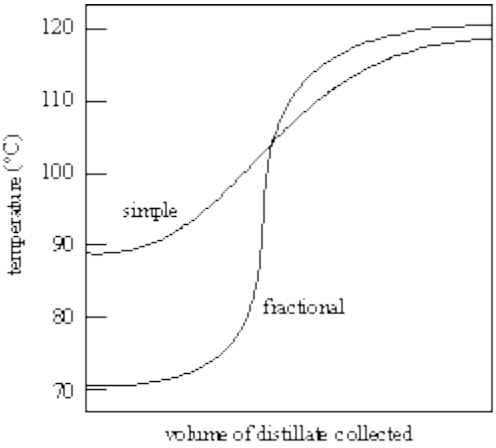

Table 1: *Data Before and After Heating Ethanol-Water Mixture*

Before Heating Distillation Flask (mL)	**20**
After Heating Distillation Flask (mL)	**10.5**
Before Heating Receiving Flask (mL)	**0**
After Heating Reveing Flask (mL)	**9.5**

Discussion

The result from the data shows the amount of Solution before heating and distillate formed after vaporization of the solution. In the distillation process, 10.5mL of 50/50 ethanol water solution remained in the heating flask. In the collecting flask, 9.5mL of ethanol were collected after the distillation process. According to the Figure 1, Graph from the book, as the temperature increased, the amount of distillation per second should increase. During the experiment, the ethanol was removed from the 50/50 ethanol water solution and collected in a graduated cylinder. According to the data, the amount of ethanol collected is correlated to the temperature of the heated solution. As the temperature increased and reached the lower boiling point of ethanol, the amount of ethanol in collecting flask started to increase. According to Figure 1 it shows that the temperature of the vapor hovered around 79^{o}C and then rapidly increased to the boiling point of the diluted water. In this experiment the boiling point of water was found to 89^{o}C.

The amount of time to heat the ethanol and vaporize the element was quick and fast because of the copper sponge in the fractional distillation. Copper sponge accepted heat because it is a good electrical conductor. Using copper metal allowed fast cooling of the vapor thus cooling the vapor and reheating it for re-distillation. The copper was used in a sponge form so that the increased surface area can allow a faster rate of heat exchange.

Another important part of the distillation was the open apparatus. The fractional distillation was only possible by the use of vapor pressure, that once increased can give significant force on the walls of the apparatus thus causing an explosion. The apparatus should always be opened and allow even gas exchange to the environment in order to

release the vapor pressure to the environment. Once this occurs, this can continue the heating of the solution and create even vapor formation.

The hypothesis in the experiment was to see if the 50/50 ethanol-water yields 50 percent ethanol in collecting flask after heating the solution. As the results depicts, the fractional distillation yield nearly 50 percent ethanol as expected. Therefore, it shows that distillation is an effective way of separating the two elements in a mixture.

Conclusion

Fractional distillation yield 9.5 ml of ethanol in collecting flask from 20 ml of ethanol-water. The theoretical value of the separating should have yield 10ml of ethanol, which meant 5% error. Therefore the results were reasonable and as expected. However, there was still some error which could be improved when processing experiment next time. The error could have been found due to improper heating and lack of temperature control. If the solution was continuously reheated the percent of water in the solution would reduce. If the instrument was correctly attached with tuning could allow proper removal of vapor form the instrument. Increasing the number of trials would provide for more accurate results. Also, performing experiment with a more precise graduated cylinder. All in all, the process of distillation is a effective way of separating two solution in a mixture.

Literature Cited

Williamson, K, Minard, R, & Masters, K (2007). *Macroscale And Microscale Organic Experiments*. New York, NY: Houghton Mifflin.