

Simple fermentation can only produce solutions that contain about 10-15% alcohol, because at this level the yeast organisms are actually poisoned by the ethanol. To achieve higher alcohol content, the ethanol must be distilled from the water. Distillation is a process by which two liquids with different boiling points may be separated from each other. In distillation, the mixture to be separated is placed in a distilling flask. When heat is applied, the component with the lower boiling point (in this case, ethanol) tends to vaporize first. The vapor then travels through the distillation apparatus until it contacts a cool surface, at which point it condenses. (The copper coils in Hawkeye's still in MASH serve this purpose.) The liquid that drips out of the end of the distillation apparatus is enriched in the lower boiling component. In this case, the boiling point of ethanol (78° C) is close enough to that of water that the separation is not complete. Even with a very efficient distillation apparatus, the best that one can do is 95% ethanol and 5% water. In applications where the ethanol must be at least 99.8% dry before it can be used, such as a fuel blend, further drying must be done. This is usually accomplished by redistilling the aqueous ethanol and/or passing the distillate through molecular sieves, which absorb the remaining water.

Procedure: Part II

Weigh the beaker containing the corn solution (this is called the "mash").

A. Distillation of Ethanol from Mash

1. Add the fermented mash to a 500 mL round bottom flask. Avoid getting chunks of your starch source in the round bottom. Using a Buchner funnel without filter paper usually is sufficient to filter out chunks.
2. Set up the distillation apparatus. In order to do this properly:
 - a. Make sure to grease the ground glass joints before connecting. This helps to prevent any vapor from escaping and the joints from freezing together.
 - b. Place 5 boiling chips in the 500 mL round bottom flask to promote even boiling.
 - c. You will use a thermwell to provide the heat necessary to do the distillation. The thermwell becomes extremely hot.
 - d. As a safety valve, you should be able to raise or lower the thermwell. Supporting the thermwell on an iron ring will allow you to remove it quickly from the distilling flask if necessary.
 - e. Before you actually apply heat to your distillation apparatus, have your lab instructor inspect it.
 - f. Attach the round bottom to the ring stand with a steel clamp.
 - g. The best separation of alcohol will occur if the distillation is allowed to occur slowly!!
3. Weigh a clean Erlenmeyer flask or your 50 mL round bottom.
4. Collect the distillate into the (preweighed) flask. Note temperature range over which it is collected. Collect about 10 mL of distillate.
5. Weigh the flask and distillate after the distillation has been completed.

The remaining mash and distillation solution should be placed in the appropriate disposal container.

2) What does poisoned corn flakes have in common with Charles Manson?

(Answer below)

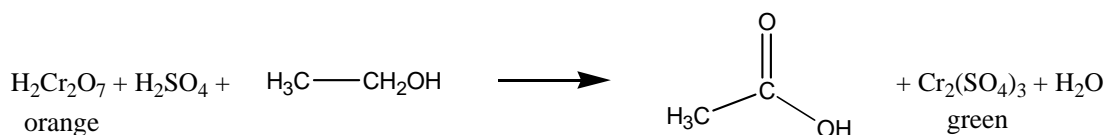
3) What did the guy say to his girlfriend when he saw that they were being followed by a corn plant?

(Answer below)

B. Characterization of the Distillate.

The percent composition of the ethanol in your distillate will be determined by measuring its refractive index. The refractive index of water at 20° C is 1.3330. The refractive index of ethanol at 20° C is 1.3639. A calibration curve can be drawn which can be used to determine the composition of a mixture of water and ethanol.

To characterize your distillate you can perform a variation of the famous breath analysis test given to catch drunk drivers. Place 10 drops of chromic acid reagent in a small test tube. Add several drops of your distillate, one drop at a time, with shaking.



A positive test is indicated by the formation of a green precipitate and a loss of the orange color in the reagent.

After you are sure that you no longer need any of your sample, you may try to light it on fire. Pour a small amount of it on a watch glass. Make sure that there are no other flammable materials nearby. Ignite it with a match and look closely, as alcohol flames are often difficult to see.

2) They are both “serial” killers

3) “Don’t look now but I think we are being followed by a stalker.”

Increasing ethanol production provides a much-needed economic boost to rural America. Record harvests have resulted in historically low commodity prices. Ethanol provides a vital value-added market for corn and other commodities. The use of grain for ethanol production adds up to 30 cents to every bushel of corn. Not only do farmers benefit from the higher price, an increasing number of farmers are joining together in cooperatives to build ethanol production facilities - thereby directly taking advantage of the value-added market through ownership.

Checklist for completing the "Prelab" section: Part II

___ *Flowchart.* Use images and flowchart organization

___ *Calculations.* Complete the sample problem on page 7:

Experimental Observations and Data: Part II

Hand in a copy of your experimental observations and data before you leave the lab!

Lab Report Checklist: Due the week after completing Part II.**Results: Show Calculations!**

___ Mass of ethanol produced by CO₂ loss method.

___ % yield (from corn weight) using CO₂ loss data.

___ Mass of ethanol produced by distillation method.

___ % yield (from corn weight) using distillation data.

Discussion and Conclusion.

___ What are two advantages of using distillation to separate two or more liquids?

___ What are two disadvantages of using distillation to separate two or more liquids?

___ How did your two percent yields compare? Explain why they are different.

___ Give two techniques you could use to continue to purify your distillate.

___ Why do you need to cool down the cooked corn in part I before adding enzymes and yeast?

___ Suggest two ways to improve the over-all yield of ethanol from corn. (How can you get more ethanol from the same amount of corn?)

___ Currently ethanol made from field corn is being added to gasoline being sold at gas stations (about 10% ethanol). Are you in favor of this practice? Briefly defend your opinion with at least two points.

Sample problem: (to be completed before attempting Part II)

1) CO₂ loss method of determining ethanol yield.

Sample data: 50.06g Mass of corn
 172.76g Mass of beaker
 283.76g Mass of beaker + fermentation solution.
 279.21g Final mass of beaker + mash after fermentation.



Assume that all of the mass loss in the fermentation process was due to carbon dioxide (CO₂) escaping.

a) molecular weight (MW) of C₂H₅OH = _____ g/mole

b) molecular weight (MW) of CO₂ = _____ g/mole

c) weight fraction = $\frac{2 \times (\text{MW C}_2\text{H}_5\text{OH})}{2 \times (\text{MW CO}_2)}$

d) mass of CO₂ = (Mass of beaker + fermentation sol.) – (Final mass of beaker + mash)

e) mass of CO₂ x weight fraction = _____ grams of ethanol produced

f) grams of ethanol x 100 / mass of corn = _____ % yield

2) Distillation method of determining ethanol yield.

total mass of mash = (Final mass of beaker + mash after fermentation) - (mass of beaker)
 27.55g distillate flask
 44.65g distillate flask + distillate
 1.3462 Refractive Index of distillate = 19% ethanol in distillate.

Calculate how much ethanol would have been collected if all of the mash would have been distilled:

a) Mass of distillate = distillate flask + distillate - distillate flask = _____ g

b) Mass of ethanol in distillate = percent alcohol x 0.01 x mass of distillate = _____ g

c) mass of ethanol in total mash x 100/ grams of corn = _____ % yield.

Fun Quiz:

Match the alcoholic beverage with its sugar source or special flavoring:

- a) Whiskey
- b) Oogoro
- c) Beer
- d) Rum
- e) Ulanzi
- f) Brandy
- g) Wine
- h) Urwaga
- i) Vodka
- j) Saké
- k) Yakupa
- l) Bourbon
- m) Amaretto
- n) Gin
- o) Scotch
- p) Tequila

- _____ Barley malts (aged in Scotland)
- _____ Almonds and/or Apricot pits
- _____ potatoes
- _____ barley and hops
- _____ Manioc (Cassava root)
- _____ rice
- _____ banana
- _____ wine (redistilled)
- _____ grapes or other fruits
- _____ Palm tree sap
- _____ Bamboo tree sap
- _____ at least 50% corn + other grains (aged)
- _____ sap of blue agave plant
- _____ juniper berries
- _____ sugar cane
- _____ grains: rye, corn and barley

Wine is a mocker, strong drink is raging.
Bible, Proverbs 20:1

Drink to me only with thine eyes,
And I will pledge with mine;
Or leave a kiss but in the cup,
And I'll not look for wine.
Ben Jonson, To Celia