CHEMISTRY EXTENDED ESSAY

"Invastigating the efficiency of the organic materials: Sugarcane, sugar beet and corn in ethanol production"

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Abstract:

In this experiment I investigated the research question, “Which one between the corn, sugarcane and sugar beet will produce more biofuel from same amount of material measuring by a precise measuring cylinder?”

Humantiy used various types of energy sources in order to ease their lives. The very first invention that changed the developement the humanity was the discovery of manupulating fire. Humanity started to use fire as a weapon, as a shield and as source of energy which helped them to cook raw meat and other materials. Fire is something that needs to be feeded with various fuel. From wood to fossil fuels like petroleum. Nowadays people use fossil fuels as their energy source to make their car engines and heating systems work. Fossil fuels may be cheap but isn’t infinite. In case of a fossil fuel shortage there are alternative fuel types such as biofuels which is obtained from biological mass. In other words biofuel can be called ethanol which is basically ethyl alcohol. While fossil fuel can run out, Biofuels can be produced by a few steps from fresh organic crops such as sugar cane, sugar beet and corn. The investigation was about which one of these organic crops would have the highest produced ethanol and used organic substance ratio.

The results of investigation showed that the higher the substance is composed of sugar,higher the amount of ethanol produced. The datas clearified the amount of sugar differs from the substances and the corn had the greatest ratio among other substances (sugar beet and sugarcane). From the results highest amount of ethanol produced from the substances is to be found 56.3 ml from corn. All results suggested that Corn is the most efficient organic material to use in ethanol production.

Word Count: 291

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1.Introduction

Biofuel is a fuel type that can be obtained by using organic materials, such as animal fats and plant sugars. Also other than biological materials biofuel can be produced by using organic material such as materials from plants, or agricultural waste. Basically any organic matter which has organic sugar in it. The same type of carbon fixation occur in algea and plant organisms in photosynthesis process. These fuels are obtained by the process of convertion of biomass. The biomass conversion can be resulted in three different phases liquid, solid or gas. One of those liquid biofuels is the bioethanol

Bioethanol is a type of alcohol produced by using the methods of fermantation. Commonly it is obtained from the sugars inside starch corps such as sugar beet, sugarcane and corn. From the non-food biomass sources such as grass like plants, the bioethanol can be produced. The bioethanol in it's pure form is also can be used as a source of energy and fuel for vehicle engines. Bioethanol is currently used as a octane increaser by adding ethanol to gasoline which improves the vehicle emmission. Bioethanol is currently preferable in USA and commonly used as a performance upgrader.

2.Reasearch Question

Which one between the corn, sugarcane and sugar beet will produce more biofuel from same amount of material measuring by a precise measuring cylinder

3.Background Information

3.1.Introduction to biofuel

As of 2011, global biofuel production has reached 105 billion liters, increased 17% since 2009, biofuels consists the 2.7% of the global fuel for internal-combustioned motor vehicles, this contribution is greatly caused by the ethanol and biodiesel. Global biofuel production reached 86 billion liters in 2010, Brasil and US as the leading ethanol producers, together Brasil and US make up to 90% of global ethanol production. Aside of Brasil and US, world's leading biodiesel producer is Europian Union, which takes on the 52% of the World's entire biodiesel production in year 2010. The biofuel production caused a new type of automotive industry type in some countries like Brazil. 79% of entire cars that are in the traffic of Brazil are manifactured with a hybrid system that is compatible with biofuels. The International Energy Agency has created a goal which is meeting the ¼ of global fuel demand with biofuel by the year 2050.[1]

A lot of different economic, envorimental and technical problems related to production of biofuel are being debated on social medias and scientific journals. Examples of these topic are: carbon emission levels, sustainable biofuel production and deforestation etc.

[1] http://www.afdc.energy.gov/fuels/ethanol_production.html

3.2.Information on sugar cane, sugar beet and corn

Corn, which is also called maize, is the primary crop that is cultivated by the natives of the South America in the prehistoric times. Corn has high amount of sugar in it. It has a leafy stalk that grows wide ear like leafs that are called ears contain the grain. These are seeds called kernels. Corn kernels are commonly used in cooking as starch.

Sugarcane is one of the several species of tall perennial true grasses of the genus *Saccharum*, tribe *Andropogoneae*, native to the warm temperate to tropical regions of South Asia, and used for sugar production.

Sugarcane has a structure which rich in sugar, and they can be measured up to six meters tall. All sugar cane species interbreed and the major commercial cultivars are complex hybrids.

Sugarcane can be considered as member of the grass family (Poaceae), which includes important products such as wheat, maize and rice and many other daily used crops. The primary product of the sugarcane is sucrose. Sucrose is used as a raw material in food industries or is fermented to produce Ethanol. Ethanol production is very important for some countries such as Brazil, the sugarcane industry is producing ethanol from sugarcane on a large scale.

Sugarcane is taking the lead in world's biggest crop production by quantity. In 2012, Food and Agriculture Organization estimates it was cultivated on about 26 000 000 hectares, in more than ninety countries, which has a global harvest quantity of 1 830 000 000 tons of product. Brazil was the leading producer of sugarcane in the world. Besides Brazil, the other five major producers, in decresing amounts of production, were Pakistan, Mexico, Thailand, India and China.

The world demand for sugar is the primary reason of sugarcane agriculture. Sugarcane makes up the 80% of the sugar produced: the rest of it is mostly made from sugar beets. Sugarcane predominantly grows in the tropical and subtropical regions, and sugar beet predominantly grows in

colder temperatures of the world. Other than sugar, products derived from sugarcane include falernum which is a sweet syrup, rum, cachaça, a traditional spirit from Brazil, and ethanol. In other parts of the world, people also use sugarcane reeds to craft screens, thactch and pens. The young unexpanded iflorescence of tebu telor is eaten raw, toasted and steamed. Can be prepared in may ways.

Between sixth and forth centruies Before Christ, In India people discovered the sugarcane which was called “reeds that produce honey without bees”. Right after discovering the sugar production from sugarcane, people started to spread and adopt the sugarcane agriculture. It was too long before merchants start to trade sugar as an expensive and luxury spice. Until e18th century, people anknowledged sugar as a valuable spice. Before the 18th century, sugarcane was almost unique to India but in 19 th century with the result of large scaled human migrations, it started to spread around the world.[2]

Sugar beet is plant that is has high amount of sucrose in it. The most of the sugar is stored in it’s roots. Sugar beet is mainly used for sugar production. It is a member of Beta vulgaris family. Other family members are chard and beetroot, has a common wild ancestor called sea beet.

In 2011, France, the United States, Germany, Russia, and Ukraine were the world's five largest sugar beet producers by mass, whilst by value Turkey takes the place of Ukraine. However, in 2010–2011, North America, Western Europe, and Eastern Europe did not produce enough sugar from sugar beets to meet overall demand for sugar, and were all net importers of sugar. The US harvested 1,004,600 acres (406,547 ha) of sugar beets in 2008. In 2009, sugar beets accounted for 20% of the world's sugar production. [3]

[2] http://www.scielo.br/pdf/cta/v31n3/a40v31n3.pdf
[3] http://www.ars.usda.gov/is/pr/2011/110609.htm

3.3.Distillation

Distillation process is a process that is used to separate a pure liquid from a mixture of liquids. In order to make this system work, the liquids that are in the mixture must have different boiling points. Distillation is commonly used to separate ethanol from water.[4]

Distilation process of Ethanol from water

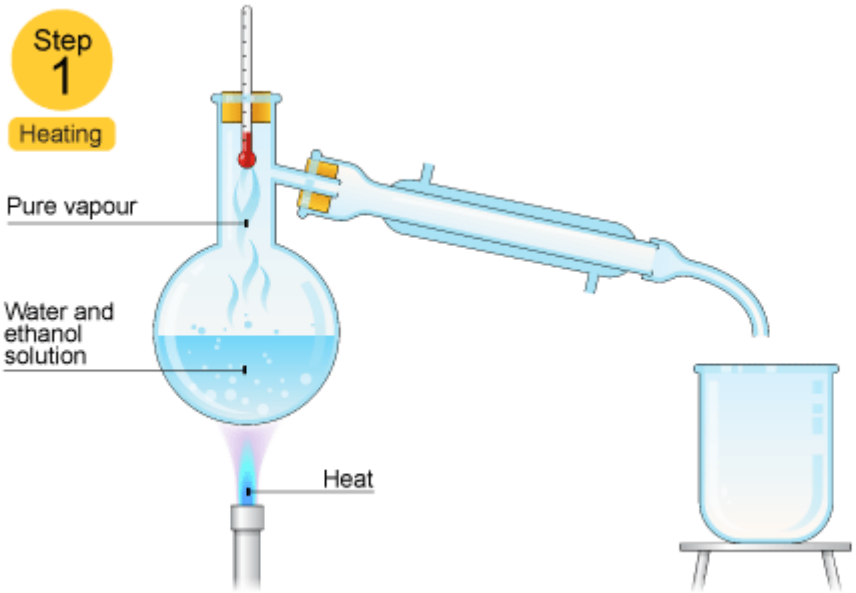

*Figure was taken from

http://www.bbc.co.uk/schools/gcsebitesize/science/edexcel_pre_2011/oneearth/fuelsrev1.shtml

The mixture of water and ethanol is heated in flask. Since ethanol has a lower boiling point than water this system can work on the system and ethanol evaporates earlier than water. When the ethanol vapour is condenced, the cooled in condencer it form a pure ethanol liquid. Temperature in flask stays constant while ethanol is being evaporated. When all the ethanol is evaporated, the temperature starts to rise again.

[4] http://www.bbc.co.uk/schools/gcsbitesize/science/edexcel_pre_2011/oneearth/fuelsrev1.shtml

3.4.Fermantation of Ethanol

Ethanol fermantation, in other words alcoholic fermantation, is the process of convertion of fundamental sugar such as glucose into energy. This process causes ethanol along with carbon dioxide. Yeasts are the performing component in this convertion. With no trace of oxygen in entire process, fermantation of ethanol is basically an anaerobic process.

Ethanol fermantation is commonly used in production of alcoholic beverages. Other than the beverages it is also used in the production of biofuels. Biofuel is not a type of fuel that is popular worldwide but in countries like Brazil, cars are manifactured with a hybrid system that can work with using biofuel as fuel source.[5]

[5] Lynn Ellen Doxon. *The Alcohol Fuel Handbook*. InfinityPublishing.com. ISBN 0-7414-0646-2.

4.Data Processing

Type of Organic Matter	Trial	Mass of Organic Matter (±0.1 g)	Volume of Ethanol Produced (±0.01 ml)
Sugarcane	1	250.0	17.54
Sugarcane	2	250.0	17.41
Sugarcane	3	250.0	17.43
Corn	1	250.0	56.23
Corn	2	250.0	55.97
Corn	3	250.0	56.78
Sugar beet	1	250.0	22.55
Sugar beet	2	250.0	20.98
Sugar beet	3	250.0	21.73

Table 1: Volume of ethanol obtained from the specific mass of the organic matter.

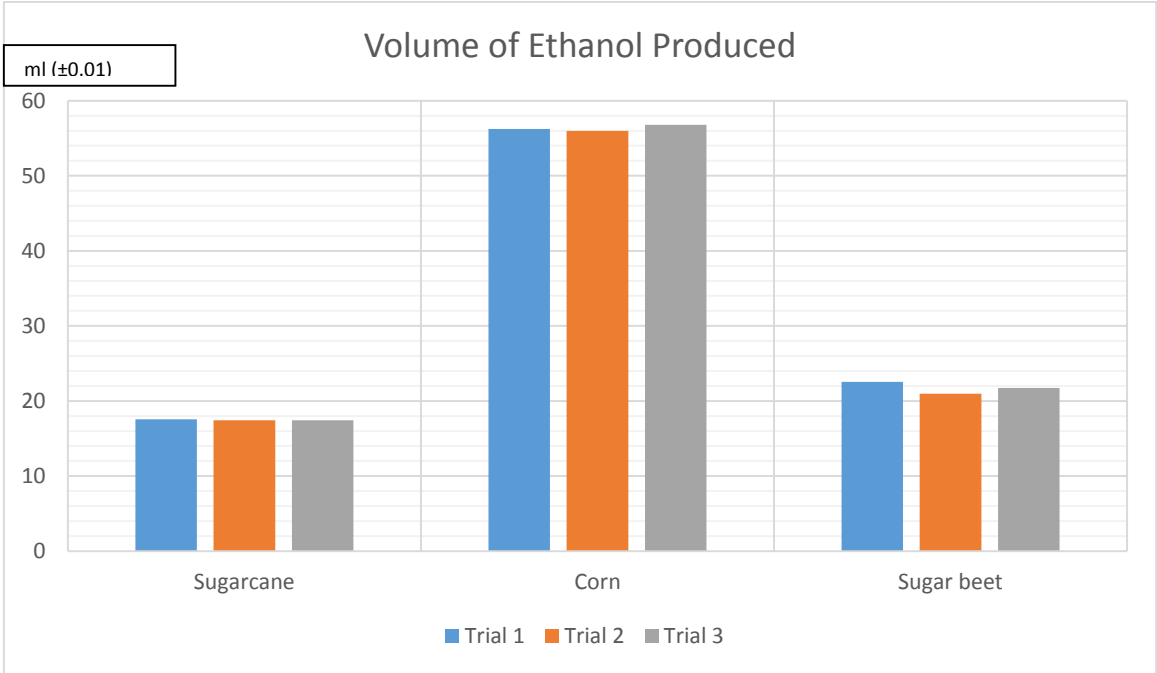

Chart 1: Chart of the datas obtained from Table 1

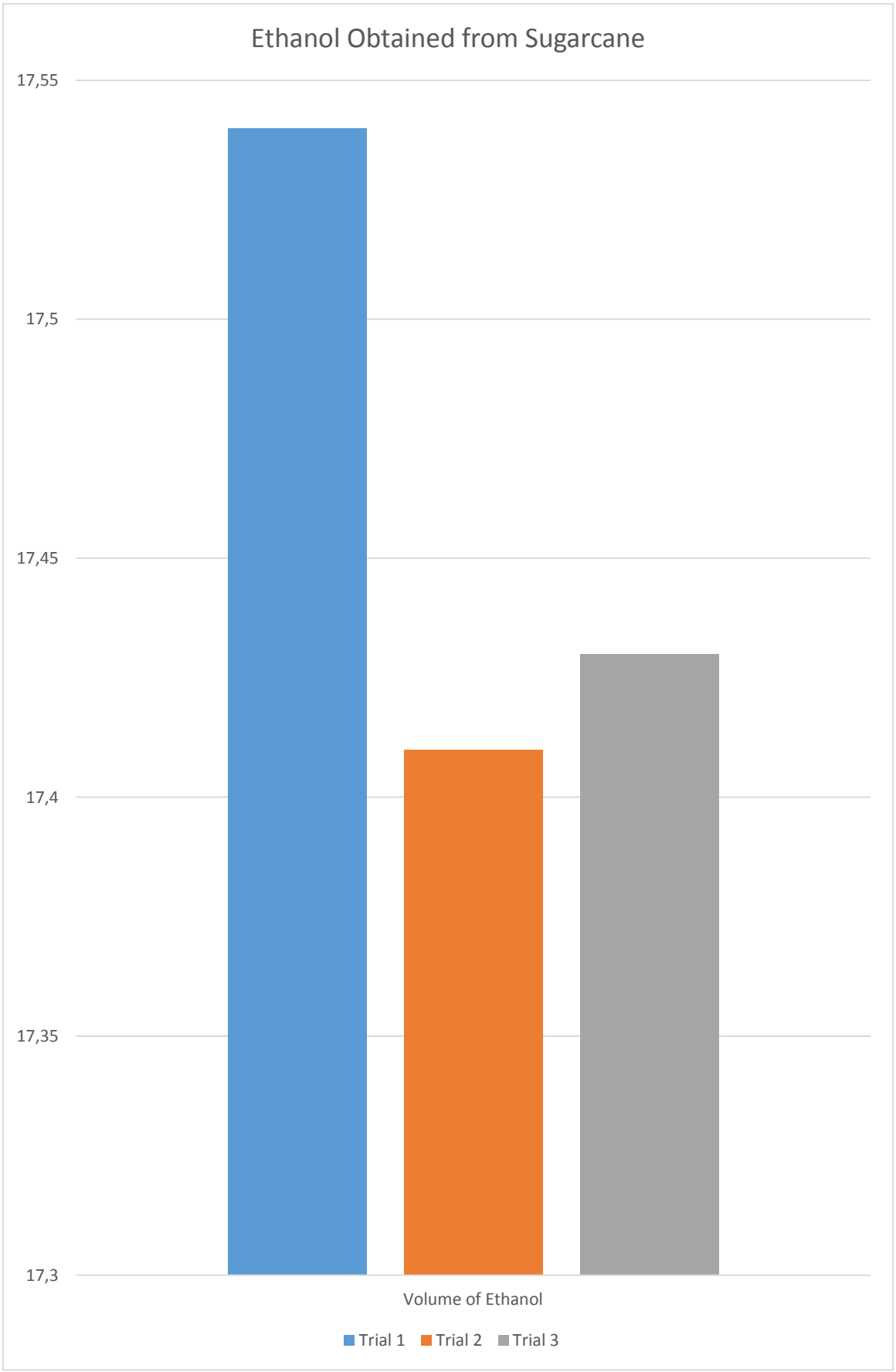

Chart 2: Comparison of volumes of the ethanol in trial that is produced from 250 g sugarcane

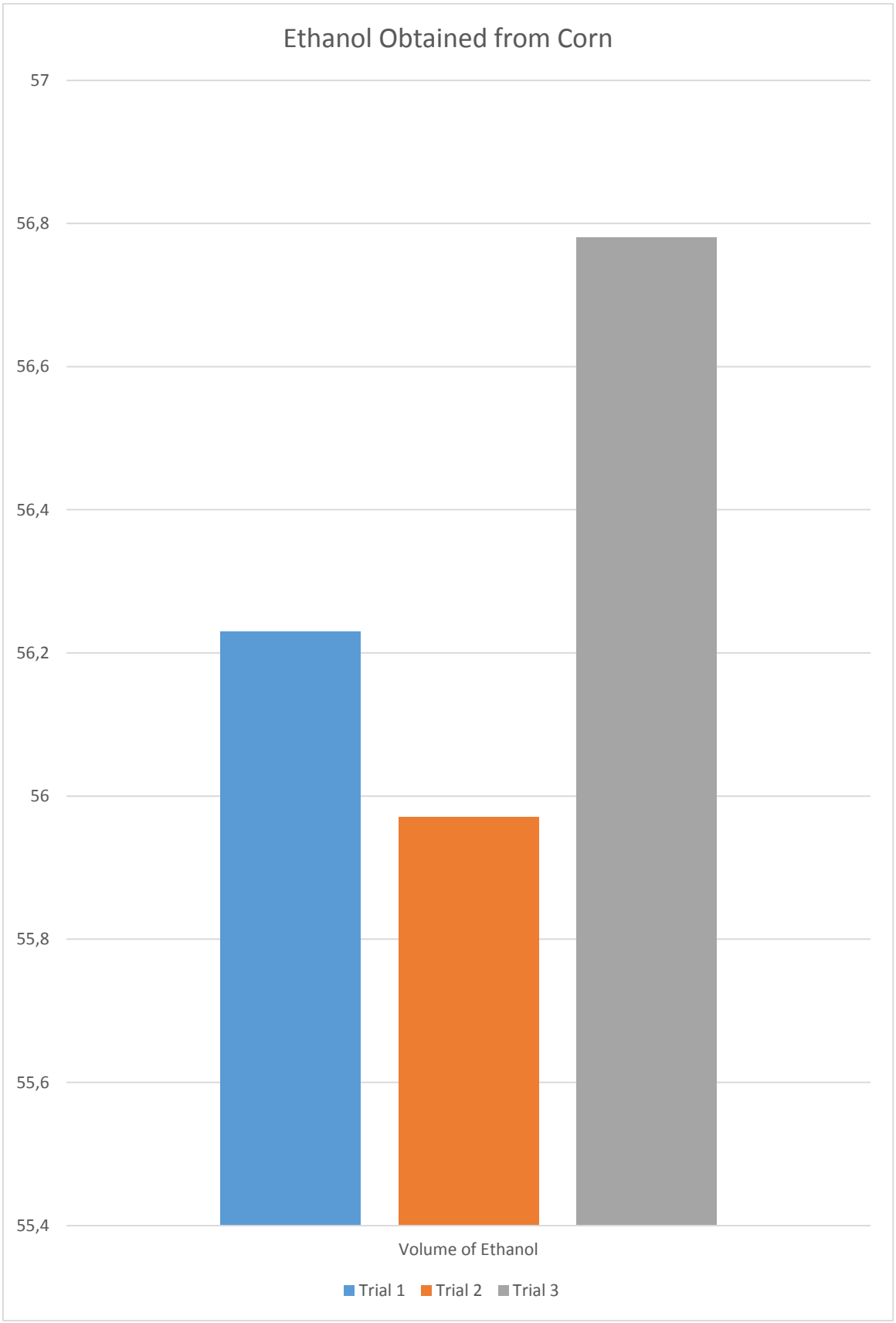

Chart 3: Comparison of volumes of the ethanol in trial that is produced from 250 g corn

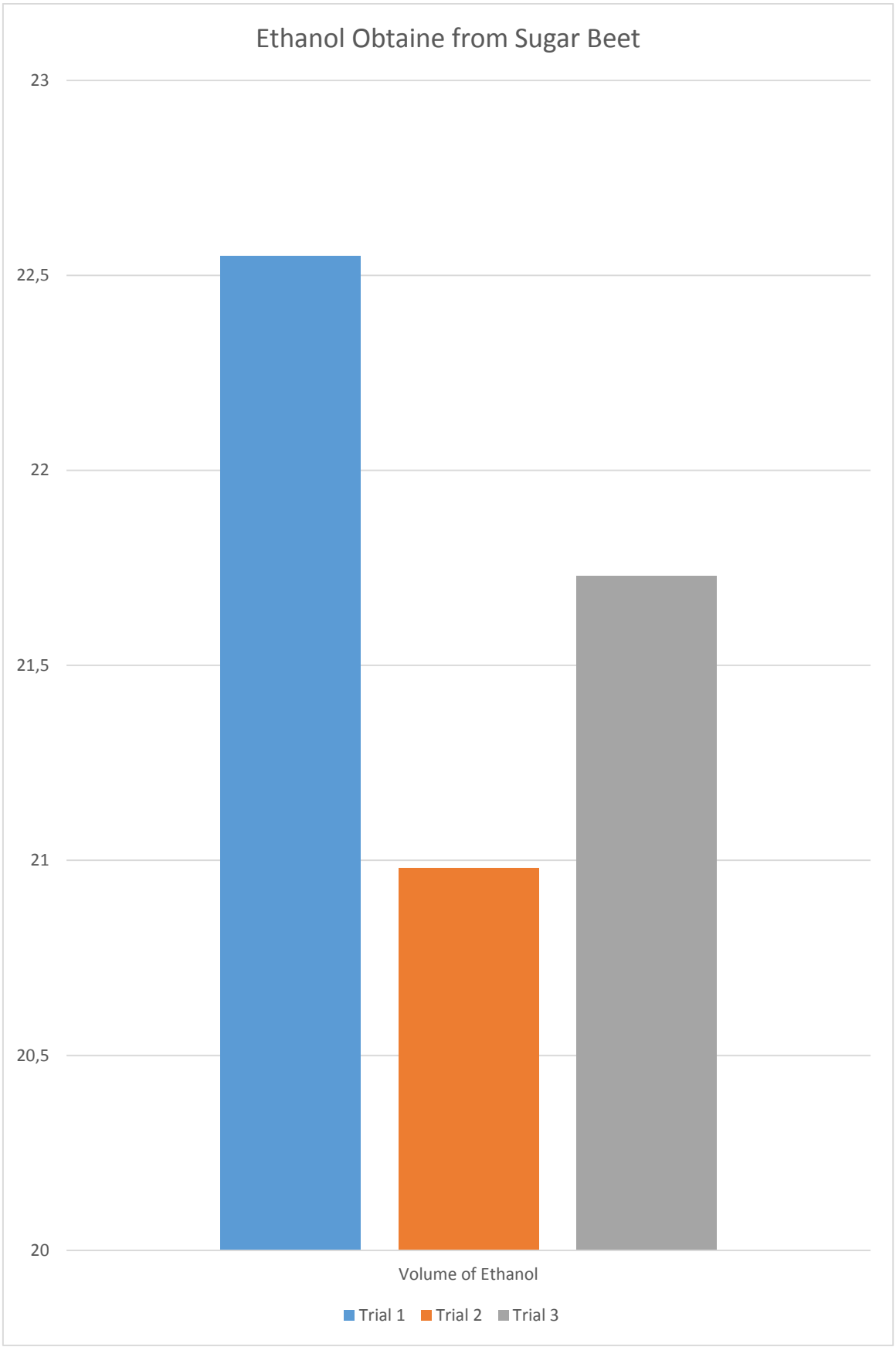

Chart 4: Comparison of volumes of the ethanol in trial that is produced from 250 g sugar beet

5.Results

The experiment showed that the among the 3 different types of organic material which are, sugarcane, corn and sugar beet, corn is the most suitable for the ethanol in other words biofuel production. Looking at the data's which are collected during the experiment, corn has the highest (Produced Ethanol/Organic matter mass) ratio. Datas showed a little difference in each trial but the values between each type of material showed great difference.

In the experiment all of the materials that was gone through the experiment had a mass of 250 g at the begginning. After going through the processes in experiment. Corn was the most efficient in the ethanol production ratio. Aproxemetly 56.3 ml Ethanol can be produced from the 250 g Corn. When looked at the other Organic materials such as sugarcane, it can only supply 17.4 ml ethanol which causes it to have a very low (Produced Ethanol/ Organic matter) ratio.

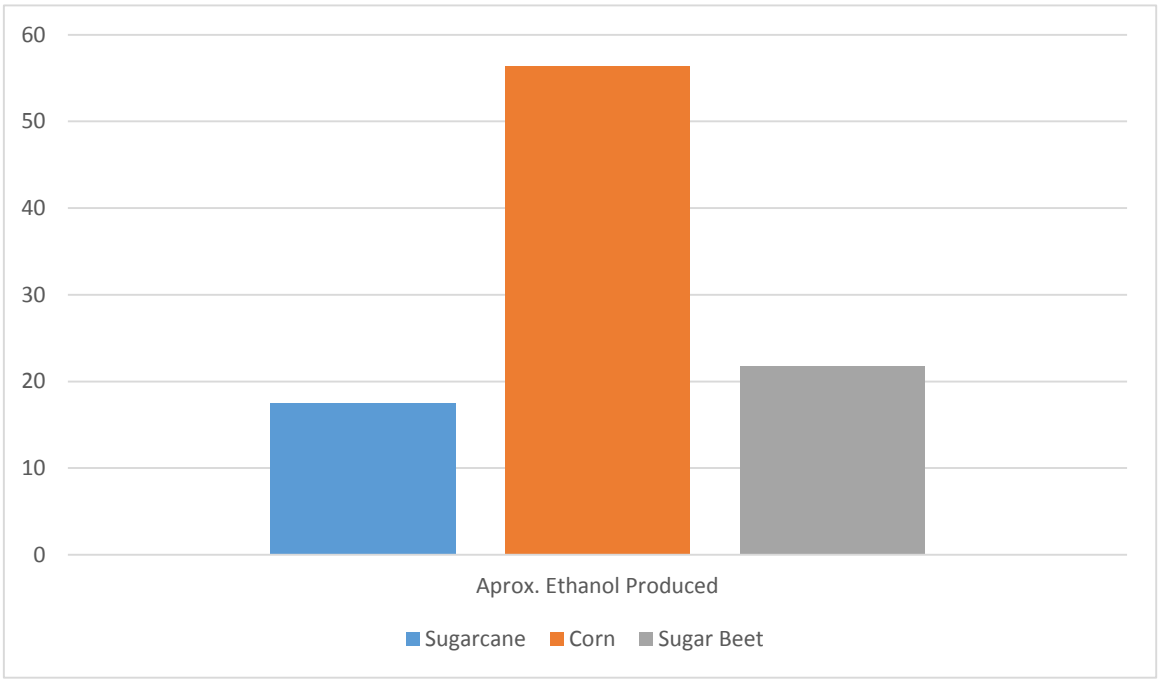

Chart 5: Approximate (mean values) Ethanol volume produced from Sugarcane, Corn and Sugar beet

6.Error Propagation

Ethanol can be produced from sugar and it's percentages are almost the half mass of the amount of sugar in the organic matter. The accurate percentage is 52%

Mass of sugar composites it's %45 of it is sugar.[6]

$$Random\ Error = \frac{|Observed\ Value - Theoretical\ Value|}{Theoratical\ Value} \times 100$$

*Equation of random error calculation

Error calculation between the theoretical value and obtained value for ethanol production from Sugarcane:

$$0{,}86\% = \frac{|51{,}55 - 52{,}00|}{52{,}00} \times 100$$

From Corn:

$$3{,}76\% = \frac{|50.04 - 52.00|}{52.00} \times 100$$

From Sugar beet:

$$7{,}05\% = \frac{|48{,}33 - 52{,}00|}{52{,}00} \times 100$$

[6] http://www.starch.dk/isi/starch/tm18www-corn.htm

7.Conclusion

To Conclude, the volume of ethanol produced from each sample of organic matter showed difference among each other. The main cause of this difference was the mass of sugar in their structure differed from each other. For example 250 g of Sugarcane has equavalent of approximately 18% sugar of it's total mass. While same percentage for corn is 45%. 250 g corn can be used to produce 56,3 ml Ethanol. When looked at the chart 1, chart 2, chart 3 and chart 4, amounts of Ethanol that is produced by each type of sample and the difference between them is visibly identificable. The difference is of these values is the proof of different sugar percentage that each type of organic matter has. Theoretically amount of ethanol that can be produced is the 52% of mass of the total sugar component which the organic matter has. 250 g Corn is visibly the most suitable organic matter to produce Ethanol among Sugarcane and sugar beet. Chart 1 makes this fact obviously visible.

Ethanol production is going to be a very important industrial application since it is suitable for internal-combustion motored vehicles. Currently approximately 95% of the vehicles which is used for transportation is using gasoline as fuel. Gasoline is a type of fuel which easy and low costed fuel but a disadvantage of this type of fuel is that it isn't a renewable source. Currently petroleum is the fragments of organism that lived 1 000 000 years ago. Which makes it impossible to replace which is used. Pure ethanol can be used as fuel for internal-combustion motor vehicles. Since ethanol is a renewable type of source which is produced from fresh crops and the used sources can be replaced almost in a year. This property of bioethanol gives the upper hand to ethanol over gasoline. Currently Ethanol is used as a performance upgrader and only a addition material to gasoline but with enough time given Bioethanol can replace gasoline as a fuel

8.Evaluation:

There are some random errors which is pointed out in the error propagation section, makes it visibly clear that experiment was not 100% correctly done. Most accurate experiment, which is near perfect, was done to the sugarcane whose error percentage was 0.86%. Mean while the error percentage of corn was 3.76% and error percentage of sugar beet was 7.05%. This is a proof of the difference in amounts of sugar which composes the organic matter. Also the theoratical value for the ethanol convertion can differ from every different type of organic matter.

The intervals of beaker which indicated volume was too far apart and was not percise enough in order to obtain more accurate values in experiment. Other than that the fractional distillation would be more suitable in order to obtain the pure form of ethanol. Since it is hard to find the proper equipment for setting up the fractional distilation, the experiment was done with using regular distilation system, the 100% pure form of ethanol wasn't obtained which caused some random error in the experimenting process. In order to have more accurate datas, the regular distillation setup that is used in the experiment should be changed with the fractional distillation setup. This change will help improve the purity of the ethanol that is produced. There also could have been some more random errors since the experiment wasn't done by professional scientist. For example there could be a drop of ethanol left in the collecting container which hasn't been able to be tranferred in to the high precised measuring cylinder.

In addition the the results the results show only which one of Sugar beet, corn or sugarcane is more suitable for the ethanl production. There can be another organic substance which is a lot more suitable for ethanol production because of it's components. The experiment can not be applied to general organic substances since it is only about sugar beet, corn and sugarcane. Since experiment showed that corn is more suitable for ethanol than sugarcane but sugarcane is globally primary source of current biofuel production.

Possible improvement for this study to give more accurate datas in determining the most suitable organic matter to produce ethanol would be doing a larger scaled investigation on plants costs, the optimum size of area for plant to grow. This experiment only showed that with the same amount of organic matter, corn is more efficient to produce ethanol. This is just the chemistry side of a great issue

9.Appendix

Purpose: To determine which one of sugarcane, corn and sugar beet is more suitable to be a organic material source for producing ethanol by using fermantation and distillation.

Variables:

- Independent Variables: Type of organic material (Sugarcane, Corn and Sugar Beet)
- Dependent Variables: Amount of Ethanol produced (ml),
- Controlled Variables
    - Mass of organic material (250 g)
    - Temperature of the surrounding of experiment (24.5 ˚C)
    - Pressure of the surrounding of the experiment (1021.9 hPa)

Materials:

- 250 g fresh sugarcane
- 250 g fresh corn
- 250 g fresh sugar beet
- 100 ml beaker
- Thermometer (-10˚C - 110˚C)
- Barometer (hPa)
- Graduated Cylinder
- Filter
- Yeast
- Liebig Condencer
- Distilling Flask
- Ring Stand
- Rubber tubing (16”-24”)
- Bunsen burner
- Rubber stopper

Method:

1. Gather the materials that are given in the Experiment sheet.
2. Check the temperature and the pressure of the surrounding envoriment in order to have same envorimental condition for each trial
3. Take 250 g of organic material (sugar beet, corn or sugarcane) and put it in a beaker
4. After that add yeast and close the beaker with plastic wrap
5. Wait for 7 days in order to organic material and yeast to complete the convertion of sugar into the ethanol
6. After 7 days take the mixture of ethanol, organic waste and water and filter the organic waste from ethanol and water mixture.
7. In order to seperate ethanol and water from each other use distillation process which is;
    a. Attach a utility clamp to each ring stand.
    b. Carefully insert the flask sidearm into a one-hole stopper or cork. Use a twisting motion with *gentle pressure*. Protect your hands with paper towels, and use water or glycerin to lubricate the sidearm. 1 cm or less of the sidearm should stick out of the stopper when finished.
    c. Attach the distilling flask to one of the mounted utility clamps. Place the jaws of the clamp below the sidearm of the flask. Adjust the height of the clamp and flask to leave enough room for the Bunsen burner.
    d. Carefully insert a thermometer into a one-hole stopper or cork. Use a twisting motion with *gentle pressure*. Protect your hands with paper towels, and use water or glycerin to lubricate the thermometer. Place the stopper in the opening of the flask's neck. Adjust the level of the thermometer so that the bulb is the same height as the flask sidearm.

e. Attach the Liebig condenser to the second mounted utility clamp. The angle of the clamp will need to be adjusted so that it matches the angle the flask sidearm makes with the flask neck. Adjust the height of the condenser utility clamp and move the condenser ring stand so that the opening of the condenser column is even with the sidearm stopper.

f. Insert the sidearm stopper into the opening of the condenser column and ensure that there is a snug fit.

g. Attach one length of rubber tubing to the lower condenser jacket sidearm. The other end of the rubber tubing should be placed over the nozzle of the lab sink.

h. Attach the second length of rubber tubing to the upper condenser jacket sidearm. The other end of the rubber tubing should be placed into the sink to allow the condenser water to drain.

i. Place a beaker underneath the spout of the condenser to collect the distillate.

j. Attach a Bunsen burner to a gas jet, and adjust the tubing so that the burner sits safely beneath the distilling flask.[7]

8. After the distillation process measure the volume of seperated ethanol by using a measuring beaker
9. Do steps 1-8 for 3 trial
10. Do steps 1-9 for each Organic material (sugarcane, corn and sugar beet)

[7] http://www.mreisley.com/tutorials/equipment/distillation.html

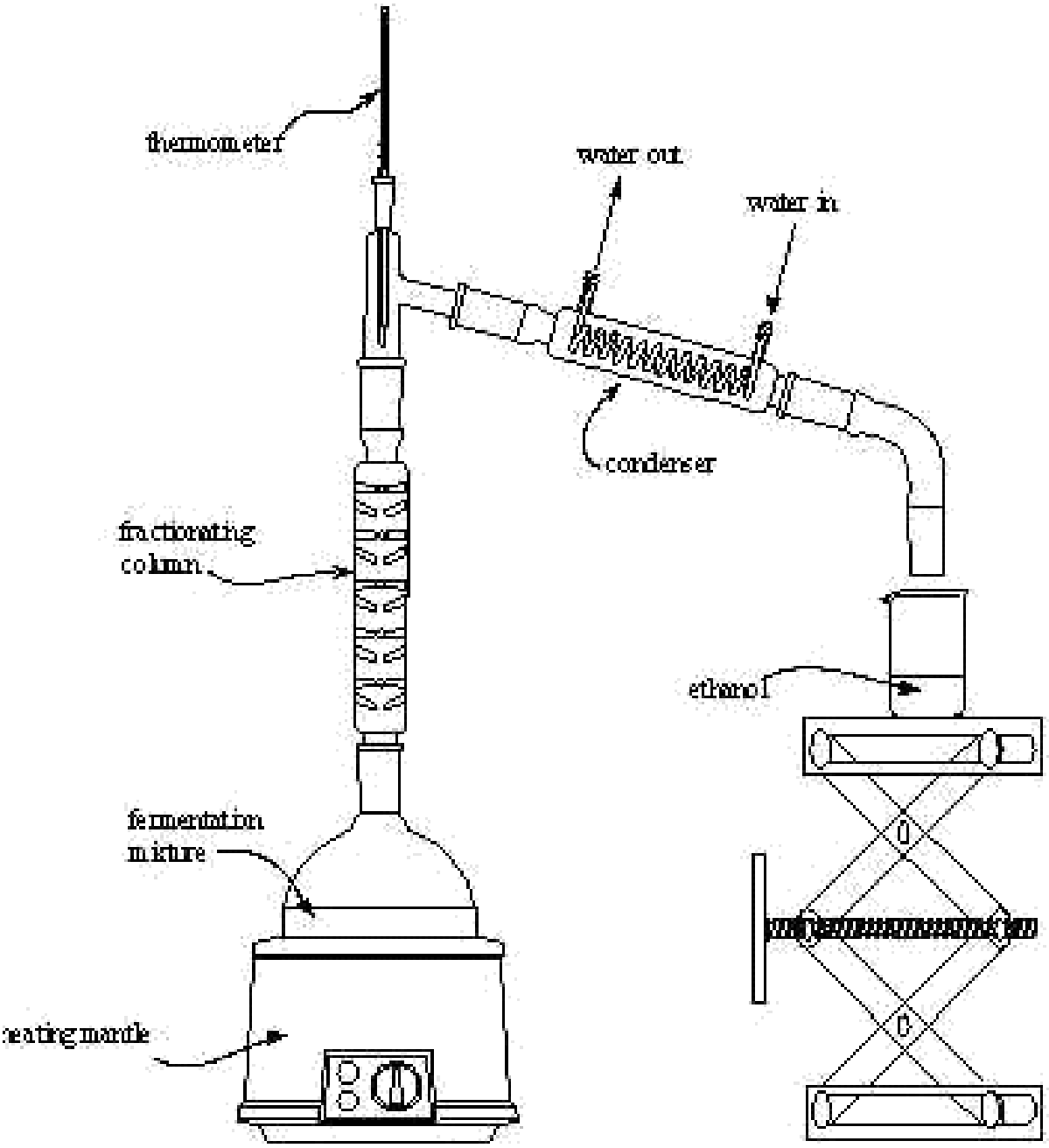

Image 2: The diagram of Regular Distillation

*Taken from : http://www.chemistryrules.me.uk/junior/organic.htm

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