Kansas Corn: Top Fuel

qrco.de/topfuel

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kscorn.com

Kansas Corn: Top Fuel
Grade Level: High School

Overview
In this lab, students will learn about ethanol and its important role in our world's ever-increasing demand for energy. After students go through the process of fermenting and distilling corn for ethanol production this lab allows them to analyze and compare their fuel. It is suggested that this lab be used as a follow-up after performing Kansas Corn: Fermenting Fuel – Designing a Procedure for Fast Fermentation and Corn Mash and Distillation (available online at kansascornstem.com). When using this approach to the lab, students use their data to produce their own procedure and compete to see which group can produce the most efficient fermentation and distill the highest volume and percentage of ethanol. This lab could also be used following a distillation of a mixture of ethanol and water.

Kansas College and Career Ready Standards
Science
- **MS-PS1.A.** Structure and Properties of Matter: The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.
- **HS-LS2-3.** Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.
- **HS-CCC 5.** Energy and Matter Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior. Energy drives the cycling of matter within and between systems.

Learning Objectives
- Determine the percent ethanol in the distillate sample.
- Determine the total volume of ethanol collected.
- Determine the energy density of student's distillate samples.

Materials
- Top Fuel PowerPoint available at kansascornstem.com
- Top Fuel Student Handout (pg. S1 – S5, available at kansascornstem.com)
- Ring stand
- Evaporating dish
- Graduated cylinder or volumetric pipet
- Balance
- Thermometer or Vernier Go Temp
- 12 oz. soda can
- Distilled water

- Goggles or safety glasses

Safety Considerations

- Ethanol is highly combustible. When it is exposed to open flames or heat sources can result in fire. When burning samples make certain that other ethanol samples are safely stored away from the flame.
- Eye protection should be worn at all times.
- Heated glassware and lab apparatus can cause burns. Be careful to allow time to cool.
- Keep hands, clothing and hair away from the open flames.

Procedures for Instruction

1. After distillation record the total volume of the distillate collected.
2. Determine the density of the distillate.
3. This can be determined by several methods. In any case it will involve carefully measuring the volume of a sample and determining its mass. Density is calculated by dividing the mass in grams by the volume in milliliters.
   a. Use a graduated cylinder to record the total volume of distillate collected.
   b. Place a 10 ml graduated cylinder on a balance and tare, or zero the balance.
   c. Add approximately 9.5 mL of the distillate and record the volume to the hundredths of a mL. (3 significant digits)
   d. Record the mass of the sample in grams.
   e. Calculate the density of the distillate by dividing the mass by the volume.

Alternate procedure using pipette.

a. Use a graduated cylinder to record the total volume of distillate collected.
b. Place the evaporating dish on a balance and tare, or zero the balance.
c. Using a pipette, add approximately 9.5 mL of the distillate and record the volume to the hundredths of a ml. (3 significant digits)
d. Record the mass of the sample in grams.
e. Calculate the density of the distillate by dividing the mass by the volume.

Distillate Volume	Small sample volume	Small sample mass	Density of distillate

a. Use the Percent ethanol by density calculator to determine the percent ethanol by volume.
b. Multiply the total sample volume by the percentage to determine the total ethanol collected.

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Ethanol Percent by volume	Total volume of ethanol collected

Percent by volume/Density
https://handymath.com/cgi-bin/ethanolwater3.cgi?submit=Entry

Top Fuel
Testing fuel energy density using calorimetry.

This lab is adapted from "Soda Can Calorimetry" Flinn Scientific
(https://www.flinnsci.com/api/library/Download/f9560a5fc7ef4a6b8f4598fea30626eb)

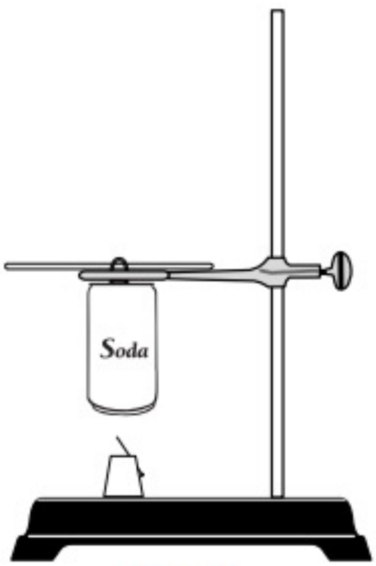

Figure 2.

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Procedure

1. Mass an empty. clean soda can.
2. Using a graduated cylinder. Measure and add 100.0 mL of water to the soda can. Measure and record the mass of the water.
3. Pour the sample of ethanol used to calculate density into a clean evaporating dish. Record the volume.
4. Place the evaporating dish on the base of a support stand.
5. Bend the tab on the soda can and slide a glass stirring rod through the hole. Suspend the can on a support stand using a metal ring (see Figure 2). Adjust the height of the can so that it is about 2.5 cm above the evaporating dish.
6. Insert a thermometer into the can. Measure and record the initial temperature of the water.
7. Light the ethanol sample and center it under the soda can. Allow the water to be heated until the ethanol stops burning. Record the maximum (final) temperature of the water in the can.
8. Measure and record the final mass of the food holder and sample.
9. Allow the can and dish to cool and remove any liquid from the dish.
10. (Optional) Repeat steps 1–9 with another sample of distillate.

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Teacher Resources

Visit www.kansascornstem.com for videos and resources to assist with this lab.

Science and Agriculture Careers

To learn more about agriculture careers, visit www.agexplorer.com. You can also find career profiles at www.kansascornstem.com.

Any educator electing to perform demonstrations is expected to follow *NSTA Minimum Safety Practices and Regulations for Demonstrations, Experiments, and Workshops*, which are available at http://static.nsta.org/pdfs/MinimumSafetyPracticesAndRegulations.pdf, as well as all school policies and rules and all state and federal laws, regulations, codes and professional standards. Educators are under a duty of care to make laboratories and demonstrations in and out of the classroom as safe as possible. If in doubt, do not perform the demonstrations.

Densities of Mixtures of Ethanol and Water at 20°C					
Concentration (% Ethanol by Volume)					
%	Density (g/mL)	%	Density (g/mL)	%	Density (g/mL)
0	0.99823	34	0.95703	68	0.89050
1	0.99675	35	0.95563	69	0.88805
2	0.99528	36	0.95419	70	0.88559
3	0.99384	37	0.95272	71	0.88309
4	0.99243	38	0.95120	72	0.88056
5	0.99106	39	0.94964	73	0.87801
6	0.98973	40	0.94805	74	0.87542
7	0.98845	41	0.94643	75	0.87282
8	0.98719	42	0.94477	76	0.87019
9	0.98596	43	0.94308	77	0.86751
10	0.98476	44	0.94135	78	0.86481
11	0.98356	45	0.93957	79	0.86206
12	0.98238	46	0.93776	80	0.85929
13	0.98122	47	0.93591	81	0.85649
14	0.98009	48	0.93404	82	0.85364
15	0.97897	49	0.93213	83	0.85077
16	0.97786	50	0.93017	84	0.84787
17	0.97678	51	0.92818	85	0.84489
18	0.97570	52	0.92617	86	0.84188
19	0.97464	53	0.92415	87	0.83881
20	0.97359	54	0.92209	88	0.83569
21	0.97253	55	0.91999	89	0.83251
22	0.97145	56	0.91789	90	0.82925
23	0.97036	57	0.91575	91	0.82590
24	0.96925	58	0.91358	92	0.82246
25	0.96812	59	0.91138	93	0.81893
26	0.96699	60	0.90916	94	0.81526
27	0.96583	61	0.90691	95	0.81145
28	0.96465	62	0.90463	96	0.80749
29	0.96346	63	0.90234	97	0.80336
30	0.96224	64	0.90001	98	0.79901
31	0.96100	65	0.89767	99	0.79432
32	0.95972	66	0.89531	100	0.78934
33	0.95839	67	0.89292		

Source: https://handymath.com/cgi-bin/ethanolwater3.cgi

Name:
Class:
Lab Group:

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Percent by volume/Density
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Top Fuel

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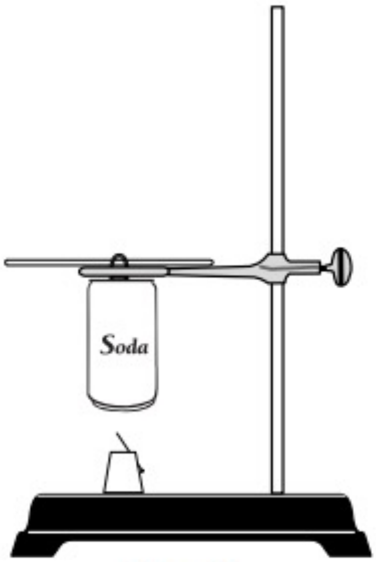

Figure 2.

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9. Allow the can and dish to cool and remove any liquid from the dish.
10. (Optional) Repeat steps 1–9 with another sample of distillate.

Yeast

	Fleischmann's	Red Star DADY	Ethanol Red
cost	41 cents/ g	27 cents/g	25 cents/g

Buffer Solutions

Solutions	Buffer pH 5	Amylase	Glucoamylase
cost	2 cents/ ml	5 cent/ml	15 cents/ml

Fermentation Temperature above 20 C is 2 cents/degree

Protocol Amount	**Unit Cost**	**Total cost**
g yeast	X______ cost	
ml of buffer solution	ml x 2 cents/ml	
ml of amylase	ml x 5 cents/ml	
ml of glucoamylase	ml x 15 cents/ml	
Fermentation Temp setting	Temp – 20 __ ___x 2 cents	
50 g boiled corn grind	$1.00	
Distillation	$1.00	
Total Production Cost		

	Sample 1	Sample 2	Sample 3
Mass of Soda Can			
Mass of Soda Can and Water			
Mass of water			
Volume of ethanol			
Initial Temp of water			
Highest Temp of Water			
ΔT (Tfinal – Tinitial)			
Q = Energy in Joules Q = mcΔt c = 4.18 J/°C·g			
Energy Density Joules/Milliliter			
Total Energy (J) (Energy Density x Total distillate volume)			

Assessment

1. If 9.95 mL of ethanol distillate was a mass of 8.25 g, what is its density?

2. Using the calculated density, determine the percent ethanol of the sample.

3. It the total volume of distillate was 24.0 mL, how much pure ethanol was collected?

4. If a 9.95 mL sample of ethanol was used to heat 50.00 g of water from 20.0°C to 35°C, what is the energy density of the sample?

5. Using the calculation of energy density, determine the total energy in the 24.0 mL sample.