Ethanol: Not a Kernel of Science in It

by Laurence Hecht

Ethanol is an excellent substance to tank up on. Just don't drive on it. It slows reaction time, impairs judgment, and it's illegal. In excess, it can make you giddy, stupid, mean, sour, depressed, and violent. It might even make you President.

Here we will inform you what ethanol is, why it is a worse than stupid way to replace our oil dependency, and why development of nuclear power is the only sane way to provide ourselves an economic future.

Ethyl alcohol or ethanol (C_2H_5OH) is the second in what chemists call the homologous series of alcohols, which include methyl, ethyl, propyl, butyl, and amyl alcohol, each one distinguished from the previous by the addition of an atom of carbon and two of hydrogen (CH_2). Man has been making ethyl alcohol since long before the discovery of its chemical and structural formula. Almost any plant substance can serve as the raw material—grapes, apples, corn, grain, and potatoes are traditional ingredients. To make some yourself, start with some store-bought apple juice which has been bottled without preservatives. Put it in a clean glass container, and let it sit several days. Yeast, naturally present in the air, will act on the fruit sugars—according to a process first deduced by Louis Pasteur—to change them into alcohol. This is called fermentation. Make sure you use a loosely fitting cover, because carbon dioxide gas is released in the process, and could explode a tightly closed container.

If you wait too long, the fermentation will go to the next stage, converting the alcohol to vinegar (acetic acid). If you stop it at the right moment, you will have an apple cider of perhaps 5-10% alcohol content. The alcohol will be mixed in with the sugary fruit juice. A simple way to separate the alcohol is to freeze the mixture. The alcohol, which has a lower freezing point than the rest of the mix, will collect in a cylindrical hollow in the center of the frozen substance. One can also separate the alcohol with a still, or what chemists call a distillation apparatus. Ethyl alcohol has a boiling point of 173°F, well below that of water. By heating the mixture, the ethyl alcohol boils off first; its vapor can be collected by condensation on a cool part of the apparatus called a condenser. Both of these methods of separation are types of fractional distillation.

The Cost of Scaling Up

To produce ethanol on a commercial basis, the laboratory process of fermentation and distillation must be scaled up.

Remembering that our original intention was to save on the use of petroleum products, we must therefore examine the amount of gasoline and other petroleum fuels that would go into the production of ethanol as a replacement for gasoline. First we have the production of the corn or other vegetable product which is going to provide the sugars for fermentation. Modern agriculture is a highly energy-intensive operation: tractors and farm vehicles require a lot of gasoline or diesel fuel; ammonia fertilizers use natural gas as a feedstock; irrigation requires large amounts of electrical energy; farm work also requires human physical and mental labor, which requires energy for its maintenance. Bulk raw materials must now be transported from the farm to the still, for processing and distillation, another energy-intensive process, frequently using natural gas. In fact, more than the total current national consumption of natural gas would be required to power the stills to produce enough ethanol to replace our petroleum dependence.

When all of these inputs are taken together—studies by Dr. David Pimentel of Cornell University and Tad W. Patzek of the Dept. of Civil and Environmental Engineering at Berkeley have shown—alcohol production consumes more units of fossil fuel energy than it yields when burned as fuel. Corn ethanol, switchgrass ethanol, and wood alcohol (methanol) consume respectively 29%, 45%, and 57% *more* units of fossil-fuel energy than they give back on burning.

If we were so insane as to attempt to replace our petroleum usage with corn ethanol (the least inefficient of the choices), it would require placing 1.8 million square miles, or 51% of the land area of the 50 states, under corn cultivation, according to the calculations of retired University of Connecticut physics profesor Howard Hayden (*21st Century Science & Technology,* Spring 2005, pp. 10-11). However, this is a physical impossibility, for not only could we not find the arable land; we would lack the fossil-fuel supply with which to generate our replacement fuel! Need we also mention that a large portion of the human population is suffering from malnutrition? Knowing that, can any moral person justify taking our productive agricultural land out of food production to feed this swindle?

The high cost of the energy inputs required for ethanol production is actually reflected in the price of the product. When all the tax credits and government subsidies are taken into account, the cost of ethanol comes to $7.24 per gallon of "imported gasoline replaced" (see http://zfacts.com for an exhaustive study). A bipartisan grouping of Senators has now moved to remove the Federal requirement of a 10% ethanol additive to gasoline, because it is adding 30-40 cents per gallon to the price of gas. Not surprisingly, the largest financial beneficiary of the government subsidies have been the grain cartels—Archer, Daniels, Midland and Cargill—and hedge fund speculators who have recently moved in on the ethanol boondoggle.

Let us now see why nuclear power is an enormously better, and absolutely necessary alternative to the funny fuel.

How Alcohol and Gasoline Burn

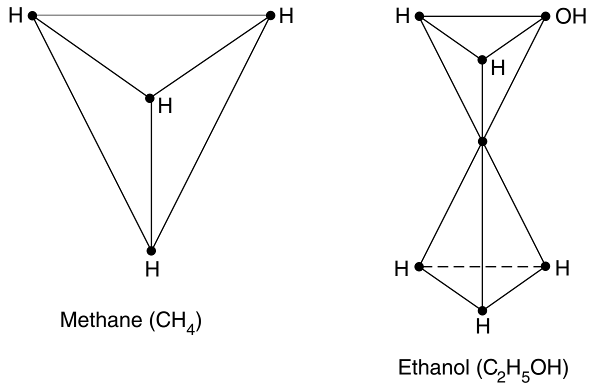
Structurally, alcohols are similar to hydrocarbons which are what make up the combustible parts of coal, oil, and gasoline. The hydrocarbons form a simple, homologous series, like the alcohols. Methane, one of the ingredients of natural gas, is the simplest hydrocarbon, consisting of a single carbon atom surrounded by four hydrogens. In the 1870s, two brilliant young chemists, Joseph Achille LeBel and Jacobus Henricus van't Hoff, deduced that carbon bonds with other atoms in a tetrahedral arrangement. Thus, the methane molecule (CH_4) could be pictured as a tetrahedron with a carbon in the center and a hydrogen atom at each of the four vertices. Ethane, the second in the hydrocarbon series, consists of two tetrahedra joined at their vertices (see **Figure 1**). Knowing this, its formula may be easily deduced by construction, as C_2H_6, and so forth. The alcohol series are much like the hydrocarbons, except that one of the hydrogen atoms is replaced by a molecule consisting of a combination of oxygen and hydrogen (OH).

The connection between one atom and another is called a bond. We understand these bonds today as attractive relationships between the electrons in the outer orbitals of the atoms. Their exact nature, despite much study, is not yet fully understood. However, the branch of physical chemistry known as thermodynamics has been able to create a kind of accounting system, which doesn't worry about what the actual physical geometric process of transformation is. It merely keeps track of the energy relationships, on the assumption that no new energy is created or destroyed in a chemical change. Thus, the attractive bond between the electrons is thought of as containing a certain amount of energy. When a hydrocarbon or an alcohol burns, that is combines with oxygen in the air, these bonds are broken. The energy contained in them is now converted into heat. We don't know exactly how, but we can measure precisely how much.

Heat is measured in a unit called a calorie, which was developed out of the work of Antoine Lavoisier (1743-1793) in experiments on the specific heats of the elements. It is the amount of heat required to raise the temperature of one gram of water (at a temperature of 14.5°C) by one degree centigrade. Because this unit is so small, we often employ the kilocalorie, which is the amount of heat required to raise the temperature of one kilogram (2.2 pounds) of water by one degree centigrade. (Heat may also be measured by the unit of work known as the joule—there are 4.18 joules in a calorie—and the British Thermal Unit (Btu) which is equal to 252 calories). Using any of these units, we can determine the amount of heat produced when a certain quantity of alcohol, gasoline, coal, or any other combustible substance is burned.

The burning of one kilogram of gasoline produces about 10,500 kilocalories. Burning one kilogram of ethanol pro-

FIGURE 1



duces about 7,140 kilocalories, about 68% that of gasoline. Thus, a car running on pure ethanol will require a fuel tank that is almost half again larger than a gasoline-powered vehicle.[1]

The Nuclear Domain

However, these relatively small differences are negligible in comparison to the heat released by nuclear processes. The fissioning of one gram of uranium releases about 2 million times as much heat as is produced by burning an equivalent weight of gasoline or oil, and 3 million times the heat produced in burning that weight of coal.

These enormous energies are not released from the chemical bonds. We are speaking now about a new physical domain. In the breaking apart of the uranium nucleus, we are releasing the much stronger forces which hold the nucleus together. Here, in a space about one-millionth the size of the whole atom, we find 92 charged particles, known as protons, each 1836 times heavier than the extra-nuclear electrons, which are the actors in chemical reactions. The protons are held together by some powerful agent, conventionally known as the strong force. In addition to these 92 protons, a nucleus of fissionable uranium-235 contains another 143 neutral particles about the same mass as the proton. When a uranium nucleus shatters, fragments containing these particles go flying apart at velocities up to one-tenth the speed of light.

For more than 60 years, since the operation of the first atomic pile on Dec. 2, 1942, we have known how to control this process. For over 50 years, we have harnessed the heat generated by the fission of the nucleus to produce electricity, safely and cheaply. With a complete fuel cycle which includes reprocessing, *there is no nuclear waste.*

1. Ethanol is able to deliver about the same amount of power as gasoline, because it requires less air to burn, and thus a greater portion of the gaseous mixture found in the cylinder on each stroke is made up of ethanol. Because of its air requirement, only about one third as much gasoline vapor as ethanol can fit into a cyclinder of a given size.

Nuclear is a fully renewable energy resource. It is also only the beginning. For in 25 years we will begin to commercialize an even more powerful source of energy from the nucleus, fusion power.

With abundant nuclear power, we can virtually eliminate our dependence on imported oil, without having to cover the whole nation with ethanol cornfields and eliminate our food and animal production. Nuclear will provide the electricity to recharge the batteries for electric-powered transport on the trips of under 30 miles that make up the majority of vehicle use.

Nuclear will also generate the fuel to replace gasoline for use on longer trips. With the temperatures of 700-800 degrees, which can be produced by the new fourth generation of nuclear reactors, we can easily separate hydrogen from water, using electrolysis and even more efficient chemical separation methods. The hydrogen will power fuel cells to run electric motors, or be burned in internal combustion engines. Soon, as a result of advances in fast pulse laser machining processes, ceramic turbines, capable of operating at temperatures of 3,000 degrees and thus achieving efficiencies three times that of conventional engines, will be available.

Hydrogen Fuel

With a heat of combustion of 34,200 kilocalories per kilogram, hydrogen carries more than three times the energy content by weight of gasoline, and nearly five times that of ethanol. That is why it is used as rocket fuel. The leading problem in using hydrogen to power vehicles has been the cost of compressing it to a usable size. However, a variety of options are available and in the works to solve this problem.

The byproduct of the burning of hydrogen is water. The byproduct of the production of hydrogen from water is oxygen. Releasing oxygen to the atmosphere by the industrial production of hydrogen, will solve what is by far the most serious atmospheric environmental threat we face. That threat is not the release of carbon dioxide from combustion of carbonaceous fuels—for carbon dioxide enhances plant life, helps produce cloud cover, and has never been proven to increase the Earth's temperature. The real danger to be feared from the greatly expanded use of carbon-based fuels, is the depletion of atmospheric oxygen. Nuclear power and the hydrogen cycle will give the children of the next century the air they need to breathe.

As a growing fraction of intelligent young people are coming to recognize, the often sexually-tinged anti-nuclear obsessions of their parents' generation have contributed in large part to the new generation's lack of access to the levels of educational, healthcare, and employment opportunities which Americans had come to expect. It is time for those still embracing such fantasies to grow up and admit their past errors, or get out of the way. Woodstock, EarthDay, and the rest of those youthful hijinks are a thing of the far-distant past. The nation's future is at stake.