CHAPTER 23

METHANOL AND BUTANOL

There are hundreds of alcohols, ranging in form from liquids to greases to waxes. In addition to ethanol, several other alcohols—methanol, **butanol**, and, to a lesser degree, **propanol**—can be used as auto fuels.

Like most other organic chemicals, alcohols are named by the number of carbons that are in the molecular structure typical of all the chemicals in the same group (in this case, the alcohols group). Methanol has a single carbon, ethanol has two carbons, propanol has three carbons, and butanol is a four-carbon alcohol. (Beeswax is a 13-carbon alcohol.)

These other alcohols are a little different than ethanol. Each has advantages and disadvantages.

We won't say much about propanol here, since it is not generally considered a good candidate for auto fuel. Yeast make a tiny amount of it in the process of producing ethanol. Propanol is hard on fuel system materials. Commercially, it is made from petroleum products or propane, and its emissions are quite a bit higher than ethanol's.

METHANOL

At one time, methanol (**wood alcohol**) was commercially produced by the **destructive distillation** of wood. Destructive distillation is essentially how you make charcoal, by heating wood in the absence of oxygen. Instead of the wood burning, volatile components react and gas off, leaving behind the almost pure carbon of charcoal. Much of what gases off is methanol.

If methanol were made by destructive distillation from biomass, it would actually be a renewable fuel. But that's not the case right now. Today almost all methanol is made from natural gas (methane)—the cheapest source for methanol on the large scale. MegaOilron has periodically proposed that methanol could be made from coal, as well.

Small-scale production of methanol is generally neither economical nor desirable. But in the case

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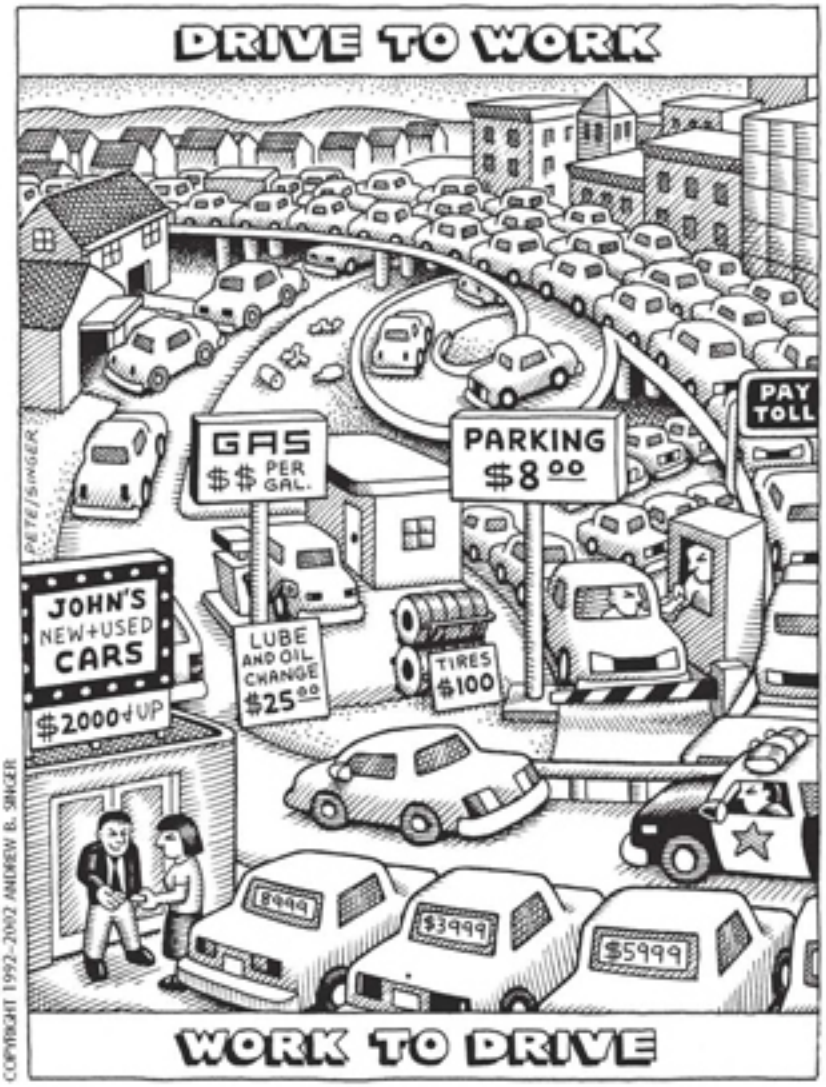

Fig. 23-1

gasoline. Since methanol and ethanol have about the same octane rating, some of methanol's mileage loss is mitigated if the engine compression ratio is raised.

Methanol is going to be cheaper to make from fossil fuels for some time to come, but it will not reduce greenhouse emissions of carbon dioxide. Methanol's use in biodiesel production unfortunately makes "*bio*diesel" a misnomer.

BUTANOL

Butanol can be used as an auto fuel. Although it is currently produced from petrochemicals, it can be produced by fermentation of carbohydrates, and some fats. During World War II, butanol produced this way was used for making explosives, and many butanol plants sprang up around the country. One of the largest wartime plants was based in Peoria, Illinois. Many of these facilities were converted to making ethanol after the war.

The organism that converts carbohydrates to butanol is not a yeast, but a member of the *Clostridium* group of bacteria. Once the bacteria ferment the carbohydrates, you can then boil and condense the vapors out of the mash to 180 proof without a fractional distilling column. You end up with a mixture of approximately 30% acetone, 60% butanol, and 10% ethanol (with some water). This mixture is generally referred to as **ABE**.

The butanol and acetone tend to float on top of the ethanol and water. The three solvents tend to separate into three distinct layers after cooling. Adding various mineral salts to the mixture makes the three-phase separation even more distinct. You can literally (carefully) pour off, or drain off, each layer by itself. A **fractional distillation**, such as in our packed column designs, will distill acetone and ethanol first, leaving a relatively pure butanol to follow.

Sounds easy, right? But there are a number of problems and issues to consider.

One big problem with butanol fermentation is that it is toxic to the very bacteria that produce it. So in traditional butanol fermentation, once the concentration reaches 1.3%, it kills the bacteria that make it. (Yeast can tolerate more than 13% ethanol, or ten times as much ethanol as the bacteria can tolerate of butanol.) This very dilute mixture means that a lot of energy is used to boil the bacterial mash in order to distill off the relatively tiny amount of ABE.

Newer butanol fermentations exceed this limit a little bit by using two separate species of *Clostridium*. When *C. tyrobutyricum* and *C. acetobutylicum* are mixed, one of them turns carbohydrates into hydrogen and butyric acid, and the other turns the butyric acid to butanol. So in this fermentation, you end up with very little ethanol and acetone. Done this way, it's claimed that after distillation, you will get as much straight butanol from a bushel of corn as you would get ethanol, plus some hydrogen to boot. It's important to note that this process has not been used outside of laboratory scale, though.[1]

"The Stone Age did not end for lack of stone, and the Oil Age will end long before the world runs out of oil."

—SHEIK ZAKI YAMANI OF SAUDI ARABIA

Butanol fermentation is pretty smelly. Odors of rotting meat or gangrene are a result of other *Clostridium* species, to give you an idea of how bad the smell can be. It's not something you'd want to do in your garage in any large quantity without good odor control. And disposing of the smelly spent mash is an overlooked issue in butanol production.

Butanol is also quite toxic, but not nearly as deadly as methanol. Workers who routinely inhale butanol vapor are prone to lose their hearing, and suffer damage to their liver and kidneys. Absorption through skin has a similar effect to ingestion or inhalation. Less serious symptoms of butanol poisoning are neurological, e.g., blurred vision, nausea, and dizziness. Very good plant design is necessary to avoid exposure to butanol.

Butanol is often cited as being corrosive. Supposedly, it corrodes everything that methanol does, plus almost every other common rubber material used in automobiles. Modern fluoroelastomers may be immune. Very little modern work has been done on emissions, but at least one report claims a high level of cleanliness compared to gasoline—but still quite a bit dirtier than ethanol.[2]

Even with the drawbacks discussed above, butanol has some distinct advantages and potential uses which you may find valuable, depending on your overall plant design. First of all, butanol is a valuable commercial solvent selling for about $6 a gallon. Acetone is also priced higher than auto fuel.