Fossil fuel from biomass?

Finding a replacement for fossil fuels is a science in itself, says S.Ananthanaryanan.

James A Dumesic of Wisconsin and others have combined chemical and biological methods to convert biomass into a fuel that has the properties that ideal fuel should have.

Suitable fuels

The great concern of diminishing fuels is in the transport sector. In this sector, a fuel needs to be powerful, stable and convenient to store and carry. Petrol and diesel seem to be perfect – they contain about 45 Mega Joules of energy in a kg (as we know, this is enough to drive a car about 15 km), they do not easily vaporize or draw moisture and they can be stored and carried in drums and tankers. Sadly, the reserves are not likely to last long.

Other fuels available in good quantity are wood coal, carbohydrates, sugars, alcohol. These all have much lower specific energy content (between 15 to 23 MJ/kg) and are bulky and easily spoiled. The alternative to fossil fuels needs to be not only made from biomass, the best candidate, but should also have the qualities of fossil fuels

The alternative

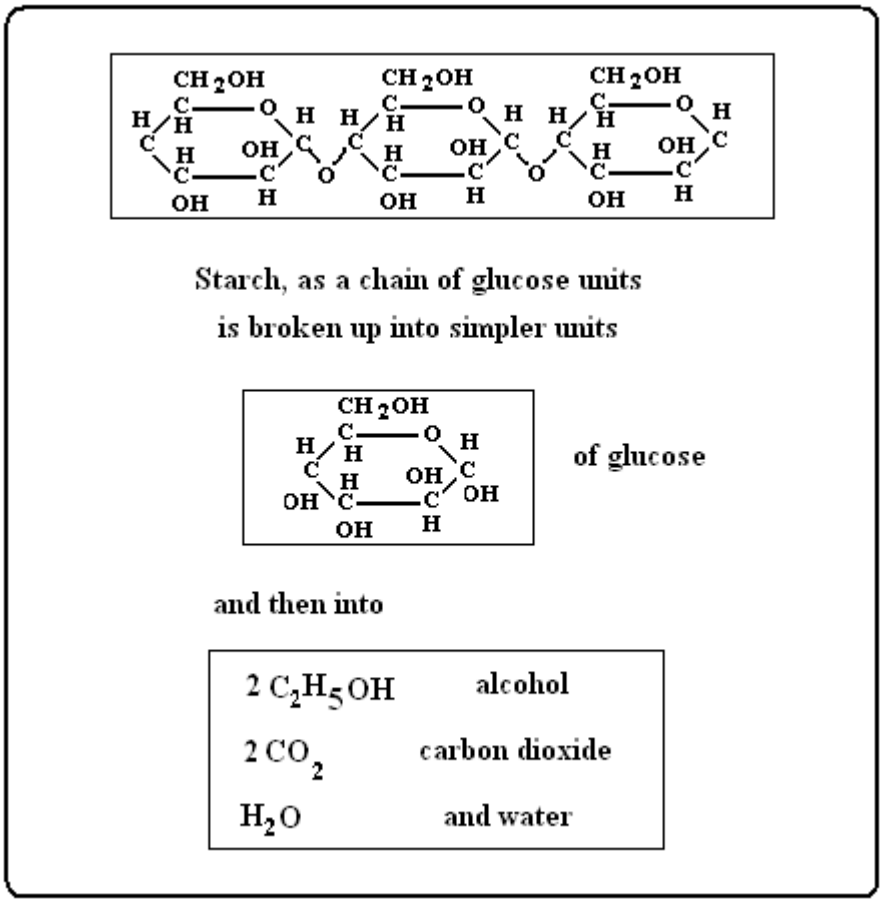
The reason that starches, sugars and even alcohol pack less energy is that their molecules already contain a good portion of oxygen. It is when the carbon content combines with oxygen, in burning, that energy is released. If a sugar already has oxygen, then there is only a little to be added in burning. Alcohol has a little less oxygen. So it has a little more energy to yield, when it burns.

But fuels like petrol have many carbon atoms (and some sulphur) and few oxygen atoms, which allows plenty of combination with oxygen. The molecules are also more compact and are stable. An alternate fuel should thus have a high carbon to oxygen ratio.

In creating fuel out of biomass, then, the objective is to break large carbohydrate molecules into smaller bits and then to improve the carbon-oxygen ratio. One method was to heat substances that contained carbon in steam, where the carbon combined with part of the oxygen in steam to form carbon monoxide, an inflammable gas, while the steam, depleted of oxygen, was left as hydrogen. The product, known as synthesis gas, was used for many years to generate electricity. There was also a method to treat the synthesis gas over metal catalysts, to form synthetic diesel. The problem with the process was that the energy in the starting carbohydrate got wasted and was only partly converted.

Fermentation

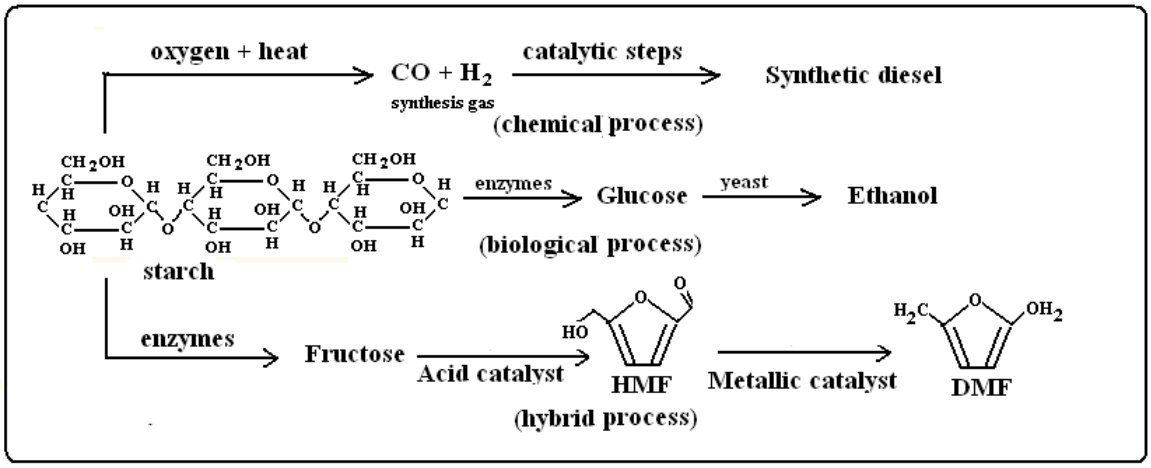
The other route was to use enzymes to break starch or cellulose into sugars and then use yeast to ferment the sugars into alcohol and carbon dioxide. This amounted to taking away two parts of oxygen for every part of carbon, from the oxygen-rich carbohydrate and thus enrich the remainder. This process has promoted large-scale ethanol plants, world-wide, to make use of cheap starch from vegetable waste or grain and then to let yeast, *saccaromyces cerevisiae,* to do the rest. The trouble with the process is that it takes time. And then, the product really does not make the grade, as alcohol has less energy per kg than other fuels, is volatile and also absorbs water from the atmosphere.



New Process

Dumesic and colleagues have combined and reversed the conventional methods, to create a fuel that is seems to be the answer. They start with biomass and use enzymes to break the starches into sugars, particularly fructose. This is the biological first stage. But now, they do not ferment the sugar, they make use of an acid catalyst to extract three oxygen atoms from each sugar molecule. The acid provides hydrogen, which combines with the oxygen and converts to water.

The product, which is called HMF, may become an important building block with useful applications, but it is not suitable as fuel. There is thus another stage in the process, where a special catalyst pulls another two carbon atoms out, with the help of hydrogen, to leave a proper fuel material, called DMF.



The process takes a short-cut by going from fructose directly to the final product, without coming down to carbon monoxide and building up to diesel. The other advantage is that fermentation, which is time consuming, is avoided. DMF may then become the fuel of the future.

Its properties for combustion in engines as well how it would affect health and environment need to be studied.