http://www.esru.strath.ac.uk/EandE/Web_sites/02-03/biofuels/what_bioethanol.htm

Energy Systems Research Unit (ESRU)

Bioethanol

What is Bioethanol?

The principle fuel used as a petrol substitute for road transport vehicles is bioethanol. Bioethanol fuel is mainly produced by the sugar fermentation process, although it can also be manufactured by the chemical process of reacting ethene with steam.

Sugarbeet soon to be produced into ethanol

The main sources of sugar required to produce ethanol come from fuel or energy crops. These crops are grown specifically for energy use and include corn, maize and wheat crops, waste straw, willow and popular trees, sawdust, reed canary grass, cord grasses, jerusalem artichoke, myscanthus and sorghum plants. There is also ongoing research and development into the use of municipal solid wastes to produce ethanol fuel.

Ethanol or ethyl alcohol (C_2H_5OH) is a clear colourless liquid, it is biodegradable, low in toxicity and causes little environmental pollution if spilt. Ethanol burns to produce carbon dioxide and water. Ethanol is a high octane fuel and has replaced lead as an octane enhancer in petrol. By blending ethanol with gasoline we can also oxygenate the fuel mixture so it burns more completely and reduces polluting emissions. Ethanol fuel blends are widely sold in the United States. The most common blend is 10% ethanol and 90% petrol (E10). Vehicle engines require no modifications to run on E10 and vehicle warranties are unaffected also. Only flexible fuel vehicles can run on up to 85% ethanol and 15% petrol blends (E85).

What are the benefits of Bioethanol?

Bioethanol has a number of advantages over conventional fuels. It comes from a renewable resource i.e. crops and not from a finite resource and the crops it derives from can grow well in the UK (like cereals, sugar beet and maize). Another benefit over fossil fuels is the greenhouse gas emissions. The road transport network accounts for 22% (www.foodfen.org.uk) of all greenhouse gas emissions and through the use of bioethanol, some of these emissions will be reduced as the fuel crops absorb the CO2 they emit through growing. Also, blending bioethanol with petrol will help extend the life of the UK's diminishing oil supplies and ensure greater fuel security, avoiding heavy reliance on oil producing nations. By encouraging bioethanol's use, the rural economy would also receive a boost from growing the necessary crops. Bioethanol is also biodegradable and far less toxic that fossil fuels. In addition, by using bioethanol in older engines can help reduce the amount of carbon monoxide produced by the vehicle thus improving air quality. Another advantage of bioethanol is the ease with which it can be easily integrated into the existing road transport fuel system. In quantities up to 5%, bioethanol can be blended with conventional fuel without the need of engine modifications (E5) . Bioethanol is produced using familiar methods, such as fermentation, and it can be distributed using the same petrol forecourts and transportation systems as before.

Bioethanol Production

Ethanol can be produced from biomass by the hydrolysis and sugar fermentation processes. Biomass wastes contain a complex mixture of carbohydrate polymers from the plant cell walls known as cellulose, hemi cellulose and lignin. In order to produce sugars from the biomass, the biomass is pre-treated with acids or enzymes in order to reduce the size of the feedstock and to open up the plant structure. The cellulose and the hemi cellulose portions are broken down (hydrolysed) by enzymes or dilute acids into sucrose sugar that is then fermented into ethanol. The lignin which is also present in the biomass is normally used as a fuel for the ethanol production plants boilers. There are three principle methods of extracting sugars from biomass. These are concentrated acid hydrolysis, dilute acid hydrolysis and enzymatic hydrolysis.

Sugar Fermentation Process

The hydrolysis process breaks down the cellulose part of the biomass or corn into sugar solutions that can then be fermented into ethanol. Yeast is added to the solution, which is then heated. The yeast contains an enzyme called invertase, which acts as a catalyst and helps to convert the sucrose sugars into glucose and fructose (both $C_6H_{12}O_6$).

The chemical reaction is shown below:

			Invertase			
$C_{12}H_{22}O_{11}$	+	H_2O	→	$C_6H_{12}O_6$	+	$C_6H_{12}O_6$
Sucrose		**Water**	**Catalyst**	**Fructose**		**Glucose**

The fructose and glucose sugars then react with another enzyme called zymase, which is also contained in the yeast to produce ethanol and carbon dioxide.

The chemical reaction is shown below:

	Zymase			
$C_6H_{12}O_6$	→	$2C_2H_5OH$	+	$2CO_2$
Fructose / Glucose	**Catalyst**	**Ethanol**		

The fermentation process takes around three days to complete and is carried out at a temperature of between 250C and 300C.

Fractional Distillation Process

The ethanol, which is produced from the fermentation process, still contains a significant quantity of water, which must be removed. This is achieved by using the fractional distillation process. The distillation process works by boiling the water and ethanol mixture. Since ethanol has a lower boiling point (78.3C) compared to that of water (100C), the ethanol turns into the vapour state before the water and can be condensed and separated.