Biofuels:
Fuel Of The Future

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Introduction

Henry Ford stated the following about biofuel to the New York Times in 1925 "There is fuel in every bit of the vegetable matter that can be fermented. There's enough alcohol in one years yield of an acre of potatoes to drive the machinery necessary to cultivate the fields for a 100 years." Such is the potential of bio-fuels. Since his quote, the search for alternative sustainable fuels has grown enormously.

Recent studies have revealed that fossil fuels are running out at a much faster rate than was previously anticipated. As a result, prices for gasoline and other fossil fuels are going to reach disastrous levels in next fifty years due to (a) Prices of petroleum in the global market has a raising trend; (b) Petroleum reserves are a monopoly of some countries; (c) Number of vehicles based on petroleum fuels is on increase worldwide.

The term bio-fuel is referred to as liquid or gaseous fuels for the transport sector that are predominantly produced from biomass. Advantages of bio-fuels over conventional fuels are, (a) easily available from common biomass sources; (b) security of supply (c) biodegradable and contribute to sustainability; (d) reduced greenhouse gas emissions (GHG) and (d) facilitates regional development. Worldwide energy consumption has increased 17 fold in the last century and emissions of CO_2, SO_2 and NO_x from fossil-fuel combustion are primary causes of atmospheric pollution (Türe et al., 1997). Known petroleum reserves are estimated to be depleted in less than 50 years at the present rate of consumption (Sheehan et al., 1998).

What is biomass?

Biomass is biological material derived from living, or lately living organisms. In the context of energy, biomass is often used to mean plant based material composed of hemicelluloses, cellulose and lignin with minor amounts of extractives, but biomass can equally apply to both animal and vegetable derived materials. Biomass is primarily made of carbon which is absorbed from the atmosphere as carbon dioxide (CO_2) by plants using energy from the sun. Plants are subsequently eaten by animals and thus converted into animal biomass. The uneaten plant material is either broken down by microorganisms or burned. If it is broken down the carbon is released back into the atmosphere, chiefly as carbon dioxide (CO_2) or methane (CH_4), depending upon the conditions and processes involved. On the other hand if burnt carbon is returned to the atmosphere as CO_2. These processes form the carbon cycle.

Difference between fossil fuels and biomass

Well known fossil fuels (coal, oil and natural gas) are also derived from biological materials; however these materials absorbed CO_2 from the atmosphere many millions of years ago. As fuels, they offer high energy density, using this energy involves burning the fuel resulting in the oxidation of carbon to carbon dioxide and hydrogen to water vapour. These combustion products are released to the atmosphere, returning carbon sequestered millions of years ago and thus contributing to increased atmospheric CO_2 concentrations. On the contrary, biomass takes carbon out of the atmosphere while growing (photosynthesis), and returns it as it is burned and therefore is a controlled closed loop process. This maintains the atmospheric CO_2 levels at a constant level.

Conversion of biomass to fuel

All biomass materials can be converted to energy via thermochemical and biochemical processes. In a thermochemical process heat is the dominant mechanism to convert the biomass into another chemical form. Some of the commonly used conversion processes are pyrolysis, gasification and liquefaction producing syn-oil, syn-gas and bio-chemicals. The synthesis gas is composed of H_2 and carbon monoxide (CO) which is also known as syn-gas.

On the other hand, biochemical conversion makes use of the enzymes of bacteria and other micro-organisms to break down biomass to produce fuels. Commonly used conversion processes are anaerobic digestion, fermentation and transesterification to produce biohydrogen, bioethanol and biodiesel. Some of the main sources of hydrogen are glucose, starch, food wastes and agricultural residues rich in carbohydrates; for bioethanol wheat, maize, sugar beet, potatoes; and for biodiesel rapeseed, soybean, palm and sunflower.

Insight into production of automotive biofuels: Bioethanol and Biodiesel

Bioethanol and biodiesel are predominantly used as liquid fuels in the automotive industries. Carbohydrates (hemicelluloses and cellulose) in plant materials can be converted to sugars by hydrolysis process. Fermentation is an anaerobic biological process where sugars are converted to alcohol by the action of microorganisms, usually yeast. The resulting alcohol is ethanol. Under the EU quality standard EN 228 bioethanol can be used as a 5% blend with petrol which does not require engine modification and is covered by vehicle warranties (Demirbas 2007). With engine modification, bioethanol can be used at higher levels, for example, E85 (85% bioethanol).

Vegetable oil (m)ethyl esters is commonly referred to as "biodiesel" is a prominent candidates as an alternative to diesel fuels. The name biodiesel has been given to transesterified vegetable oil to describe its use as diesel fuel. It is less polluting and renewable in nature as compared to the conventional diesel. Biodiesel is technically competitive and offers technical advantages compared to conventional petroleum diesel fuel. The vegetable oils can be converted to their (m)ethyl esters via transesterification process in the presence of catalyst. Methyl, ethyl, 2-propyl and butyl esters are prepared from vegetable oils through transesterification using potassium and/or sodium alkoxides as catalysts. The purpose of the transesterification process is to lower the viscosity of the oil. Ideally, transesterification is a less expensive way of transforming the large, branched molecular structure of bio-oils into smaller, straight chain molecules of the type required in regular diesel combustion engines.

Market scenario for biofuels

Although biofuels offer more benefits in terms of cost and environmentally friendly compared to fossil fuels. Energy policies need to be reviewed for world wide conversion to biofuels. According to Mathews (2007), the major barrier faced by biofuels in the international market is that bioethaol and biodiesel are classified as food stuffs by the WTO rather than fuels. Another element involved in the creation of a global market is the setting of global standards for bioethanol, biodiesel and biofuels more generally. The petrofuels market is already well regulated by a variety of standards governing processes and product specifications (such as ASTM D975 for diesel fuel oils), and the same now has to be set in place for biofuels without national biases.

Even though Malaysia is the world's top palm oil producer and leads in the development of the Asian biofuel industry, shrinking profit margins due to rising feedstock costs, slumping oil prices and uncertain government support makes biofuels competitive with fossil fuels.

Concluding remarks

Use of biofuels will contribute enormously to the reduction of green house gas emissions and one that has immediate effects. It provides an option that is immediate and practicable. Ethanol is a near-perfect substitute for petrol (gasoline) in the transport sector because of its closeness to the energy content of gasoline while burning more cleanly (less pollution and untoward health effects) and being safer for the environment. Biodiesel is a near-perfect substitute for petrodiesel. Both these biofuels can be accommodated by existing infrastructure without any significant upheavals. Other nations have to emulate Brazil in shifting to biofuels, which is the world's largest bioethanol producer since 1970 from sugar cane and bioethanol energy user.

References

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