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AN OVERVIEW OF BIOFUELS

*I. H.QURESHI and S. AHMAD

Pakistan Institute of Nuclear Science and Technology (PINSTECH), P.O. Nilore, Islamabad. Pakistan

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Biofuels for transport have received considerable attention due to rising oil prices and growing concern about greenhouse gas emissions. Biofuels namely ethanol and esters of fatty acids have the potential to displace a substantial amount of petroleum fuel in the next few decades which will help to conserve fossil fuel resources. Life cycle analyses show that biofuels release lesser amount of greenhouse gases and other air pollutants. Thus biofuels are seen as a pragmatic step towards reducing carbon dioxide emission from transport sector. Biofuels are compatible with petroleum and combustion engines can easily operate with 10% ethanol and 20% biodiesel blended fuel with no modification. However higher concentrations require “flex-fuel” engines which automatically adjust fuel injection depending upon fuel mix. Biofuels are derived from renewable biomass and can be produced from a variety of feedstocks. The only limiting factors are the availability of cropland, growth of plants and the climate. Countries with warmer climate can get about five times more biofuel crops from each acre of land than cold climate countries. Genetically modified crops and fast growing trees are being developed to increase the production of energy crops.

Keywords: Biofuels, Petroleum, Transport sector, Air pollution, Life cycle emission, Production of biofuels.

1. Introduction

Efficient and rapid transportation of man and material is an essential requirement of all socio-economic development activities. The pace of social and economic growth is closely linked to the proficiency with which people and materials can be transported from one place to another place. Significant improvement in transportation was made by the invention of internal combustion engine. The first internal combustion engine was built in 19th century in Lucca by Meucci and Barsanti, which used hydrogen as fuel [1]. Later Henry Ford and Rudolf Diesel invented other internal combustion engines, which were expected to run on fuels derived from plants. Initially peanut oil was used as fuel by Rudolf Diesel to run his first engine in 1897. However petroleum, due to its low cost at that time, became popular fuel for these machines. Ever since the 1973 oil embargo, prices of oil are increasing and in recent years it touched high mark of $70 per barrel. Now with the rising oil prices it has become necessary to utilize other sources of power for cars, trucks and aircrafts.

The transportation sector, with its great demand for gasoline and diesel fuel, relies mainly on petroleum for energy and the demand is rapidly increasing every year. During the last 30 years the consumption of petroleum in transportation sector has increased from 900 million tonnes in 1973 to 1800 million tonnes in 2003 [2].

The global production of oil in 2004 is estimated to be 3888 million tonnes whereas that of gas is estimated to be 2794.5 billion cubic meters [2]. Only ten countries are the major producers of oil and gas and the other countries import these in varying amount. The global consumption of oil in 1973 was 2141 million tonnes of which 42.3% was used for transportation whereas consumption in 2003 was 3108 million tonnes of which 57.8% was used for transportation [2]. Similarly the consumption of gas for transportation has increased from 17.45 million tonnes of oil equivalent (Mtoe) in 1973 to 61.98 Mtoe in 2003. The production of oil and gas in 2004-2005 in Pakistan is estimated to be 3.235 million tonnes and 1344.9 billion cubic feet respectively [3]. Total consumption of oil in Pakistan in 2004-2005 was 14.67 million tonnes of which 61.5% was used in transportation compared to 46.8% of 17.77 million tonnes consumption in 1999-2000 [3].

Pakistan and many other countries import oil for their energy requirements. Pakistan spent US. $ 1998.26 million for the import of 5,675, 485 tonnes of petroleum in 2004-2005 [3], which will continue

* Corresponding author : driqbalqureshi@yahoo.com

to rise every year with increasing development activities. High oil prices during the last decade have adversely affected the economy of developing countries. The demand of oil and gas is increasing with rapid population growth and increased socio-economic activities. To cope with the increasing demand it is necessary to utilize other sources of energy in addition to oil and gas for transportation. The consumption of petroleum can be substantially reduced by utilizing alternate sources of energy such as hydrogen gas, hydrogen fuel cell and bio-fuels. There are various estimates regarding the future supply of fossil fuels. According to some estimates the known oil and gas reserves, at the present rate of consumption are expected to last for about 40 to 50 years. Bio-fuels can reduce dependence on petroleum oil and minimize fossil fuel consumption, which will help to conserve substantial amount of oil and gas and also reduce spending on import of petroleum. This paper presents an overview of environmental issues related to combustion of fossil fuels, life cycle analysis of biofuels and production cost of biofuels with the objective to use biofuels as an economic alternate energy source.

2. Bio-fuels

Bio-fuels are renewable fuel substitutes made from plant materials. These include ethyl alcohol (ethanol) and alkyl esters of fatty acids, known as biodiesel. Both of these are produced from renewable biomass and used as fuel substitute for petrol, gas and petroleum diesel for motor vehicles and airplanes. Combustion engines can easily run on petrol blended with 10% ethyl alcohol with no engine modifications. Higher concentration of ethanol requires “flex-fuel” engines, which automatically adjust fuel injections depending on the fuel mix. In Brazil and some other countries many new cars have such engines. Biodiesel is very similar to oil diesel as such conventional diesel engines can easily tolerate 20% biodiesel blended petroleum diesel. Higher concentrations require engine modifications. In Europe many new motor vehicles have modified engines, which run on 100% biodiesel.

3. Environmental Concerns

The burning of fossil fuels during the last century has significantly increased the levels of carbon dioxide and other greenhouse gases in the atmosphere. The level of CO_2 has increased from 280 ppm in 1750 to 368 ppm in 2000 [4]. The emission of carbon dioxide during the last three decades has increased by about 30% as shown in Fig. 1 [5, 6]. The level of carbon dioxide has increased to 379 ppm in 2005 and the global carbon dioxide output in 2006 approached to 32 billion tonnes [7]. The presence of substantial quantities of these gases in the atmosphere interfere in the natural process of heat exchange between upper atmosphere and outer space. Thus heat is trapped which may cause global warming. The average global temperature has increased by 0.6 degree centigrade during the last century [4,5]. The combustion of petrol and diesel in motor vehicles is one of the sources of carbon dioxide emission in the atmosphere. Motor vehicles contribute about 20% to global greenhouse emissions [8]. Vehicles also release a number of pollutants, which affect the quality of local environment. The main pollutants released by internal combustion engine include carbon dioxide, carbon monoxide, unburnt hydrocarbons, oxides of nitrogen and sulphur, organic compounds, particulates, smoke and odour. The amount of pollutants released from the tailpipe of automobiles vary from vehicle to vehicle depending upon the adjustment of engine parameters such as tuning, fuel injection system and mode of operations. Average tailpipe emission of pollutants from a petrol car is given in Table 1, which shows that carbon monoxide is the major pollutant [9]. A comparison of the emission of main pollutants from the use of diesel, petrol and compressed natural gas (CNG) as fuel in cars is given in Table 2, which shows that the emission of pollutants from a new diesel car is lower than that of petrol and CNG cars [9]. However, diesel vehicles release higher amount of carbon dioxide, smoke and particulate matter containing Polycyclic aromatic compounds.

Air pollution from the use of gasoline and diesel in automobiles is increasing with the increasing number of motor vehicles, which is adversely affecting the quality of air. Transport emission of CO, SOx, and particulate matter significantly contribute to urban concentrations of these pollutants, which pose public health risks. Therefore, reduction in tailpipe emission of these pollutants is a power tool for improving the quality of air. The use of bio-diesel in buses operating in urban areas significantly reduces the emission of these pollutants. In Pakistan the number of motor vehicles has increased from 2.11 millions in 1991 to 5 millions in 2005 [10]. The emission of air pollution has substantially increased due to rapid increase in the number of motor vehicles during the last five years [8]. The use of bio-fuel cannot only reduces the air pollution but can also reduce the import of petroleum.

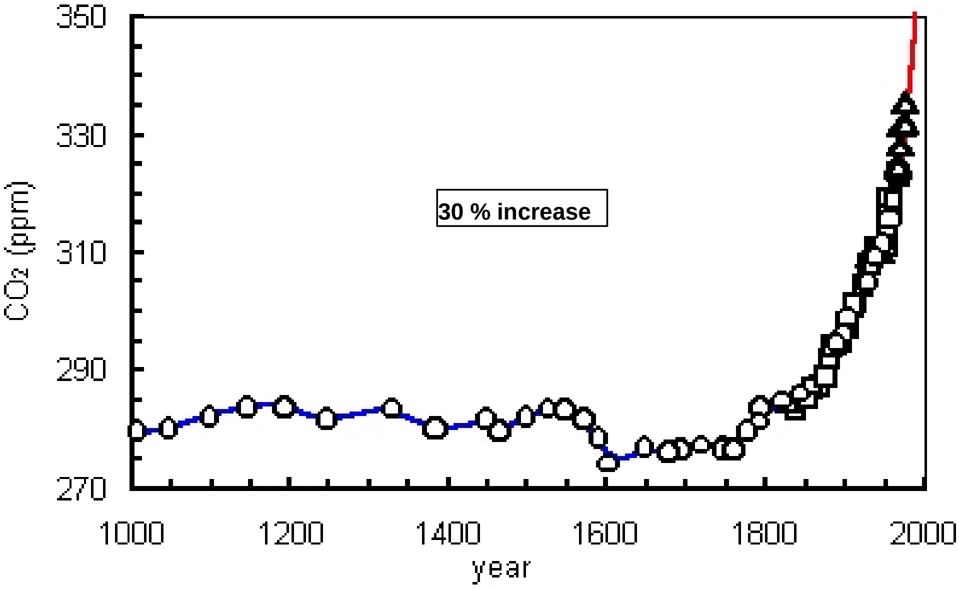


Figure 1. Atmospheric levels of CO_2.

Table 1. Average tailpipe emission of main pollutants from petrol motor vehicle [9].

Pollutants	Kg/1000L of Gasoline Used
Carbon Monoxide (CO)	300
Hydrocarbons (HC)	25
Oxides of Nitrogen (NOx)	14
Particulates (PM)	1.5
Oxides of Sulphur (SOx)	1.0
Aldehydes	0.5
Organic Acids (acetic)	0.5
Benzo (a) Pyrene*	0.06

*g/1000L

Table 2. Average tailpipe emissions of pollutants from diesel, petrol and compressed natural gas motor vehicles (g/100 Km) [9].

Pollutants	Diesel		Petrol		CNG	
	New	Medium	New	Medium	New	Medium
CO	9	396	214	4422	54	1106
HC	1.7	50	41	856	2	43
NOx	13	89	16	114	16	114
PM	<1	84	<1	4	-	2

Table 3. Life cycle air emissions for petroleum diesel, biodiesel - B20, and B100 (mg/bhp-h) [11].

Pollutant	Petroleum Diesel	B20	B100
*Carbon dioxide (CO_2)	633.3	534.1	136.5
Carbon monoxide (CO)	1269.8	1182.2	831.7
Methane (CH_4)	202.84	201.8	197.6
Non methane hydrocarbons (NMHC)	131.47	194.1	444.5
Benzene	0.04	0.03	0.002
Formaldehyde	0.5	0.46	0.02
Total particulates	130.2	123.9	98.3
Particulates 10 microns (PM -10)	84.1	76.6	46.6
Oxides of Sulphur (SO_x)	926.3	911.5	851.9
Oxides of nitrogen (NO_x)	5008.5	5142.3	5677.3
Hydrochloric acid (HCl)	3.16	3.25	3.59
Hydrofluoric acid (HF)	0.39	0.38	0.33
Ammonia (NH_3)	-	14.69	73.47

*g / brake-horsepower hour.

Table 4. Effect of biodiesel on tailpipe emission of main pollutants (g/bhp-h) [11].

Emission	Diesel Fuel Baseline	20% Biodiesel Blend	100% Neat Biodiesel
Carbon Dioxide	547.8	446.7	114.5
Carbon Monoxide	1.2	1.089	0.645
Hydrocarbons	0.1	0.093	0.063
Particulate Matter (PM 10)	0.08	0.069	0.025
Sulphur Oxides (as SO_2)	0.17	0.14	0
Nitrogen Oxides (as NO_2)	4.8	4.885	5.227

Table 5. Average biodiesel emissions compared to petroleum diesel [12].

Emission Type	B100	B20
Regulated		
Total Unburned Hydrocarbons (HC)	-67%	-20%
Carbon Monoxide (CO)	-48%	-12%
Particulate Matter	-47%	-12%
NOx	+10%	+2% to -2%
Non-Regulated		
Sulfates	-100%	-20%
Polycyclic Aromatic Hydrocarbons (PAH)	-80%	-13%
Nitrated PAH's (nPAH)	-90%	-50%
Ozone potential of speciated HC	-50%	-10%

4. Life Cycle Analysis of Biodiesel

Assessment of the benefits of biodiesel and emission of CO_2 requires a comprehensive life cycle analysis of biodiesel and petroleum diesel. Life cycle starts with the extraction of raw materials to make fuel and ends at the combustion of fuel in the automobile engine. This study examines energy balance, its effect on greenhouse gas emission, generation of air, water and solid waste, for every operation needed to make biodiesel and petroleum diesel fuel.

4.1. Energy requirement

Life cycle analysis estimates of the production of biodiesel and petroleum diesel indicate that the energy requirement for the production of biodiesel is less than that of petroleum diesel. In terms of effective use of fossil energy resources, biodiesel yields about 3.2 units of fuel product energy for every unit of fossil energy consumed in the life cycle whereas petroleum diesel yields only 0.83 units of fuel product energy per unit of fossil fuel consumed. In other words biodiesel uses 0.3110 Mega Joules of fossil energy to produce 1 Mega Joules of fuel product whereas, petroleum diesel uses 1.1995 Mega Joules of fossil energy to produce 1 Mega Joule of fuel product energy [11]. Thus biodiesel life cycle produces more than three times as much energy in its final fuel product as it uses in fossil energy. Energy balance analysis confirms that biodesel is a renewable energy source.

4.2. Carbon dioxide emission

Life cycle emission of carbon dioxide from petroleum diesel is estimated to be 633g per brake-horsepower hour (bhp-h) whereas that of biodiesel is 136g/bhp-h. Brake-horsepower-hour is the common unit of work performed by heavy-duty diesel engines whereas the unit for light-duty vehicle is km per litre. The major source of CO_2 emission for both the petroleum diesel and biodiesel life cycles is the combustion of fuel in the automobile. Tailpipe emission of petroleum diesel is about 86.5% of the total CO_2 emitted. Remaining amount of CO_2 comes from emission at the oil refinery. For biodiesel 84% of CO_2 emission occur at the tailpipe and the remaining amount comes from agriculture, oil seed crushing and oil conversion to biodiesel [11].

4.3. Emission of air pollutants

Life cycle emission of some other air pollutants from petroleum diesel and biodiesel are listed in Table 3 which shows that biodiesel releases lesser amount of many pollutants compared to petroleum diesel. Biodiesel reduces the emission of CO_2, CO, SO_x, HF, CH_4 and particulates by 78.5%, 35%, 8%, 15%, 2.5% and 32% respectively compared to petroleum diesel [11]. However it releases 35% higher amount of total hydrocarbons (THC) and 13.5% higher amount of NO_x. Higher emission of THC is due to release of hexane during processing of oil seeds and volatilization of agrochemicals applied on the farm [11].

4.4. Water and solid waste

Biodiesel life cycle wastewater flows are 80% lower and it generates only 5% hazardous waste compared to petroleum diesel. Biodiesel produces 0.1 litre/bhp-h whereas petroleum diesel produces 0.47 litre/bhp-h of wastewater [11]. In the petroleum diesel life cycle crude oil extraction accounts for 78% of total wastewater and 12% is associated with the refinery. In biodiesel life cycle 75% wastewater comes from oil conversion process. The water requirement of biodiesel is three times higher than petroleum diesel [11].

4.5. Tailpipe emission

Tailpipe emission of automobiles is the major contributor in the life cycle inventory of pollutants. It is the main source of air pollution in urban area which affects human health. It is, therefore, desirable to compare tailpipe emission from petroleum and biodiesel. A comparison of the tailpipe emission of main air pollutants from petroleum diesel and biodiesel vehicles in Table 4 shows that biodiesel releases lesser amount of all the pollutants except NOx [11]. The average reduction in the emission of regulated and non-regulated pollutants is mentioned in Table 5 [12]. The use of 100% biodiesel (B-100) reduces the tailpipe emission of particulates smaller than 10 microns (PM-10) by 47%, carbon monoxide by 48% and total hydrocarbon by 67% compared to petroleum diesel. Biodiesel completely eliminates tailpipe emission of SOx. However biodiesel increases the tailpipe emission of NOx by 10%. Decomposion of NO_2 in air under solar radiation produces NO and O free radicals which then react with hydrocarbon vapors and oxygen to form a number of compounds such as peroxyacetyl nitrates, organic hydroperoxides, aldehydes and ozone. Production of ozone near ground level results in the formation of photochemical smog, which causes various health disorders. Therefore, it is necessary to reduce tailpipe emission of NOx. Improvement in engine design and biodiesel formulation can help to reduce NOx emission. Installation of NOx adsorbing catalyst on vehicle can substantially reduce the emission of NOx. Relative emission of pollutants from diesel and biodiesel is presented in Fig. 2 [13].

4.6. Fuel economy

Fuel economy of biodiesel is about 8% less than that of petroleum diesel. One gallon of biodiesel generates energy equivalent to 119216 BTU whereas, petroleum diesel generates 129500 BTU. Thus the millage covered by one gallon of 100% biodiesel is about 5% less than that of petroleum diesel 11]. Lesser fuel economy of biodiesel is more than compensated by substantial reduction in the emission of CO_2 and other air pollutants.

5. Life Cycle Analysis of Ethanol

5.1. Energy requirement

Energy balance studies show that the production of ethanol from plant materials requires much lesser amount of fossil fuel energy compared to gasoline. Production of one unit of ethanol from sugar cane requires about 0.1 units of fossil fuel energy as most of the process energy is provided by bagasse. Conversion of grain to ethanol requires 0.6 to 0.8 units of fossil energy whereas conversion of cellulose to ethanol using enzymatic hydrolysis is the most energy-efficient process [8].

5.2. Emissions

Life cycle emission of CO_2 from ethanol is much lower than that of gasoline. Estimated emission of CO_2 is about 0.2 Kg per litre of ethanol compared to 2.82 Kg for gasoline. The reduction in the amount of CO_2 emission varies with the type of feedstock used for the production of ethanol. The estimated reduction of CO_2 is 35% for grains, 55% for sugar beets, 80% for cellulose and 85% for sugar cane feedstock [8].

Tailpipe emission of some air pollutants such as CO, SO_2, hydrocarbons and particulate matter is lower for ethanol blended gasoline than that of gasoline. Use of 10% ethanol blended gasoline reduces 25% emission of CO by increasing the oxygen content and promoting a more complete combustion of the fuel. However it increases the emission of volatile organic compounds due to higher vapour pressure [8].

6. Relative Greenhouse Gas Emissions

Various fuels, namely gasoline, petroleum diesel (PD), compressed natural gas (CNG), liquid petroleum gas (LPG), diesel hybrid, rechargeable batteries, 10% and 85% ethanol blended gasoline, 20% biodiesel blended diesel and 100% biodiesel have been used for transport. Relative greenhouse gas emissions from these fuels are presented in Fig. 3 which shows highest emission from gasoline and lowest from 100% biodiesel [14].

7. Production of Biofuels

In view of rising oil prices, concerns about climate change and growing anxiety over the future security of the world’s supply of crude oil, biofuels have received considerable attention worldwide. Brazil took the lead in the production of ethyl alcohol and began distilling sugar cane in 1975 for the production of fuel for motor vehicles. New generation of cars is being manufactured, which will run on 100% ethanol. Brazil has become the world’s biggest ethanol producer and supplying it to many countries. It sells ethanol at $ 25 a barrel, which is less than half the cost of crude oil. USA is the next biggest producer of ethanol, which makes 10 billion litres per year. Many other countries have started production of farm-grown ethanol fuel. Global production of ethanol from 1980 to 2003 and production of biodiesel from 1993 to 2003 are mentioned in Table 6 [8].

Biofuels namely ethanol (ethyl alcohol) and biodiesel (alkyl esters of fatty acids) are derived from plant materials. Ethanol is produced from a variety of feedstocks such as starchy grains, sugarcane, sugar beet and fast growing genetically modified grasses.

7.1. Sugar to ethanol

The simple way to produce ethanol is to use sugar crops such as sugar cane and sugar beet, which contain six-carbon sugars. The crops are processed to extract sugars by crushing, soaking and chemical treatment. The sugars are then fermented to alcohol using yeasts and other microbes. The fermented mixture is distilled to produce anhydrous ethanol, which can be blended with gasoline. The bagasse, consisting of cellulose and lignin can be used for process energy in the manufacture of alcohol.

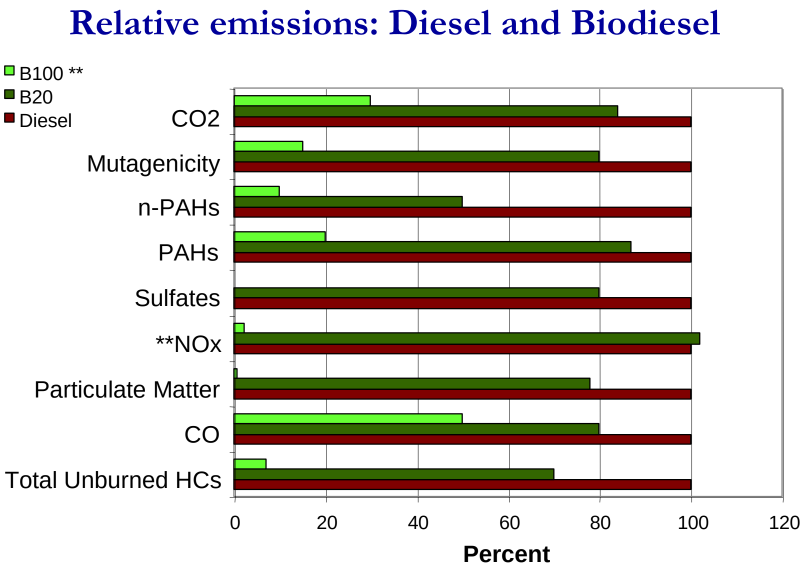


Figure 2. ** B100 (100% biodiesel) with NOx adsorbing catalyst on vehicle.

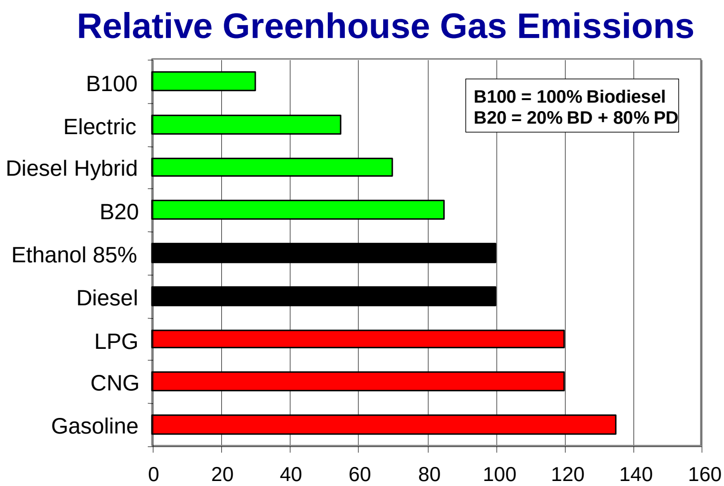


Figure 3. Data from "A Fresh look at CNG: A comparison of alternative fuels", alternative fuel vehicle program. (BD= Biodiesel, PD= Petroleum Diesel)

Table 6. Global productions of fuel ethanol and biodiesel (million litres per year) [8].

Ethanol		Biodiesel	
Year	Volume	Year	Volume
1980	4500	1993	125
1985	14800	1995	375
1900	15000	1997	550
1995	18000	1999	600
2000	17500	2001	1100
2003	28800	2003	1875

7.2. Grain to ethanol

Starchy grains are grounded and soaked in water for about 48 hours. Yeasts and other microbes are added to start fermentation. Usually a high-temperature enzyme process is used to convert the starch into six-carbon sugars, which are further fermented for 40 to 50 hours to produce ethanol. Pure ethanol is then distilled. The grain to ethanol process also yields several co-products such as protein rich animal feed and in some cases sweetener.

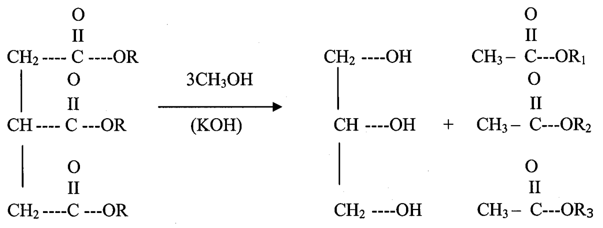
7.3. Cellulosic biomass to ethanol

The cellulosic biomass is first decomposed by a combination of physical and chemical (acid hydrolysis) processes into cellulose, hemi-celluloses and lignin. After the removal of lignin, the portion containing cellulose and hemicelluloses is hydrolyzed into sugars by treatment with dilute and concentrated acid. It produces a complex mixture of five and six-carbon sugars. This process, known as saccharification, is expensive and appears to be reaching its limit in terms of yields. Therefore, biological enzymes are now being used for hydrolysis of cellulose and hemicelluloses. The sugars are then fermented with yeasts and other microbes. An important process modification has been made for the enzymatic hydrolysis of biomass by the introduction of simultaneous saccharification and fermentation, which convert multiple sugar substrates into ethanol.

Worldwide production of ethanol fuel started in 1975 and now it has reached to more than 30 billion litres per year. Brazil is the largest producer of ethanol followed by U.S.A and China. In view of increasing demand Brazil has increased the number of sugarcane fields, which now feed a network of 320 ethanol plants. Fifty more plants will be setup in the next 5 years. U.S.A. and China are building more plants to increase the production of ethanol [8,15].

7.4. Biodiesel production

Biodiesel, a high quality, clean burning fuel similar to petroleum diesel, is produced from oily seeds such as soyabeans, rapeseeds, canola seeds, sunflower seeds, coconut oil, oil palm, waste cooking oil and animal fat. Biodiesel from fatty acid esters can be produced by a variety of estrification technologies most of these processes follow a similar basic approach. The oil seeds are pressed to extract oil, which contain triglycerides. The oil is filtered and processed to remove water and other contaminants. The treated oil is then mixed with methyl alcohol and a catalyst such as sodium or potassium hydroxide. The mixture is then heated to start the reaction. The oil molecules are broken apart and reformed into alkyl esters of fatty acids and glycerol, which are then separated from each other and purified. Similarly waste cooking oil and animal fats are converted to biodiesel.



Triglyceride Glycol Fatty Acid Esters

Where, R_1, R_2 and R_3 may be same or different. These are radicals of palmitic acid (C_{15} H_{31} COOH) or satiric acid (C_{17} H_{35} COOH) or Oleic acids (C_{17} H_{33} COOH). The production of biodiesel started in 1990 has now reached to about 2 billion litres per year. In Europe, Germany has become the world's biggest producer of biodiesel, which is made from rapeseed. European Union plans to use 6 percent biodiesel by 2010, which would require a five-fold increase in the production of biofuel crops. To meet these demands, Malaysia is expanding oil-palm plantations and setting up biodiesel plants.

8. Crop Production

The only limiting factors for the production of biofuels are the availability of cropland, the growth of biofuel plants and the climate. In USA or Europe, to replace just 10% petroleum fuel for transport will require about 40% of cropland. However, southern countries with warmer climate can get about five times more biofuel crops from each acre of land. Thus developing countries, without too much effort, can produce enough biofuel to replace 10% of global gasoline fuel.

Biotechnology offers an important new approach to increase the yields of biofuel crops. Higher crop yields per acre and per energy input will reduce the cost of production of biofuels. Genetically engineered crops have genes from other species inserted or substituted in their genomes. Transgenic transfers give a plant different characteristics very quickly and can improve crop yield. Gene mapping can be used for developing genetically modified energy crops. Genetic research into food crops has already resulted in new high-yielding variety of corn, wheat and sugar cane [11].

9. Production Cost of Biofuels

Production costs of ethanol are much lower in countries with warm climate. Brazil, which produces ethanol from sugarcane, has the lowest production cost (US$ 0.15/litre) which is less than half the cost in Europe [8]. In European countries the production cost ranges from US$ 0.35 to $ 0.60 depending upon the nature of feedstock and plant size, whereas in U.S.A the cost is $ 0.29 per liter [8]. Since plant size has a major effect on cost, construction of large plants reduces the production cost by about 20% or more. Plant feedstock is the largest ethanol cost component. About half of this cost is offset by selling co-products such as "distillers dried grains soluble" which is an animal feed. Development of advanced technologies to convert biomass feedstock to ethanol and liquid fuel like synthetic diesel will reduce the cost of production. Production cost of biodiesel varies from countries to countries depending upon the feedstock and plant size. In USA, which uses Soya oil as feedstock, the production cost ranges from US $ 0.48 to $0.73/litre whereas in Europe, which uses rapeseed oil, the cost ranges from US $ 0.35 to $ 0.65/litre [8].

10. Pakistan's Perspective

Pakistan has recently taken an initiative to use biofuel for transportation and announced the availability of 10% ethanol blended gasoline. This will help to reduce dependence on imported oil and save valuable foreign exchange. To meet the demand of ethanol blended gasoline, production of ethanol should be increased by increased growth of biofuel crops. Since Pakistan is deficient in the production of biofuel crops, it is necessary to utilize biotechnology and genetic engineering techniques for the conversion of cellulose waste and grass into ethanol. Kaller grass and caster oil can be utilized to make biofuel. Pakistan can follow the example of northern countries, which are developing new technologies to economically produce biofuel. Instead of producing fuel from a tiny part of the total plant, new factories are being built to convert a plant's entire biomass into fuel. In the present fermentation technologies only sugarcane juice is used for making ethanol while the cellulose, which gives plants their structure, is left as a waste. Similarly oil is pressed from the seeds and rest of the plant is discarded. The use of biotechnology can convert the cellulose into alcohol. Genetically engineered enzymes, which are now becoming cheaply available, are used to convert cellulose in the straw to glucose, which is then fermented to produce ethanol. Last year a Canadian firm named Iogen Corporation of Ottawa has built the world first commercial plant that takes the left over straw from the surrounding farms and covert it to ethanol. Shell Oil in cooperation with Iogen, is now investing $ 46 million to complete a bigger facility to produce 200,000 tonnes of ethanol per year at an estimated cost of $1.30 per gallon by 2008 [15]. Choren Industry in Germany is developing a process to synthesize biodiesel from the cellulose in trees and straw, which require substantial number of trees. For this purpose research is being done on genetically modified fast-growing willows and poplar trees as well as on six-headed sunflowers and strains of corn, which will be three times higher than the normal plant [15].

11. Conclusion

Biofuels are now being used worldwide for transportation as a substitute for gasoline and petroleum diesel for the last two decades. Biofuels are produced from renewable plant materials. As such, the only limiting factor in the production is the availability of cropland and plant growth. Biotechnology can play an important role to improve crop yields. Processes are now being developed to synthesize biodiesel from the cellulose in the trees and straw which will drastically cut down the land requirement and cost of production.

The main advantages of biofuels are that these can reduce our dependence on foreign petroleum and will help in conserving limited fossil fuels resources. Biofuels can help to reduce emission of greenhouse gases and other air pollutants such as particulates, carbon monoxide, hydrocarbons and oxides of sulphur which pose public health risks. Thus Biofuels are seen as a pragmatic step towards reducing carbon dioxide emission from transport sector.

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