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Potential Utilization of Different Waste Material for Power Generation

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Abstract:

In last 5 decades, the depleting petroleum reserves, tough emission regulations, increase in automobile vehicles due to rapid increase in population have driven the engine technology towards search the alternative fuels for power generation applications. The research is also going on for getting high thermal efficiency and low engine emissions. This expectation requires modification in both aspects i.e. in engine as well as in fuel. There is another issue of waste accumulation and its disposal. There are many kinds of waste which can be converted into useful form of energy and can be utilized for many applications. Many research investigations have been proved that biodiesel an attractive substitute to diesel fuel due to its renewable in nature and easy adoption in diesel engine. Also the choice of fuel has also been shifting from fossil fuel to biodiesel and fuel obtained by utilizing waste material. This research article attempts to provide an over view on various aspects of alternative fuel obtained by waste material and their implications on engine combustion, performance and emission.

1. Biogas from waste obtained from sugar industry

In view of the depletion of fossil fuel resources, considerable research is being devoted to looking for alternative fuels to comply with transportation needs while reducing the environmental impact of the transport activity sector. In this sector, off road vehicles and agricultural machinery consume a small, but vital amount of energy of around 2 Mtoe [1]. As for transport, the goal is to reduce both fuel consumption and greenhouse gas emissions by 20% in the year 2020 and the target is even to reduce these by a factor of 4 in 2050 [2] .Among biofuels, biogas is an interesting candidate, because it can easily be used to partially replace diesel fuel in the compression ignition (CI) engines generally used for tractors. Biogas is also produced from the mechanization of farm waste [3]. Anaerobic digestion is one way to produce energy from biomass.

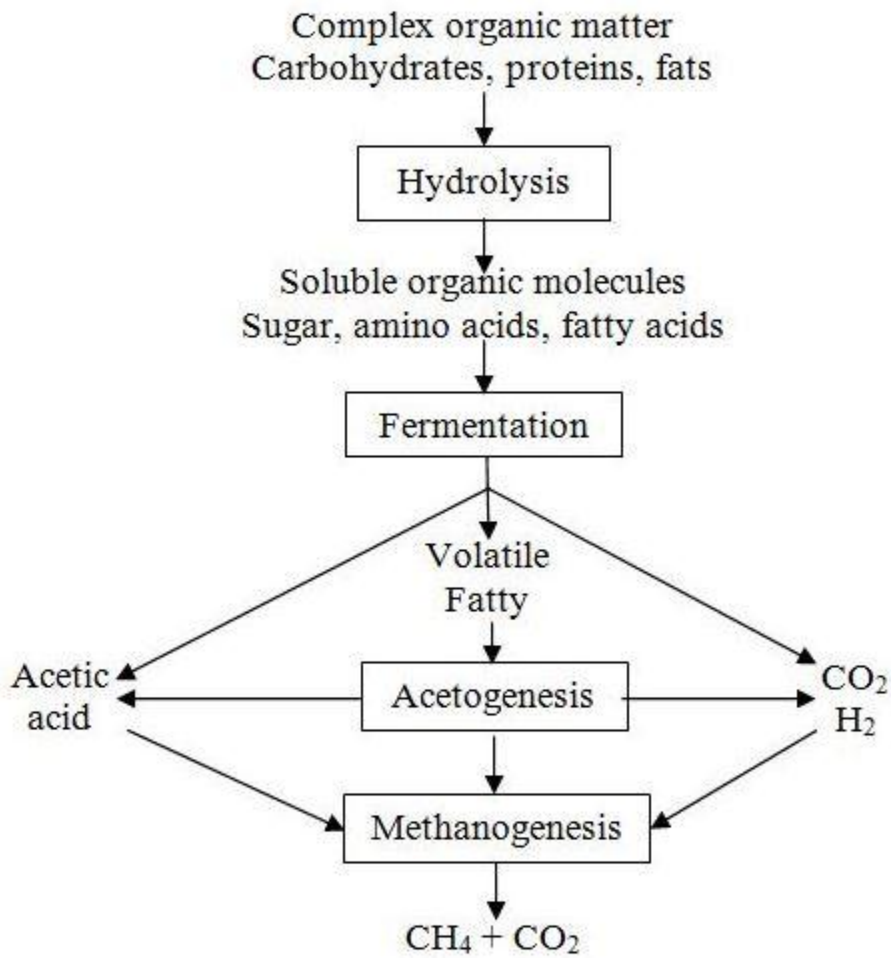

Figure 1 Pathway of anaerobic digestion process [14]

Anaerobic digestion is a biological process in which biodegradable organic matters are decomposed by bacteria forming gaseous byproducts. The gaseous byproduct consists of methane (CH_4), carbon dioxide (CO_2), and tresses of other gases [4]. The anaerobic digestion process is considered to be a minimum of two stage biological reaction, involving at least two different groups of microorganisms, one is acid forming bacteria (saprophytic) and the other is methane forming bacteria. The acid phase is generally considered to include the conversion of complex organic compounds into simpler organic compounds and finally into the organic acids i.e. acetic acid by acid forming bacteria [5-6]. It is a multi-stage process which can be divided in to four phases: hydrolysis, acid genesis, dehydrogenation/ gametogenesis, and methanation [7-9]. The first phase is namely as single stage unmixed, second phase is two stage mixed primary, the third phase is anaerobic contact process with sludge recycle and the fourth phase is anaerobic filter with methane formation. The first two processes are generally used for digestion of solid wastes and waste water sludge and the other two process are for the formation of acetic acid, CO_2, and methane CH_4 [10].During this process, the organic compounds are hydrolysed into smaller components like sugars, amino acids, alcohols and long chain fatty acids so both solubilisation of particulate matter and biological decomposition of organic polymers to monomers or dimers take place [11].

Anaerobic biological treatment is the process by which anaerobic bacteria decompose organic matter/agricultural solid waste (ASW) in to methane, carbon dioxide, and a nutrient-rich sludge involves a step-wise series of reactions requiring the cooperative action of several organisms. The rate of digestion and biogas production is affected by a variety of factors; the most important is temperature [11]. Anaerobic bacteria communities can endure temperatures ranging from below freezing to above 330.4 K, but they thrive best at temperatures of about 309.9 K (mesophilic) and 327.6 K (thermophilic). Bacteria activity, and thus biogas production, falls off significantly between about 312.6 K and 324.9 K and gradually from 308.2 K to 273.2 K [12]. Figure 1 shows the pathway of anaerobic digestion process. The first two processes are generally used for digestion of solid wastes and wastewater sludge and the other two process are for the formation of acetic acid, CO2, and methane CH4 [13].

2. Carbon Black

Carbon black is obtained as a by-product in many chemical industries such as pyrolysis of rubber from tyres [15]. Only a less percentage of carbon black is used in coating of electrical insulation cables, road pavement and production of colour pigments. Rest of the carbon black is disposed in the open land. This causes air and land pollution as the carbon black contains metals and other contaminants. The carbon black contains a considerable amount of carbon in it and also it possess a considerable heating value in it. This energy can be recovered by appropriate method and used to generate heat and power. The present investigation is aimed to characterise the diesel-carbon black mixture having carbon black in it at a lower proportions varying from 5 to 20% on volume basis.

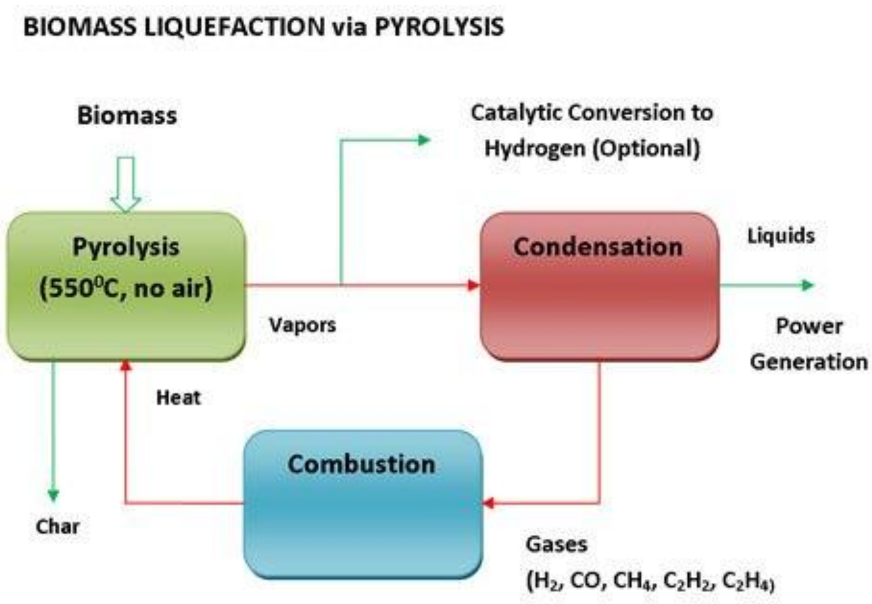

Figure 2 Pyrolysis process

Presently, waste tyres are used in few applications such as (i) Landfill (ii) Crumbing (iii) Remould (iv) Incineration and (v) Tyre derived fuel. Although the first five methods find suitable applications they are either dumped again or are of secondary importance. The waste tyres are also used as fuel sources in cement kilns, though it is banned in many states. Direct burning is also harmful to human beings and environment. Recycling or reuse is one of the possible methods adopted for solving the problem of disposal of waste automobile tyres. Pyrolysis and gasification provide better value added products that are remarkable sources of energy. Pyrolysis is a process by which waste tyres are thermally degraded in the presence of little oxygen or in the absence of oxygen to get value added products. In the pyrolysis of waste tyres three value added products namely pyrolytic oil, pyrogas and carbon black. Recently, countries such as China, Egypt, India, South Korea, Italy, France and Canada have brought pilot and commercial pyrolysis plants for recycling the automobile tyre through pyrolysis. In last five years, about 500 pyrolysis plants have been installed and commissioned in India. Some of them are running successfully and many of them are closed due to the legislations by the state governments where the plants are installed. Another reason is that, a meager profit is earned by the owners due to accumulation of carbon black that is derived from the pyrolysis process [16].

The carbon black obtained from the pyrolysis plant cannot be sold to the industries, because the purity of carbon black obtained is less than 90%. The activated carbon black with a purity of 99.9% is only used in industries for manufacturing electrical insulation, tyre manufacturing, cartridge and manufacturing pigments.

3. Bioethanol

Bioethanol is biomass derived alcohol which is clean burning and renewable in nature and it can be obtained from the conversion of carbon based feedstock. There are two types of feedstock from which bioethanol can be produced are forest (woody) biomass and agricultural biomass. Forest biomass is much more recalcitrant than agricultural biomass. Agricultural feed stocks are considered renewable because they get energy from the sun using photosynthesis, provided that all minerals required for growth (such as nitrogen and phosphorus) are returned to the land. Bioethanol are again classified into first generation and second generation bioethanol. Feed stocks for first generation bioethanol productions are sugar and starch.

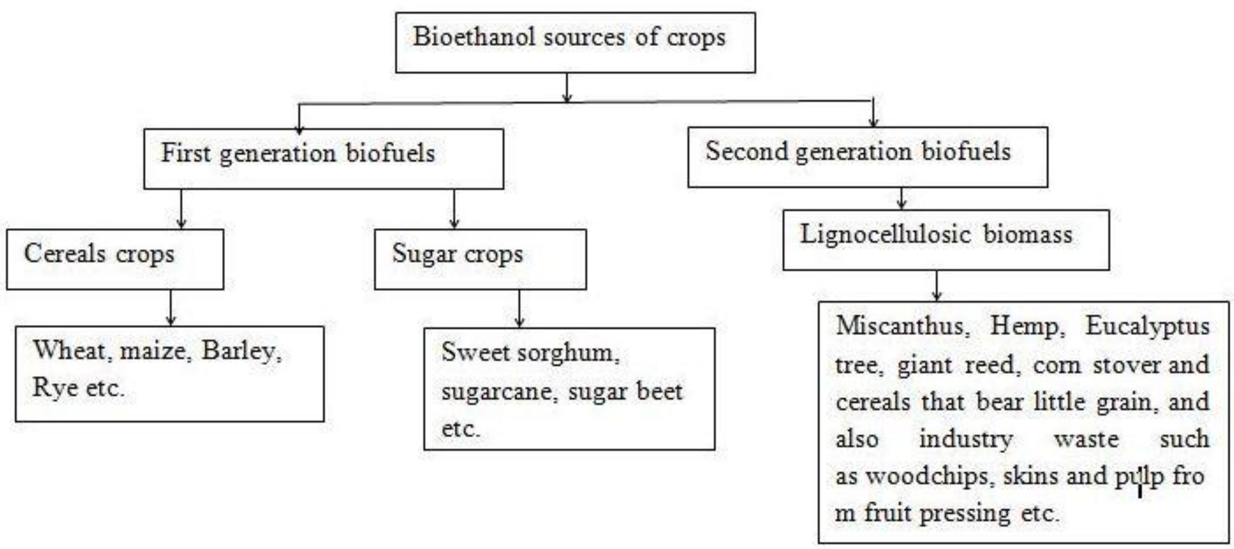

Fig. 3 Different Feed stocks used for bioethanol production

But the food-versus-fuel concerns are drawbacks of producing bioethanol from food crops like sugar or corn. Second generation bioethanol is produced from biomass consisting of the residual non-food parts of crops, such as stems, leaves and husks that are left behind once the food crop has been extracted, as well as other crops that are not used for food purposes mostly from lignocellulose feed stocks. The lignocellulose is subjected to delignification, steam explosion and dilute acid pre-hydrolysis, which is followed by enzymatic hydrolysis and fermentation into bioethanol [17]. Feedstock high in starch and sugar are most easily hydrolyzed.

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