Renewable and Sustainable Energy Reviews 32 (2014) 697–712

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Alternative fuels: An overview of current trends and scope for future

Sangeeta, Sudheshna Moka, Maneesha Pande, Monika Rani, Ruchi Gakhar, Madhur Sharma, Jyoti Rani, Ashok N. Bhaskarwar *

Department of Chemical Engineering, Indian Institute of Technology, Hauz Khas, New Delhi 110016, India

ARTICLE INFO

Article history:
Received 21 December 2012
Received in revised form
3 December 2013
Accepted 4 January 2014
Available online 7 February 2014

Keywords:
Hydrogen
Bioethanol
Fischer–Tropsch
Micro-emulsion

ABSTRACT

The concern over rapid depletion of fossil fuels has prompted the search for alternative fuels having efficiencies similar to those found for the conventional fuels being used today. The present article reviews the prospects and opportunities for using alternative fuels in different applications. The properties of these fuels and their performance as a fuel are discussed in detail. Vegetable oils present a very promising scenario of functioning as alternatives to fossil fuels. Use of biodiesel in a conventional diesel engine results in a substantial reduction in unburned hydrocarbons, carbon monoxide, particulate matter, and nitrogen oxides. Different alternative fuels have been compared with the conventional fuels, and clearly the consumption of the latter can be significantly decreased by the use the blended fuels.

Most of the alternative fuels have properties similar to those of the existing fuels, and therefore the technology required to handle them is already well known. Hydrogen is an exception to this, and its ignition properties are quite different from those of the conventional fuels. Difficulties are thus expected during the storage, transport, and use of hydrogen as a fuel. Other technologies are also discussed such as alternative routes to equivalents of conventional fuels, like CTL. Finally, the emulsified fuels including the use of oxygenates have been discussed.

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* Corresponding author. Tel.: +91 11 26591028.
E-mail address: anbhaskarwar@gmail.com (A.N. Bhaskarwar).
URL: http://www.ashoknbhaskarwar.freeservers.com (A.N. Bhaskarwar).

1364-0321/$ - see front matter
http://dx.doi.org/10.1016/j.rser.2014.01.023

1. Introduction

The fossil fuels present on our planet are limited. The conventional fuels are also a net source of green house gases. Before we run out of fossil fuels, we will have to look for other alternatives for fuels and for sources of energy. A lot of efforts are currently going on worldwide to find alternative fuels which may meet our present and future demands of energy, without causing further global-warming effects.

A comparative study of literature on various alternative fuels such as ethanol, vegetable oils, glycerol, biomass, biodiesel, diethyl ether, hydrogen, etc., and their impact on the environment has been attempted here. The article presents an extensive review of the raw materials' properties, details of manufacture and processing steps with a critical assessment of the viability of these different alternative fuels. For a fuel to be effectively used as an alternative to the conventional fuels, it should be comparable to the conventional fuels with respect to certain important properties such as ignition properties and combustion properties, which characterize the use of a material as a fuel. These properties are first defined in the following section.

2. Ignition and combustion properties of a fuel

2.1. Cetane number

Cetane number is defined as the volume of n-cetane in a mixture of n-cetane and α-methyl naphthalene, which gives the same ignition delay as the fuel under consideration, when tested in a Cooperative Fuel Research (CFR) engine. Ignition delay is the delay between the start of injection and start of combustion of the fuel. It represents the ignition quality of diesel fuel. Fuels with a higher cetane number will have a lower ignition delay period than the fuels with a lower cetane number. The cetane number is generally specific to a particular engine being used [1].

2.2. Calorific value

The heat of combustion is a direct measure of the energy content of a fuel. It is determined in terms of the quantity of heat liberated by the combustion of a unit quantity of fuel with oxygen in a standard bomb calorimeter. There are two heats of combustion, or calorific values, for every petroleum fuel, gross and net. When hydrocarbons are burnt, one of the products of combustion is water vapor. The gross calorific value includes the heat given off by the water vapor in condensing whereas the net value does not include this heat [1].

2.3. Octane number

Combustion in the spark ignition engine depends chiefly on engine design and gasoline quality. Under ideal conditions, the flame initiated at the sparking plug spreads evenly across the combustion space until all the gasoline has been burnt. The increase in temperature caused by the spreading of the flame results in an increase in pressure in the end gas zone, which is that part of the gasoline–air mixture where the flame has not yet reached. The increase in temperature and pressure in the end gas zone causes the gasoline to undergo pre-flame reactions. Among the main pre-flame reaction products are the highly temperature-sensitive peroxides. If these exceed a certain critical threshold concentration, the end gas will spontaneously ignite even before the arrival of the flame front emanating from the sparking plug, thus causing detonation or knocking. On the other hand, if the flame front reaches the end gas zone before the buildup of the critical threshold peroxides' concentration, the combustion of the gasoline–air mixture will be without knock. The various types of hydrocarbons in gasoline behave differently in their pre-flame reactions, and hence the differences in their tendency to knock. The octane number of a fuel is a measure of the knock rating of a gasoline, and is expressed as the percentage by volume of iso-octane (octane number 100, by definition) in a mixture of iso-octane and normal heptane (octane number 0, by definition), that has the same knock characteristics as the gasoline being assessed. Normal heptane and normal pentane, both paraffins, have anti-knock ratings (octane numbers) of 0 and 61.9, respectively [2].

2.4. Flash point

This is defined as the minimum temperature at which the vapors from an oil sample will give a momentary flash on application of a standard flame under specific test conditions. Abel flash point apparatus, Pensky–Martens closed cup apparatus and Cleveland open cup apparatus are the test apparatuses frequently used for the measurement of the flash point. Flash point is a parameter that can predict the possible fire hazards during transportation, handling, and storage of a fuel [1].

2.5. Volatility

The volatility of a liquid is its tendency to change from the liquid to the vapor or gaseous state. It is a primary and necessary characteristic of most liquid gasoline fuels. The distillation profile is also a measure of the relative amounts of the gasoline constituents in petroleum. The volatility of gasoline affects the performance of the engine in a number of ways, the chief ones of which are ease of starting, rate of warm-up, vapor lock, carburetor icing, and crankcase dilution (the dilution of the engine lubricating oil with the higher-boiling constituents of the gasoline).