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

Alternative fuels for transportation vehicles: A technical review

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ARTICLE INFO

Article history:

Received 28 April 2012

Received in revised form

12 April 2013

Accepted 20 April 2013

Keywords:

Alternative fuels

F-T fuels

Biodiesels

Biofuels

DME

Hydrogen

Bio-oil

ABSTRACT

Recent petroleum crises, rapidly increasing its prices and uncertainties concerning petroleum availability threaten the sustainable development of the world economy. Both the environmental concern and availability of fuels greatly affect fuel trends for transportation vehicles. The present work aims to compile a holistic scenario of different resources, production technologies, and properties of alternative fuels for transportation vehicles. Detailed descriptions of production technologies and fuel properties would help to refine and further enhance the technologies. While many production technologies have been developed, still more attention is needed to develop an effective, economical and efficient conversion process. As a broad overview of the subject, this article includes information based on the research carried out globally by scientists according to their local socio-cultural and economic situations. The integration of different technologies and hybridization is the demand of the present time for sustainable power generation and economic development.

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Contents

1. Introduction	405
1.1. Internal combustion engines and emissions	405
2. Alternative fuels	405
2.1. Methanol	406
2.2. Ethanol	406
2.3. Dimethyl ether	407
2.4. Butanol	407
2.5. Biodiesel	407
2.6. Biodiesel production	407
2.7. Ester preparation	408
2.7.1. Methyl esters	408
2.7.2. Ethyl esters	408
2.8. Monitoring of transesterification reactions	408
2.8.1. Gas chromatographic method (GCM)	408
2.8.2. High performance liquid chromatography method (HPLC)	408
2.8.3. Gel permeation chromatography method	408
2.8.4. NIR spectroscopy	409
2.9. Biodiesel from microalgae	409
2.10. Bio-oil	410
2.11. Pyrolysis	410
2.12. F-T Fuels	410
2.13. Hydrogen fuel	411
2.13.1. Steam reforming	411

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2.13.2. Steam–methane reforming	411
2.13.3. Steam bio-ethanol reforming	412
2.13.4. Thermal decomposition	412
2.13.5. Biomass-based hydrogen production methods.....	412
2.13.5. (i) Thermo-chemical processes.....	412
2.13.5. (ii) Biological conversion	412
3. Non-hydrocarbon based hydrogen production.....	413
3.1. Photodecomposition process.....	413
3.2. Photo-electrolysis and photo-electrochemical process	413
3.3. Electrolysis and photolysis of water	413
3.4. Water dissociation method	413
3.5. Hydrogen from renewable energy sources.....	414
3.5.1. The photovoltaic–electrolysis system (PV–EL)	414
3.5.2. The wind turbine–electrolysis system (W–EL)	414
3.5.3. The hydropower–electrolysis system (H–EL)	414
4. Properties of alternative fuels	415
4.1. Emission characteristics of alternative fuels.....	416
5. Conclusions	417
Acknowledgment	417
References	417

1. Introduction

Increasing urbanization and industrialization have led to a phenomenal growth in transportation demand worldwide, coupled with a concentration of vehicles in metropolitan cities. The increasing power demand for industrialization and motorization of the world has led to a steep rise in the demand of petroleum-based fuels. The availability and environmental impact of energy resources will play a critical role in the progress of human beings and the physical future of our planet. At present, fossil fuels take nearly 80% of the primary energy consumed in the world, of which up to 58% alone are consumed by the transport sector [1–3].

1.1. Internal combustion engines and emissions

The internal combustion (IC) engines emit harmful pollutants like CO, CO₂, NO_x, particulate matter, smoke, etc. Therefore, simultaneous power production and reduction in engine emissions are the most important research aspect in IC engines.

However, as engines are currently calibrated to be as efficient as possible while complying with the emission standards, there is still a trade-off between the emissions performance and efficiency. Among other solutions to reduce both NO_x and PM such as reformed exhaust gas recirculation (REGR), selective catalytic reduction (SCR) catalysts and diesel particulate filters (DPF) are being used. But there is a major pollutant CO₂, which is a greenhouse gas also responsible for global warming, that remains the culprit.

The depletion of fossil fuels, rising petroleum prices and stringent environmental regulations have stimulated intense international interest in developing alternative non-petroleum fuels for internal combustion engines [4,5]. The utilization of non-petroleum based renewable alternative fuels like biofuels such as biodiesel, methanol, ethanol, dimethyl ether, diethyl ether, butanol, bioethanol, synthetic natural gas (SNG), Fischer–Tropsch diesels hydrogen etc. in the IC engines can be helpful to tame the CO₂ emissions. This is particularly desirable if those fuels can be employed successfully in existing engines with no modifications, or with minor modifications [3,6,7].

Subramanian et al. [8] presented the policy and planning issues for the utilization of ethanol and biodiesel in automotive diesel engines in Indian context in view of environmental benefits, energy self-sufficiency and boosting of the rural economy.

The biofuel is one of the options to fulfill the need as transport fuel. It received attention as environmental friendly renewable and substitute fuel. The biodiesel, which is an important biofuel, has been investigated worldwide for production, properties and sustainability aspect. The investigations are going on to employ biodiesel of well-known composition and purity and to report detailed analyses for utilization in diesel engine. The purity levels, which are necessary for achieving adequate engine endurance, compatibility with coatings and elastomers, cold flow properties, stability, and emission's performance must be better defined [9–11]. The second-generation fuels are the suitable alternative and viable fuels for the internal combustion engines [3].

The literature survey on alternative fuels have become a curtain riser, and the fact comes out that number of articles have been published on various fuels, covering the resources and production technologies, but hardly some work was found on alternative fuels in the collective form of information. The present paper is aimed at compiling the published information at the common platform, so that better and sustainable alternative fuels can be used for transportation vehicles, and further research can be enhanced for improvement and development.

2. Alternative fuels

The research on alternative fuels for transportation vehicles contributed a lot and many fuels like—biodiesel, methanol, ethanol, butanol, dimethyl ether, diethyl ether, bioethanol, synthetic natural gas (SNG), Fischer–Tropsch diesels hydrogen, straight vegetable oils (SVO), hydrotreated vegetable oil (HVO), synthetic natural gas (SNG), F-T diesel and hydrogen emerged as possible alternative fuels [12].

The ever increasing transportation vehicle density and fuel requirement compelled the researchers and the scientists to search for the alternative sources of the transportation fuels. Over the decades, many techniques and methods have been developed and still continue for betterment in terms of yield, cost economy and sustainability. The systematic study of the various sources of the alternative fuels and their production technologies is based on the fundamental principles of fuel design for internal combustion engine, as shown in Fig. 1.

Researchers have been re-directing their interests in biomass based fuels, which currently seem to be the only logical alternative

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