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Prospects of 2nd generation biodiesel as a sustainable fuel—Part: 1 selection of feedstocks, oil extraction techniques and conversion technologies

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ABSTRACT

The transport sector, which heavily depends on oil-derived liquid products such as gasoline and diesel, globally occupies the 3rd place when total energy consumption and greenhouse gas (GHG) emissions are considered (after the industry and the building sectors). This consumption level is predicted to increase by 60% by 2030 mainly because of population growth, industrialization and exposure to better living standards. Biodiesel is one of the sustainable sources of energy for meeting increasing global transport energy demand and reducing GHG emissions significantly. The use of non-edible plant oils is very significant because it can be grown in harsh and marginal lands which require less maintenance, less soil fertility and less water as opposed to arable lands for growing edible vegetable oils. However, it is noted that the 2nd generation feedstocks can also be grown in arable lands, but this is not a general practice and is not recommended. The 2nd generation biodiesel can be considered as a promising alternative because of its feedstocks, such as non-edible vegetable oils, animal fats and waste cooking oils are cheaper in most of the countries in the world than the 1st generation feedstocks which are produced from edible-vegetable oils (food crops). Furthermore, the price of biodiesel depends on the cost of feedstocks which makes up 70–95% of the total production costs. However, extraction of non-edible oils as well as conversion process of oil into biodiesel should be well scrutinized. This paper extensively reviews on the selection of 2nd generation biodiesel feedstocks, oil extraction as well as biodiesel conversion techniques with the aim to identify the most appropriate and cost-effective feedstocks, identify the most suitable oil extraction technique and most efficient technology for producing of the 2nd generation biodiesel which will substitute the current dependence on the fossil fuel worldwide. This paper will contribute to greater understanding of the recent development and prospects of 2nd generation biodiesel as a sustainable transport fuel.

Contents

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1. Introduction

Petroleum consumption has increased over the last few decades due to expansion of human population and industrialization, which has resulted in depletion of fossil fuel reserves and increasing petroleum price [1]. Furthermore, the scarcity of conventional fossil fuels, increasing emissions of combustion-generated pollutants, greenhouse gases have led to atmospheric pollution and global warming. These and the additional effects of their growing costs will make biofuel more attractive. Petroleum based fuels have limited reserves and are concentrated in certain regions of the world. These sources are on the utmost of reaching their peak production. Therefore, the scarcity of petroleum fuel reserves has made renewable energy an attractive alternative energy source for the future [2]. However, biodiesel fuels are attracting thriving attention worldwide as a blending component or a direct replacement of diesel fuel in vehicle engines [3]. Thus, biodiesel is considered as one of the promising alternative resources for diesel engines especially from non-edible oil feedstock. In addition, biodiesels have a great potential to be a part of a sustainable energy mix in the future [4–6].

For a sustainable future of the planet, it is essential to look into renewable energy sources which implicitly include sustainable fuel sources. Biodiesel, an alternative fuel to petrodiesel is renewable, biodegradable, technically feasible, economically competitive, environmental friendly, non-toxic, portable, eco-friendly fuel and easily available [3,4,6–12]. It (fatty acid methyl esters) is derived from vegetable oils as well as animal fats through the esterification and transesterification reactions of free fatty acids (FFAs) and triglycerides, respectively, that occur naturally in renewable biological sources [3,13,14]. In other words, biodiesel can be defined as a mixture of alkyl esters of long chain fatty acids, which is synthesised through esterification and transesterification of free fatty acids (FFAs) and triglycerides (TG) [14–17]. It can offer a lot of benefits, including reduction of greenhouse gas emissions, regional development and social structure especially to developing countries [18]. In addition, biodiesel methyl esters improve the lubrication properties of the diesel fuel blend. It is a good lubricant which is about 66% better than petrodiesel [3,19]. Based on the overall life cycle analysis, biodiesel is shown to be sustainable. However, the higher cost of production of biodiesel than petroleum diesel is the main drawback for the commercialization of biodiesel [4].

Lin et al. [20] pointed out the three key driving forces and challenges to develop biodiesel industry such as (i) biodiesel fuel will play a more important role in strengthening the nation's energy security with the global energy crisis approaching; (ii) as a renewable energy biodiesel can contribute to the reduction of greenhouse-gas (GHG) emissions significantly when replacing fossil oil; (iii) the increased demand for oil crops for biodiesel production clearly has a positive impact on net farm income and reduces the government outlays to farmers by rising the market price of oil crops. However, with the global increase in the scale of biodiesel production, biodiesel has become a methodical risk with respect to its economic, ecological, and socio-political impacts. It is reported that opportunities, challenges and even threats have been raised. Especially, those linked to the 1st generation biodiesel have also received considerable criticisms recently, most notably the biodiesel potential to increase food prices and damage biodiversity; their continuing need for significant government support and subsides; and greenhouse gas emissions [20–22]. While the biodiesel industry is being established in many parts of the world, it has also been hit by the current global economic crisis. In order to overcome the adversities of the economic background, it is critical for the biodiesel industry to continuously improve on aspects that will strengthen the prospects of better market penetration [13]. Janaun and Ellis [13] and Lin et al. [20] highlighted the important aspects of biodiesel which revealed the prospect as the next generation green fuel, such as: (i) cost and environmental impact of conversion process; (ii) key drivers and challenges of biodiesel industry development; (iii) efforts towards environmentally benign and cleaner emissions; (iv) diversification of products derived from biodiesel glycerol; and (v) policy and government incentives.

There are numerous pieces of research that have been published recently focusing on the specific issues related to production process [23–25], feedstock [16,24,26], and social, economy and policy [27–29]. However, in this paper, emphasis is given on the prospects of the 2nd generation biodiesel as a sustainable fuel.

The aims of this paper are to identify the appropriate and cost-effective feedstocks, the most suitable oil extraction technique and the most efficient technology for producing 2nd generation biodiesel which will substitute the current dependence on the fossil fuel worldwide.

2. Why 2nd generation biodiesel?

The biodiesels usually produced from edible oil resources, such as soybeans, palm oil, sunflower, safflower, rapeseed, coconut and peanut are considered as the first generation biodiesel feedstock.

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