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Algal Biodiesel in Lithuania: from Promise to Reality

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Abstract

The search for alternative fuel sources of organic origin, their adaptation and promotion emerged as one of the key focus areas worldwide, which could bring positive effect on lowering down the fossil fuel prices and solving the environmental problems. Algal biodiesel intended for use in the vehicles is among the solutions for the transport sector. In this article, we made an overview of biodiesel investigation in Lithuania over 11 years. Algae are the third generation biofuel form with high production perspective. This microorganism can be found almost everywhere even in Arctic. Algae can be counted as 55 000 species organism with great number of growth and quantities of biomass per unit. Possibilities and challenges of biodiesel from algae in Lithuania have been analysed. Application and compatibility of algae biodiesel in internal combustion engine has been investigated. Many advantages of biodiesel have been presented as well as some disadvantages were found.

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Keywords: algae; biodiesel; renewables; internal combustion engines.

1. Introduction

Nowadays usage of biodiesel from algae is not available commercially. But situation may change during years of 2020–2025 when algae fuel systems will be implemented. Biodiesel from algae has high potential to displace petroleum fuel in transport sector due to inexhaustible resources, while petroleum reserves are running out irreversible until will be depleted. Petroleum may be depleted in about 50 years. Only European countries consume approximately fourth of the petroleum globally per year. Fast developing countries such as China and India increase

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the volume of petroleum consumption dramatically. Since petroleum consumption has been increased, European Union authorities started supervision of pollution and climate change control more frequently. EU authorities are interested in clean energy on purpose to reduce greenhouse gas emission from the transport sector. Development of hybrid cars or green cars with alternative fuel becoming independent of fossil fuel usage would be one step forward. In that case pollutants will be reduced dramatically changing fossil fuel to hydrogen, biofuel and electricity. Lower environmental pollution and higher economic efficiency are probably the biggest advantages of alternatives fuel to diesel. EUROPE 2020 strategy, that has set out the guidelines of alternative fuels application, promotes increase in use of biodiesel in transport (Europe 2020).

2. Alternative biodiesel fuels under investigation in Lithuania during 2003–2014

Since the year 2000, transportation biofuel-related R&D efforts in Lithuania have focused on (Europe 2020) the preparation of national biodiesel introduction recommendations by acting in a coordinated way at EU level, (Raslavičius et al. 2014) biodiesel usage in internal combustion engines are important due to the dependency on fossil fuel which must be reduced, thus research of traditional crops based biofuels and their blends, physico-chemical properties and exploitation characteristics must be analyzed. New species of crops becoming more interesting for advanced biofuels (Lebedevas et al. 2010). Leading Lithuanian universities and institutes were involved in EU-funded collaborative research (Table 1, 2), some on a large scale (Raslavičius et al. 2014).

Table 1. Alternative biodiesel fuels under investigation in Lithuania during 2003–2009.

Investigated blend ratio	Scientific activity	Year						
		2003	2004	2005	2006	2007	2008	2009
Algae biodiesel: RME (B100); REE (B100); FAME; Camelina oil methyl ester; B5; B10; B20; B30; B50; B70	Chemical composition; Life cycle assessment		(Janulis *et al.* 2004)	(Janulis *et al.* 2005)	(Lapinskienė *et al.* 2006)			(Matijošius *et al.* 2009)
	Combustion theory and modeling; Engine bench tests	(Makarevičienė *et al.* 2013)			(Labeckas *et al.* 2006), (Janulis *et al.* 2006), (Lebedevas *et al.* 2006)	(Raslavičius *et al.* 2007), (Lebedevas *et al.* 2007)	(Lingaitis *et al.* 2008)	
	On-field tests	(Kraujalis *et al.* 2003)		(Kraujalis *et al.* 2005)				(Raslavičius *et al.* 2009)
	Policy; Reviews and outlooks					(Katinas *et al.* 2007)		

Biofuel sector with the help of R&D, concentrates on biotechnology, engineering and environmental studies studying combustible liquid fuels from renewable sources using biotechnological methods. Also it concerns on culture yields grow. In a few past years one of the rapidldy growing economy sector in Lithuania became industrial biotechnology (Raslavičius et al. 2014). Communication between business, science and the State is led by the Lithuanian Biotechnology Association which was established in 1995. In 2006, the establishment of the LT National Biotechnology Platform (LNBP) has enhanced these collaborations. There are a number of universities and research institutes which focus on specific objectives using modern biotechnological investigations related to industrial biotechnology and bioprocessing: Kaunas University of Technology, Vilnius Gediminas Technical University, Institute of Biochemistry at Vilnius University, Institute of Biotechnology at Vilnius University, Aleksandras Stulginskis University, Lithuanian Institute of Horticulture, Lithuanian Institute of Agriculture, Lithuanian Institute of Chemistry, and others (Raslavičius et al. 2014).

Table 2. Alternative biodiesel fuels under investigation in Lithuania during 2010–2014.

Investigated blend ratio	Scientific activity	Year				
		2010	2011	2012	2013	2014
Algae biodiesel: RME (B100); REE (B100); FAME; Camelina oil methyl ester; B5; B10; B20; B30; B50; B70	Chemical composition; Life cycle assessment		(Makarevičienė *et al.* 2011)	(Makarevičienė *et al.* 2012)	(Makarevičienė *et al.* 2013)	(Raslavičius *et al.* 2013), (Raslavičius *et al.* 2014)
	Combustion theory and modeling; Engine bench tests	(Lebedevas *et al.* 2010), (Raslavičius *et al.* 2010)	(Lebedevas *et al.* 2011), (Raslavičius *et al.* 2011)			(Žaglinskis *et al.* 2014), (Makarevičienė *et al.* 2014)
	On-field tests					
	Policy; Reviews and outlooks	(Markevičius *et al.* 2010)	(Štreimikienė *et al.* 2011), (Colvile *et al.* 2001)		(Makarevičienė *et al.* 2013)	(Raslavičius *et al.* 2013), (Raslavičius *et al.* 2014)

3. The promise and challenges of algae

Manufacturers of biodiesel fuel from algae have been developed refineries with complete infrastructure for biomass from algae. Nevertheless, only a certain portion of technical potential can be fulfilled. However technical potential may change over time, because at the moment it is just estimation. Development of the technical potential is visible over time due to the new technologies. Later, algal biofuel may be used much wider, but it highly depends on fossil fuel price. In the future perspective price of fossil fuel should grow rapidly, what gives more benefits for algal biofuel. In other hand, future perspectives are hard to predict (Raslavičius et al. 2014).

In favourable conditions, algae grow very quickly and accumulate up to 50 percent of oil of their total weight (Raslavičius et al. 2014). Thousands species of algae could be found all over the world even in Antarctica in various size, from microscopic to the 60 m length. Usually algae lives in water, but snow in certain cases is a good medium to live. Hence, nature sufficiently endowed algae with special vital forces. The majority of them may breed twice if they live in favourable for that conditions (Raslavičius et al. 2014). The world Algae Base includes about 55 000 species of marine, brackish, fresh water and terrestrial algal species; the list is not exhaustive it is supplemented continuously with new species. Some scientists have opinion that it is possible to collect 100 tons of algae biomass from one hectare in one year. Accordingly, the essence lies in the process of photosynthesis and the function of the photosynthetic apparatus (the purpose of which is to absorb light energy and transform it to chemical energy with the help of chlorophyll molecules and pigments) of the different types of algae (Raslavičius et al. 2014). The colour of cells depends on composition of the pigments and their quantitative ratio. Cytokinesis – process by which a parent cell divides into two or more daughter cells – is an important cell cycle of monocellular or multicellular organisms (algae) (Raslavičius et al. 2014).

The main condition of algae usage is high level of biomass content, which gives economic benefit. The most widely used indicator of algae biomass is phytoplankton chlorophyll *a* concentration, which is very important in research of limnological. Investigating limnological important data can be found which is useful for further research: identification of algae biomass on a weight or volume basis, in the form of photosynthesis performance index (Raslavičius et al. 2014).

4. Application on algal biodiesel in internal combustion engines

Fuel which is produced from biomass does not contribute to CO_2 atmospheric emissions. Biodiesel has lower amount of pollutants during and after combustion process. Engine lifetime can be improved due to the biodiesel viscosity which is twice higher than petroleum diesel (Campbell et al. 2008). In the other hand high level of viscosity may have some difficulties with fuel pumping. Biodiesel is in liquid shape with high combustion

efficiency due to the oxygen. It has approximately 10–11% of oxygen. It also has lower content of sulfur and aromatic compared to petrol diesel. Higher cetane number is an advantage; biodiesel may have cetane number which is around 60–65 while petrol diesel has approximately 53. Reduction of carbon dioxide emissions by 78% can be obtained, as well as soot reduction. Biodiesel is non-toxic and non-flammable type of fuel. Important, that there is no sulfur or aromatic content in biodiesel. Reduction of particular matter can be achieved as well (Gulab et al. 2013). Biodiesel has great impact of unburned hydrocarbons reduction (Campbell et al. 2008). During combustion of biodiesel, reduction of total unburned hydrocarbons is over 90% (Gulab et al. 2012).

It also may have some disadvantages which shall be improved later if possible. High compression ratio in biodiesel engines is used which causes higher emissions of NO_x. Early start of combustion occurs due to the high content of oxygen in biodiesel. It creates relatively higher NO_2 approximately 10–14%. Small fraction of power loss is noticeable, but it may have impact of 2% only (Campbell et al. 2008). That power loss implements fuel consumption ratio, which may grow up to 10%, normally from 2% to 10% maximum. Biodiesel has excessive amount of carbon deposition which may occur gum formation (polymerization) (Gulab et al. 2013).

5. Conclusions

Synergies have the potential to offer an approach to bioenergy development that is both sustainable and beneficial (Raslavičius et al. 2014). For the 3rd and 4th generation biodiesel production, sustainable feedstock must be found taking into consideration of microalgae strains with lipid content. Usually, they contain proportionally high levels of lipids (over 30%) (Raslavičius et al. 2014). Algae cultivation can be achieved in a variety of environments. This paperwork demonstrates that algae biofuel production is one of the key elements with great prospects in the liquid biofuel sector. Algae biofuel contributed in structural changes for liquid biofuel sector having aspiration of achieving better economic returns and sustainability. Whereas the amount of fossil fuel is decreasing every year without ability to be renewable energy resource, biofuel is becoming more important due to the fact that is renewable resource which will be profitable in near future. Algal biofuel specifications and usage in internal combustion engine were analysed with advantages it may substitute petrol diesel without major loss. Some improvements for the diesel engine may be required due to the differences of both fuel characteristics and diesel engine adjustability. Study for analysing algae biodiesel disadvantages has to be involved. Major breakthroughs are indeed necessary towards design and development of advanced technologies able to increase product yields and at the same time to decrease processing costs (Raslavičius et al. 2014).

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