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## DEVELOPMENT AND VALIDATION OF MICROWAVE TECHNOLOGICAL METHODOLOGY FOR BIODIESEL PRODUCTION

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**Abstract:** Impact of energy sector on the climate change and creating the conditions for energy independence are serious challenges for society. His Holiness Pope Francis proclaims: "I ask you to ensure that humanity is served by wealth and not ruled by it!" Every step is top priority and welcomed for society that aims to encourage the security of energy-supply and to form a viable social model in sustainable way. That is why the energy is a key element for development in the European Union, so it is needed to research cost-effective producing ways of potential energy sources taking into consideration the energy and environmental aspects, as well as the sustainable requirements. This paper attempts to overview and emphasize the common role of adaptive agriculture and research leading to technological developments in an innovation-driven economy through the microwave assisted biodiesel production. In biodiesel producing technology during the transesterification process the application of the microwave energy transfer and its effects increase the efficiency. So we can contribute to realize the objectives of "Societal Challenges" topic area (such as making the local resources and the energy consumption models more sustainable, widespread utilization of energy-efficient technological developments etc.) of Horizon 2020 the EU Framework Programme for Research and Innovation.

**Keywords:** environmental aspects, microwave energy transfer, energy-supply, biodiesel production

### 1. INTRODUCTION

It can be read that *"The purpose is to create a manifold agriculture, environmental and land management, which can produce . . . , and local energy while preserving soils, drinking water resources, wildlife and our natural resources and values."* between the government objectives in the National Cooperation Programme published in 2010 [1].

However, the energy as a topic area is listed among the most important action fields of the National Council for Sustainable Development, because the European industry, transport, buildings, energy sources and energy consumption models of cities are typically not sustainable. The National Sustainable Development Strategy 2007 document draws attention (as designating a research direction) to change this: *"It is needed to encourage research and technological development in key areas such as energy resources of the future, or the materials and energy-efficient production processes." This document confirms and strengthens the importance of R&D activity of biofuels.*" [2]

However, the management of anomalies of energy supply and to access the "scarce goods" (including energy) want interdisciplinary thinking method and change in attitude. *Objective of our research supported by the National Excellence Programme is to define the framework conditions of this thinking method. The topic of this research is to develop and validate microwave assisted transesterification method of vegetable oils under laboratory circumstances.* Because in the future biodiesel will be significant as a part of sustainable energy mix in the transport sector [3].

According to the International Energy Agency the fastest and the cheapest way to solve the energy security problems, environmental protection and economical challenges is to increase energy efficiency. So the International Energy Agency has developed an energy efficiency proposal system (25 proposals) for focused areas such as transport. Energy efficiency and efficiency changes can be measured and modelled by energy indicators [4]. This is confirmed by Horizon 2020 work programme which is one of the fundamental priorities of Europe 2020 strategy – a strategy which aims to increase the global competitiveness of the continent – called "Innovative Union" flagship. Basic objectives of societal challenges priority are to help ensure implementation of smart, efficient and environmentally responsible technologies, to develop next generation technologies for biofuels and to build reliable, sustainable and competitive energy system (through energy innovation), furthermore, to support an intelligent,

environmental friendly and integrated transport sector in the area of “Secure, clean and efficient energy” topics [5]. In essence, then, it is needed to bring economical, ecological and social goals in harmony by new knowledge and technologies.

For this reason, we should deal with the non-sustainable use of fossil fuels and the enhanced utilization of renewable energy from agriculture, in addition to the production and utilization of biofuels. Furthermore, what are whether agricultural, environmental and social impacts and what are challenges for adaptive agriculture and the rural area, for the environment, as well as legislators in both domestic and EU level. As a motivating factor that the importance of interdisciplinary collaboration came to the fore and increased after EU accession of Hungary (to comply with EU directives and guidelines) especially in the context of sustainable energy. Satisfied our needs not in a sustainable way, in fact, we approach the limits of the system [6] [7].

Today, actuality of sustainability and sustainable survival is determining not only through the provision of security of energy supply and protecting the environment, but also societal well-being. It emphasizes the importance of research [8].

The excessive use of resources – including energy sources, such as “scarce goods” – deprives the developed societies of the possibility of the use of resources and multi-component global changes are induced by it.

## 2. MICROWAVE ASSISTED BIODIESEL PRODUCTION AT UNIVERSITY OF SZEGED, FACULTY OF ENGINEERING

The University of Szeged, Faculty of Engineering's mission is to serve wide sector of society with its research topics. The Faculty has diverse research areas, but is committed to energy research topics, such as the analysis of vegetable oils (rapeseed oil, sunflower oil), and the microwave electromagnetic field interactions. This research topic is in harmony with the national and European research, development and innovation strategies.

The microwave assisted biodiesel production was carried out by experimentally determined operational and process parameters [9]. The microwave treatment is most effective energetically when low flow rate, low power of magnetron and small numbers of treatments are used [10]. Figure 1 shows the sub-tasks during the experiments. To be noted, that primarily direct energy crops (grown in worse soil) or agricultural wastes and by-products should be used for energy production which is not suitable for food or feed production, or production is not economical.

80-85% of the soils of Hungary are suitable for agricultural cultivation, so the soil is considered extremely important resource [11].

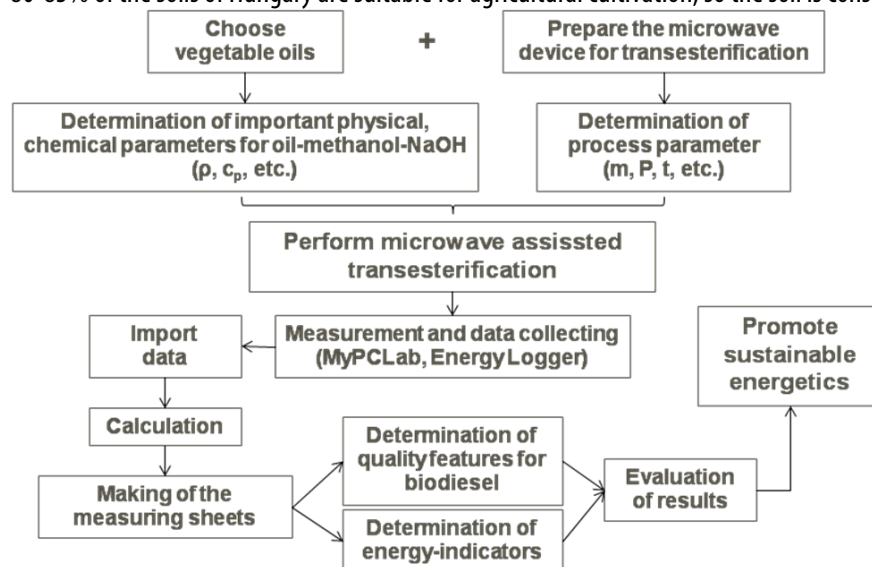


Figure 1. Methodology of microwave assisted transesterification



Figure 2. Biodiesel

The result of the transesterification process can be studied visually: Figure 2 shows the stratification. The upper lighter layer (80-90%) is biodiesel, the lower dark layer (10-20%) is the mixture of glycerol, catalyst and alcohol, while the middle milky-like layer is the soap.

We could control the quality of biodiesel by comparative measurement during the experiments. The Table 1 contains the main properties of biodiesel. Selection criteria of the parameters is the utilization as fuel in internal combustion engine, in addition to the pH value (the pH value of high quality biodiesel is about 7.5).

Conclusions come from the evaluation of experimental results, provide reliable background information for societal challenges, as well as it is needed to improve efficient technologies and to ensure their implementation, in addition to individual and national conscious behaviour.

However, in the course of evaluation of the results it should be taken into account that the research is basically part of the Multidisciplinary agricultural research field, but it is related to other disciplines such as environmental sciences, environmental risks, waste management, furthermore some social sciences such as environmental economics, environmental law, energy law

based on energy policy and environmental policy ideas and guidelines. Consequently, linking of some disciplines and revealing, analyzing of their relationship give useful results for the practice.

Main combustion parameters of rapeseed and sunflower oil indicate that the application of microwave heat transfer can be preferred to produce fuel, so the microwave field provide adequate conditions for advanced production technology not only in laboratory circumstances, because the microwave assisted transesterification is an energy efficient and fast process. From energetically point of view the pre-treatments applying lower power intensity with higher flow rate can be considered more beneficial.

**Table 1.** Combustion parameters of different fuels

Fuel	Density 15 °C [kg·l <sup>-1</sup> ]	Heat value [MJ·kg <sup>-1</sup> ]	Viscosity 40 °C [mm <sup>2</sup> ·s <sup>-1</sup> ]	Cetane number [-]	Iodine number [g/100g]	Flash point (open-cup method) [°C]
diesel fuel	0.81-0.85	40.6-44.4	2-4.5	> 51	-	> 55
rapeseed oil	0.92	37.6	35.4	-	113	289
sunflower oil	0.93	37.1	32.9	-	119	293
Biodiesel (rapeseed)	0.88	37.2	3.4	56	112	198
biodiesel (sunflower)	0.89	36.9	3.6	53	115	204

Note: MSZ EN 590 and data sheet of MOL (Hungarian Oil Company) contain the features of Diesel fuel.

University of Szeged, Faculty of Engineering contributes to the enhancement of energy efficiency through the validation of microwave assisted transesterification technology under laboratory circumstances as the elaborating of elements of conventional and smart energy systems.

### 3. CONCLUSIONS

In summary, it can be said that use of the renewable energy sources – including the biodiesel – will not solve our every energy, environmental pollution and societal problem, but is certainly promotes an environmentally friendly and sustainable energy economy, as well as a balanced agriculture. The cooperation and the responsible thinking can be common interests in conservation of circumstances of life for a long time: to realize symbiosis between fossil and renewable energies but this needs to improve the production technologies continuously.

The microwave assisted biodiesel production can be considered a cost and energy efficient technological application. Widespread use of energy efficient applications can be a cost-effective method to reduce energy demand and thus can increase the security of energy supply, can reduce the impact on the environment, as well as moderate the social challenges. The microwave assisted biodiesel production also proves the reason for the existence of energy innovation and it can be found that in the future biodiesel – produced by efficient technologies – will be significant as a part of sustainable energy mix in the transport sector in Hungary as well.

The direction of further research may be to work out the basic requirements of sustainable energetics focusing on the treatment of organic wastes from agriculture. It is also desirable to determine necessary and sufficient conditions for the sustainable farming in order to minimize risks. In addition, it is necessary to prove the importance of assessment of present in contrast with future taking sustainable use into consideration. The right direction should be marked out together with ecological economists (through the objective assessment of the opportunities and challenges).

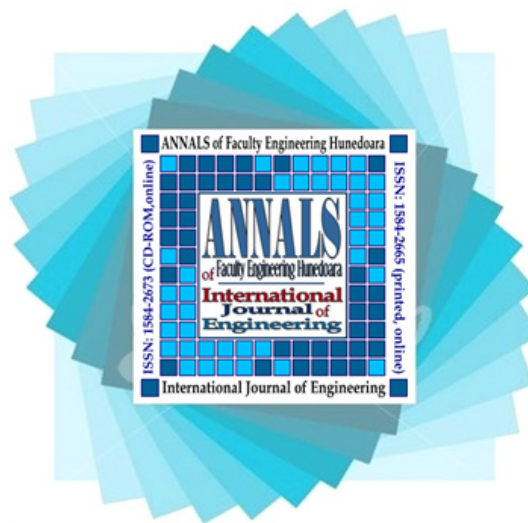
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