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# ELECTRICITY PRODUCTION FROM WASTE ENGINE OIL FROM AGRICULTURAL MACHINERY

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***Abstract***

As fuel for fuel cells can be used various substances, but generally fuel cells are powered by hydrogen. However, problems with the storage of hydrogen are the reason for the search of new fuels for fuel cells. Moreover, annually are produced huge amount of waste oils. These oils must be directed to purification and processing. It would be important to use waste engine oil as fuel for fuel cell to direct electricity production without intermediate stage e.g. combustion. The paper presents the possibility of using waste engine oil as fuel for fuel cell. The oil does not have the feature of electrical conductivity, for this reason a detergent was used for dissolving oil in an electrolyte. So, the work shows possible electrooxidation of waste engine oil (Turdus 15W40 from agriculture machinery) emulsion on a platinum electrode in an aqueous solution of $H_2SO_4$. Researches were done by the method of polarizing curves of electrooxidation of waste engine oil emulsion in glass vessel, on a smooth platinum electrode with potentiostat. In any case, the process of electrooxidation of waste engine oil emulsion occurred. A current density of about 6-20 mA/cm$^2$ was obtained for all concentrations of waste engine oil. The highest results of the potential were obtained at temperature of 333K (25 mA/cm$^2$). A fundamental possibility of electrooxidation of waste engine oil (Turdus 15W40) emulsion on platinum smooth electrode in acid electrolyte (aqueous solution of $H_2SO_4$) was presented in this paper. The obtained current density and

power of glass fuel cell is low, but it was demonstrated a fundamental possibility of electricity production in fuel cell powering with waste engine oil.

**Keywords:** fuel cell, waste engine oil, energy source, electrooxidation, renewable energy sources, environment engineering

## INTRODUCTION

With the increase of the standard of living production of wastes and wastewater increases very much. One of these wastes are waste engine oils. These oils must be directed to purification and processing. So, the solutions that will allow additionally recover the energy (e.g. in agricultural farm area) from the waste engine oil before it processing is very important. One of solution that will allow using waste engine oil to direct electricity production is a fuel cell (FC). The real efficiency of fuel cells is very high (up to 80%) and in addition, zero or low negative influence on the environment and quiet operation is what characterizes the fuel cells (Hoogers, 2003; Larminie & Dicks, 2003; O'Hayre at al., 2005; Stolten, 2010; Vielstich, 1965; Vielstich at al., 2003). Using the fuel cell to direct electricity production from waste engine oils is very interest solution. Most of waste engine oils come from agricultural machinery. It is important to using waste these oils to direct electricity production. So, it is also important to search waste from agricultural areas which will allow using their as fuel for high efficiency energy source like FCs. The search of new catalysts for FCs is also very important to lower costs of electrodes production; but first there is the need to evaluate a basic possibility of waste engine oil electrooxidation with reference (Pt) catalyst (Twigg, 1989; Bockris & Reddy, 2000). The paper presents the electrooxidation of waste engine oils come from agricultural machinery with Pt catalyst in acid electrolyte ($H_2SO_4$) in various temperatures, and various concentration of oil. So, the paper presents the possibility of direct use of waste engine oils come from agricultural machinery as the fuel for low temperature acid fuel cells.

## MATERIAL AND METHODS

Waste engine oil from agricultural machinery (Turdus 15W40) was used as the fuel in measurements. Oil was first pre-cleaned in automotive oil filter. Filtration enables to get rid of solid contaminants. In the case of waste oils is difficult to determine the initial parameters of these oils. This situation results from the fact that it is difficult to define engine oil refills (often oils with different viscosity classes), exploitation mode of engine, cold running time of engine and other.

Engine oil is a hydrophobic substance and does not conduct the electric current. In the case of using any fuel as the fuel for a fuel cell, conducting the electric current is important (Bockris & Reddy, 2000). To cause the conduction there was used an intermediate agent to solve waste engine oil in water. Syntanol DS-10 it was used as a detergent (Włodarczyk & Włodarczyk, 2013; Włodarczyk & Włodarczyk, 2015a; Włodarczyk & Włodarczyk, 2015b; Włodarczyk & Włodarczyk, 2016a; Włodarczyk & Włodarczyk, 2016b; Włodarczyk & Włodarczyk, 2016c; Włodarczyk & Włodarczyk, 2016d; Włodarczyk & Włodarczyk, 2016e, Włodarczyk & Włodarczyk, 2017). Syntanol DS-10 was used due to excellent emulsification properties (Sakharov at al., 1975). DS-10 is characterized by high superficial activity, dispersion, emulgation and solubilisation capabilities (Survila at al., 2005; Paraska & Karvan, 2010). Syntanol DS-10 can be degraded e.g. promoted by energy transfer reactions or by bacteria (Ignatov at al., 1995; Kravchenko at al., 1994). So, after electrooxidation of emulsion Syntanol DS-10 can be degraded in natural environment.

Emulsion of waste engine oil was obtained by mixing in various ratios of oil, detergent and water. Emulsion was obtained by mixing with using a mechanical stirrer with the speed of about 1200 rpm (Włodarczyk & Włodarczyk, 2013; Włodarczyk & Włodarczyk, 2015a; Włodarczyk & Włodarczyk, 2015b; Włodarczyk & Włodarczyk, 2016a; Włodarczyk & Włodarczyk, 2016b; Włodarczyk & Włodarczyk, 2016c; Włodarczyk & Włodarczyk, 2016d; Włodarczyk & Włodarczyk, 2016e, Włodarczyk & Włodarczyk, 2017). Stabilization time of emulsion was about 2 hours.

Platinum was used as a catalyst of working electrode and saturated calomel electrode (SCE) was used as a reference electrode (Holtzer & Staronka, 2000). Platinum was chosen as catalyst due to excellent catalytic properties (Bockris & Reddy, 2000; Twigg, 1989). Measurements were done by the method of polarizing curves of electrooxidation of waste engine oil from agriculture machine in glass vessel, on a smooth platinum electrode in $H_2SO_4$ electrolyte. The scheme and view (figure 1) shows the research position for measurements of waste engine oil electrooxidation.

Researches on electrooxidation of the emulsion based on waste engine oil in acid electrolyte (aqueous solution of $H_2SO_4$) for various concentrations of oil in various temperatures (293-333K) were conducted. Electrochemical measurements were conducted in a glass cell with AMEL System 5000 potentiostat. The potentiostat was connected with computer to data recording.

Next there was built a prototype fuel cell powered by waste engine oil. Prototype fuel cell was built as glass cell with platinum anode and Ni-Co alloy as catalyst of cathode (Włodarczyk & Włodarczyk, 2015c). The electrodes were used in the mesh form with dimensions 4x1.5 cm. The cathode was immersed in aqueous solution of $H_2SO_4$ (catholyte). Nafion 117 was used as a proton exchange membrane (PEM). Thickness of PEM was equal 183 μm. PEM separates

the anode and cathode area. The cathode during working was aerated. So, it is necessary to separate aerated and non-aerated area. The perforated ABS material was used as PEM cover (printed on 3D printer) (Włodarczyk & Włodarczyk, 2016e). Figure 2 shows the view of fuel cell powering of waste engine oil emulsion. Fuel cell was built as glass vessel with platinum anode and Ni-Co cathode in ABS cover with $H_2SO_4$ catholyte.

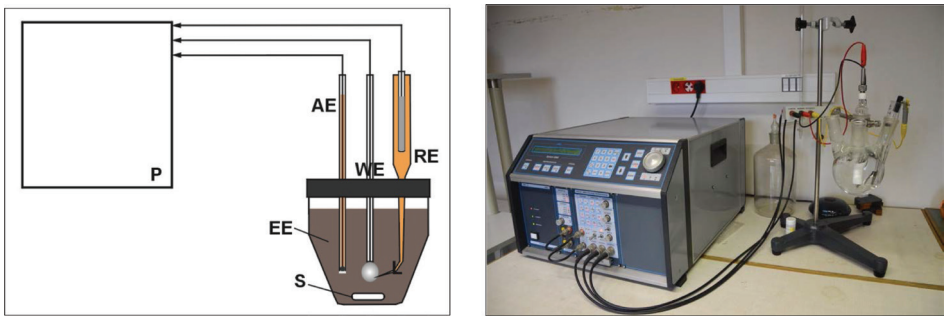


**Figure 1.** Scheme and view of research position for waste engine oil from agriculture machine electrooxidation [own compilation]: P – potentiostat (AMEL System 5000), WE – working electrode (Pt smooth electrode), AE – auxiliary electrode, RE – reference electrode (SCE), EE – electrolyte with waste engine oil emulsion, L – Luggin capillary, S – stirrer

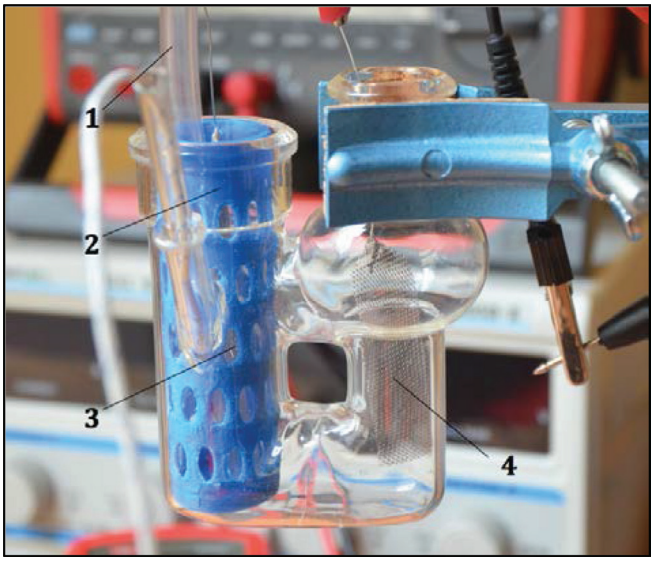


**Figure 2.** View of prototype fuel cell powering of waste engine oil emulsion [own compilation] 1 – influent of air, 2 – membrane cover, 3 – anode, 4 – cathode

## RESULTS

There were carried measurements on waste engine oil (from agriculture machinery) emulsion electrooxidation. Figures 3-5 show the polarization curves of electrooxidation in various concentration of oil. The electrooxidation was carried out at temperature of 293-333K. Before electrooxidation of emulsion there were carried measurements only of Syntanol DS-10 electrooxidation in acid electrolyte ($H_2SO_4$), to assess whether the current density was formed from waste engine oil electrooxidation or only from detergent.

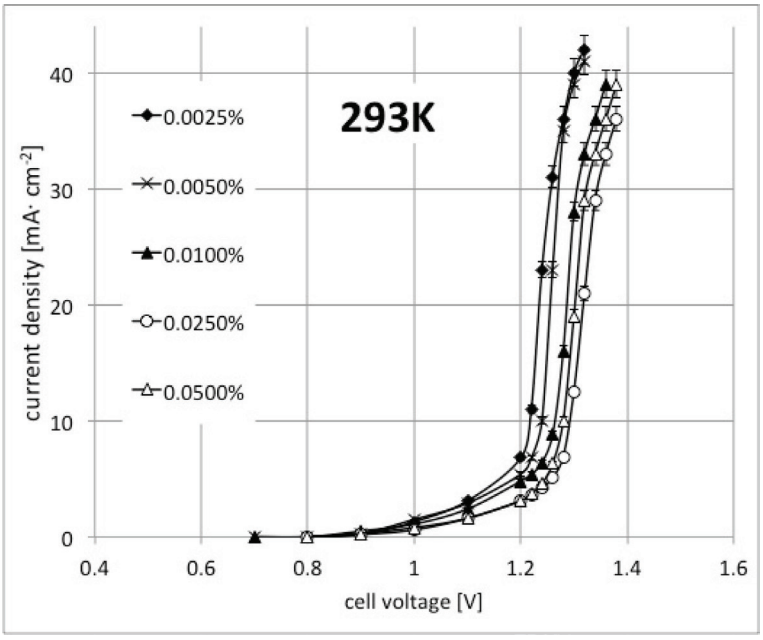


**Figure 3.** Polarization curves of waste engine oil (from agriculture machinery) emulsion electrooxidation in 0.1n concentration of electrolyte $H_2SO_4$ at temperature 293K; Concentration of waste engine oil was equal 0.0025%; 0.0050%; 0.0100%; 0.025% and 0.0500%

Figure 6 shows the power curve of glass fuel cell powering waste engine oil emulsion. The measurement was carried out at the temperature of 313K. The concentration of oil was equal 0.0025%.

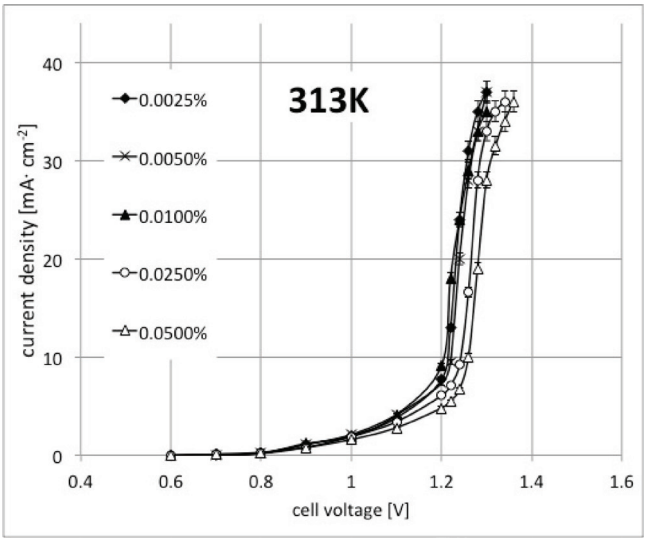


**Figure 4.** Polarization curves of waste engine oil (from agriculture machinery) emulsion electrooxidation in 0.1n concentration of electrolyte $H_2SO_4$ at temperature 313K; Concentration of waste engine oil was equal 0.0025%; 0.0050%; 0.0100%; 0.025% and 0.0500%

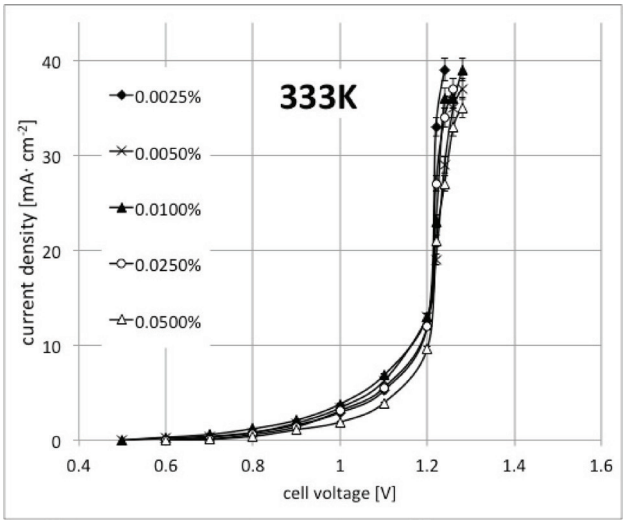


**Figure 5.** Polarization curves of waste engine oil (from agriculture machinery) emulsion electrooxidation in 0.1n concentration of electrolyte $H_2SO_4$ at temperature 333K; Concentration of waste engine oil was equal 0.0025%; 0.0050%; 0.0100%; 0.025% and 0.0500%

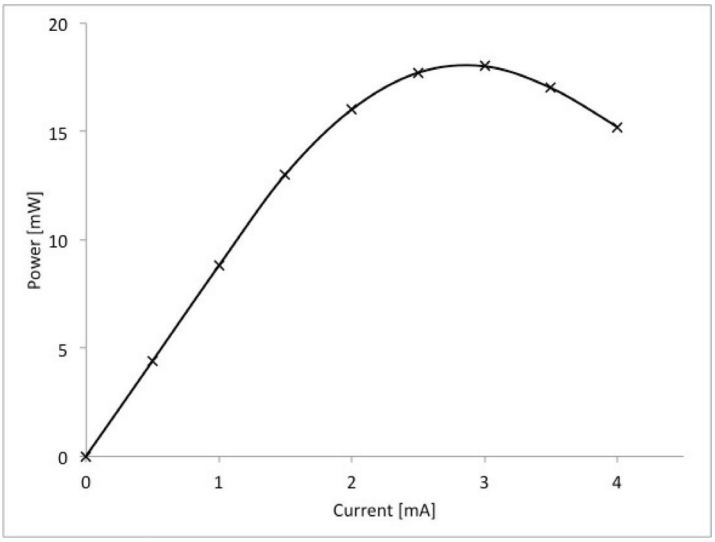


**Figure 6.** Power curve of glass fuel cell (fig. 2) powering waste engine oil emulsion

## CONCLUSIONS

In any case, the process of electrooxidation of waste engine oil (Turdus 15W40) emulsion occurred. A current density of about 6-20 mA/cm$^2$ was obtained for all concentrations of waste engine oil. With the increase in temperature to 333K the first electrooxidation of Syntanol DS-10 took place, and only then of waste engine oil. The highest results of the potential were obtained at temperature of 333K (25 mA from 1 cm$^2$ of smooth surface platinum electrode). The potential of the working electrode was establishing in time of about 29 minutes and was badly reproducible. Stationary, current-free real potential depends on waste engine oil concentration and is included in potentials range from 0.61-1.18 V. The glass fuel cell (fig. 2) was characterized by power of about 18 mW (fig. 6).

A fundamental possibility of electrooxidation of waste engine oil (Turdus 15W40) emulsion on platinum smooth electrode in acid electrolyte (aqueous solution of $H_2SO_4$) was presented in this paper. The obtained current density and power of glass fuel cell is low, but it was demonstrated a fundamental possibility of powering fuel cell with waste engine oil. Moreover, there was also demonstrated a possible construction of direct powering the fuel cell with waste engine oil. So, it is necessary to conduct research for increase of current density e.g. with another detergent, fuels or catalyst. The increase of current density will allow to power the fuel cells with waste oil from e.g. agricultural machinery engine. So, this solution will allow recover the energy (e.g. in agricultural farm

area) from the waste engine oil before it processing. The next research will cover what remains after electrooxidation of waste engine oil (Turdus 15W40) emulsion. And the next step of research (after analysis residue after electrooxidation process) will be how should treat these substances, for what process can these substances be used.

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