INTRODUCTION

Food industry is the driving force for the world economy. It is also the driving force of Polish economy. Unfortunately, the essential feature of food industry is a large amount of wastewater. An example of such wastewater is wastewater from yeast industry. Wastewater from this industry has not only a high pollutants load but it is produced in great amounts as well. Technical devices that can accomplish the wastewater treatment and electricity production from wastewater is a microbial fuel cell. In microbial fuel cells activated sludge bacteria can be used for electricity production during wastewater treatment. The possibility of using the Cu-B alloy as cathode catalyst for microbial fuel cells to wastewater treatment of wastewater from yeast industry is presented in this paper. The reduction time for COD with the use of microbial fuel cell with the Cu-B catalyst (with 5, 10 and 15% amount of B) is similar to the reduction time with aeration. The obtained power (4.1 mW) and the amount of energy (0.93 Wh) are low. But, if one can accept a longer COD reduction time, the obtained amount of energy will allow elimination of the energy needed for reactor aeration.

Keywords: microbial fuel cell, cathode, wastewater treatment, yeast industry, renewable energy sources, environment engineering

MICROBIAL FUEL CELL WITH CU-B CATHODE POWERING WITH WASTEWATER FROM YEAST PRODUCTION

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With the increasing standard of living, energy consumption increases as well. So, waste production, including wastewater, increases as well. One of the types of wastewater is wastewater from yeast industry. Wastewater from this industry has not only a high pollutants load but it is produced in great amounts as well. Technical devices that can accomplish the wastewater treatment and electricity production from wastewater is a microbial fuel cell. In microbial fuel cells activated sludge bacteria can be used for electricity production during wastewater treatment. The possibility of using the Cu-B alloy as cathode catalyst for microbial fuel cells to wastewater treatment of wastewater from yeast industry is presented in this paper. The reduction time for COD with the use of microbial fuel cell with the Cu-B catalyst (with 5, 10 and 15% amount of B) is similar to the reduction time with aeration. The obtained power (4.1 mW) and the amount of energy (0.93 Wh) are low. But, if one can accept a longer COD reduction time, the obtained amount of energy will allow elimination of the energy needed for reactor aeration.

ABSTRACT

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INTRODUCTION

Food industry is the driving force for the world economy. It is also the driving force of Polish economy. Unfortunately, the essential feature of food industry is a large amount of wastewater. An example of such wastewater is wastewater from yeast industry. Wastewater from the yeast industry has not only a high pollutants load but it is produced in great amounts as well. The main technology components of polluting effluents are: nitrogen, potassium, total suspension, COD and BOD. Such wastewater is mainly supplied to the agricultural fields (AF) [Kutera 1986]. Those fields utilize the wastewater in the plant-soil environment [Brendecke et al. 1993, Kobya and Delipinar 2008, Thornton 2001, Zub et al. 2008]. For wastewater treatment are used also another methods [Nowak et al. 2013, Pluciennik-Koropczuk et al. 2013]. Most of them are suitable for transformation into raw materials for other technologies. This way we can reduce their negative impact on the environment and use them as a new source of raw materials. However, part of wastewater from yeast industry is sent to the treatment plant. These wastewater can be used to electricity production before final cleaning in treatment plant. Technical device that can accomplish this task is a microbial fuel cell (MFC) [Logan 2008]. Moreover, MFCs allow simultaneously wastewater treatment. In MFC activated sludge bacteria can be used for electricity production during wastewater treatment [Rabaey and Verstraete 2005, Logan et al. 2006]. The concept of MFC was created the 1960’s [Davis and Yarbrough 1962, Logan 2008]. Bacteria that were identified as capable of creating electricity in fuel cells include a wealth of genera of bacteria e.g. Geobacter, Shewanella or Pseudomonas [Bond and Lovley 2003, Chaudhuri and Lovley 2003, Kim et al. 2002, Park et al. 2001, Pham et al. 2003]. So, activated sludge is capable of producing electrons e⁻ and H⁺ ions.
MFCs are bio-electrochemical systems that are devices that use bacteria as catalysts to oxidize organic and inorganic matter and generate current [Berk and Canfield 1964, Logan 2008]. Industrial wastewater (so, also from the yeast industry) is well suited for use in MFC [Angenent at al. 2004, Verstraete at al. 2005].

In MFC a catalyst of anode are microbes. So, it is important to find a catalyst for cathode. In MFCs carbon is most often used as the cathode catalyst. It is also possible to use metal catalysts for cathode of MFCs [Dumas at al. 2006, Martin at al. 2011]. Theoretical current density is described by the Butler-Volmer exponential function [Bockris and Reddy 2000]. Unfortunately, in real conditions the choice of catalyst is mainly carried out by experimental methods [Bockris and Reddy 2000, Twigg 1989]. For this reason experimental researches of search a new catalysts for MFCs are still conducted [Cheng at al. 2006, Dumas at al. 2006, Logan at al. 2006, Martin at al. 2011, Włodarczyk and Włodarczyk 2015a, Włodarczyk and Włodarczyk 2015b, Włodarczyk and Włodarczyk 2015c, Włodarczyk and Włodarczyk 2016a, Włodarczyk and Włodarczyk 2016b, Włodarczyk and Włodarczyk 2016c, Włodarczyk and Włodarczyk 2016d, Włodarczyk and Włodarczyk 2016e, Włodarczyk and Włodarczyk 2017]. The authors have attempted to demonstrate the possibilities of wastewater from yeast industry treatment using the Cu-B alloy as cathode catalyst for MFC.

MATERIAL AND METHODS

The wastewater from yeast factory (Lesaffre Polska S.A.) was used in measurements. The main stream is directed to agricultural fields as fertilizer, but part of this wastewater is directed to biological treatment plant. The wastewater from factory’s biological treatment plant was used in measurements.

The alloys were deposited from a mixture mainly of NaBH₄ (0.02 mol/l), CuSO₄·7H₂O (0.05 mol/l), NaOH (1.00 mol/l) and Trilon B (0.12 mol/l) [Włodarczyk and Włodarczyk 2016f]. The alloys were obtained at temperature 365K. Cu-B alloy was obtained by the method of electrochemical deposition. The alloy was deposited on mesh copper. Before the deposition of the alloy, mesh copper electrode was degreased in 25% aqueous solution of KOH (after degreas-
Figure 1. Scheme of cathode
1 – ABS cover, 2 – PEM, 3 – cathode, 4 – aqueous solution of KOH, 5 – air supply, 6 – air bubbles

Figure 2. View of cathode during work
1 – ABS cover, 2 – PEM, 3 – air supply
Figure 3. Change of concentration of COD during municipal wastewater treatment without aeration, with aeration and with using a MFC (with Cu-B cathode) powering with wastewater from yeast industry. The colours indicate the trend lines of individual data.

Figure 4. Change of concentration of COD during municipal wastewater treatment without aeration, with aeration and with using a MFC (with Cu-B cathode) powering with wastewater from yeast industry. The colours indicate the trend lines of individual data.
Based on voltage and current the power curve was determined. Figure 5 shows power curve of MFC with Cu-B catalyst (5, 10, and 15% of B) powering with wastewater from yeast industry.

CONCLUSIONS

The measurements show that in any cases (without aeration, with aeration and with MFC) the reduction of COD was 90%. So, measurements have shown the effectiveness of COD reduction in any cases. The time for 90% effectiveness reduction of COD with the use of MFC (with Cu-B cathode) is similar to the reduction time with aeration. But, the characteristics of curves for MFC (with different amount of B) are different in any cases. So, for MFC different amount of B, the time of COD reduction is different. The high effectiveness of COD reduction for 10% amount of B was obtained. The characteristic curve of aeration is more preferred than characteristic curve of MFC (with Cu-B cathode) because about 80% effectiveness of COD reduction after about 4.5 days.

Figure 5. Power curve of MFC (powering with wastewater from yeast industry) with Cu-B catalyst (5, 10, and 15% of B).

Based on voltage and current have been determined current density and power curve. The power obtained during work of MFC with Cu-B cathode is equal 3.8–4.1 mW and average amount of energy for this MFC is equal 0.93 Wh. The high power obtained for Cu-B catalyst with 10% amount of B – 4.1 mW. So, the average current density and the amount of energy obtained in MFC are low. But, if one can accept a longer COD reduction time, the obtained amount of energy will allow elimination of the energy needed for reactor aeration. So, a fundamental possibility of using of Cu-B alloy as cathode catalyst of MFC for wastewater from yeast industry was obtained in this paper.

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