Comparative Analysis of Electrogenic Activity of Complex Microbial Preparations in Microbial Fuel Cells

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Abstract. The ability of a variety of commercial microbiological preparations for local wastewater purification and recycling of various solid waste to generate electricity in a microbial fuel cell for disposal of various products was investigated. The dynamics of transformation of substrates, and various changes in the environment settings anolyte and catholyte in the process of the microbial fuel cell was studied.

1. Introduction
Recycling of various wastes and wastewater components remains one of the main problems of today. The problem of finding new energy resources is becoming more acutely. A promising area in solving both issues is the use of biofuel cells. They allow you not only to purify waste water, but also to convert the chemical energy of their components directly into electrical energy [1, 2]. One of the barriers widespread use of microbial fuel cell (MFC) in practice is a limited number of strains of microorganisms suitable for use in the MFC [3]. The disadvantage of cultures of microorganisms already in use as the biological agents is a relatively narrow range of applicable substrates. Currently available a large number of commercial microbiological preparations for local wastewater purification, recycling of various solid waste, preparations for cesspools, etc. [4]. These consortia contain a large number of strains capable of using as substrates a wide range of materials under different conditions. In connection with the foregoing, the purpose of this report was to evaluate the possibility of using some commercial complex microbial preparations as biological agents to generate electricity in the MFC as well as search approaches to intensification of work MFC.

2. Materials and equipment
We used the model sample MFC made of Plexiglas [5, 6, 7, 8]. It consisted of two identical chambers of 370 ml. The cells were separated by a proton exchange membrane Nafion (USA, the thickness of 0.45 ± 0.025 mm, the exchange capacity of 1.6 ± 0.1 mEq / g, the electrical resistance of <30 Om / cm2). Medium that fills anode and cathode space is a model waste water prepared in accordance with
the GOST R 50595-93 and pre-sterilized by autoclaving. Electrodes for MFC made of electrically conducting carbon cloth ("SvetogorskKhimVolokno", Belarus) (Fig. 1).

Figure 1. Photo of the microbial fuel cell (MFC).

In the hermetic anode chamber were added investigated microbial preparations and substrates (peptone, glucose, sodium acetate, ammonia nitrogen, etc.). A cathode chamber by means of air bubbled laboratory microcompressors (Dezzie model D-044, air flow rate of 1.5 l / min). Registration of the current and voltage strength was performed using automatic data logging systems. The basis for it was the microprocessor board "Arduino Mega 2560".

As the biological agents in the MFC used commercial microbiological preparations:

1. The preparation "Vostok EM-1" (manufacturer: "Seaside EM-Centre», Vladivostok, Russia) - a concentrated culture of effective microorganisms. Initially, the preparation "Vostok EM-1" was in a stable inactive state designed for long-term storage. The basis of the concentrate composed three groups of microorganisms: photosynthetic bacteria, lactic acid bacteria and yeasts [3].

2. The preparation "Baikal EM-1" (Manufacturer: LLC "EM Co-operation", Russia) - microbiological fertilizer, contains lactic acid bacteria, photosynthetic bacteria, the bacteria that fix nitrogen, Saccharomyces, the culture fluid [9].

3. "Biem" (ST Dugarova D. C., Republic of Buryatia, Ulan-Ude) - microbiological agent for odor control and waste recycling. Composition: blend of microbial cultures, products of live activity of microorganisms, nutrient medium.

4. "Tamir" (LLC "EM Co-operation", Russia) - microbial preparation containing natural live microorganisms, metabolites, the culture fluid.

5. "Bioasenizator" (LLC "SPC " Biosynthesis ", Russia) - The bioactivator for processing the contents of cesspools, which contains the dry soil microorganisms, filler.

6. The preparation "Dr. Robic" for cesspools and septic tanks (LLC "VIPEKO", Russia). A strong composition of 4 specially selected microbial cultures. Culture soil, in the spore; able to utilize fat, protein, starch, cellulose, urea.

7. Biopreparation "Saneks" (CJS Company "K & K", Russia) - a mixture of enzymes and microorganisms. It accelerates the natural biological processes of waste decomposition. It destroys odors, waste products, including food waste, fats, starch, cellulose.

8. The preparation "Lucky" for toilets and cesspools (LLC RIE "Bashlnkom" Russian). Ingredients: bacteria spores that can release beneficial enzymes that break down the waste, filler.

Liquid preparations are introduced into the anode compartment MFC 20 ml of dry - 1 g
In the experiments recorded voltage, current, expected MFC power, as well as the measure concentrations of the substrates, the COC content of the anode space MFC. The findings made during the forecast probability of error-free $P > 0.95$.

3. Results and discussions

Studies have have shown perspectivity applications for electricity in microbial fuel cells a number of complex microbiological preparations: "Vostok EM-1," "Dr. Robic 109K", "Baikal EM-1", "Tamir", "BiEm", "Bioasenizator" "Lucky", "Saneks", "Ekstrasol". Particularly effective biological agents for use in the MFC were "Vostok EM-1," "Dr. Robic 109K", "Baikal EM-1" (Fig. 2).

![Figure 2. Voltage gain in MFC, containing different preparations (electrodes - carbon cloth).](Image)

In parallel with the study of the electrical characteristics of microbial fuel cells studied dynamic transformation substrates by microorganisms of complex preparations.

As carbon and energy source, particularly in research practice, for a wide range of microorganisms in microbial fuel cells using glucose [10, 11, 12]. In this paper also analyzed the dynamics of the transformation of glucose by microorganisms preparations "Dr. Robic 109K" and "Vostok EM-1" in microbial fuel cells.

Within one day of incubation the concentration of glucose in microbial fuel cells decreased slightly. Subsequent incubation degree transformation of the substrate is significantly increased. On day 3 the glucose content in microbial fuel cells with preparations decreased 15 times of the original. Therefore, preparations "Vostok EM-1" and "Dr. Robic 109K" intensively utilize glucose under MFC (Fig. 3).

![Figure 3. The dynamics of the glucose concentration in the anode chamber microbial fuel cell having a microorganisms preparations "Vostok EM-1" and "Dr. Robic 109K" (Medium - a model waste water, substrate - glucose 3 g/dm³, electrodes - carbon cloth).](Image)
In a series of experiments we evaluated the relationship between the rate of glucose transformation and its original content in the medium. Experiments showed that when adding a microbial fuel cells 0.1 - 0.2% of its glucose elimination occurs in the first 12 hours of incubation. Increasing the content of glucose in the medium to 0.3 - 0.4% led to an increase in the time of its transformation - up to 42 hours. After 52 h incubation at an initial concentration of glucose 0.5 g / l, it is no longer detectable in the solution (Fig. 4).

![Figure 4](image_url)

**Figure 4.** The dependence of the transformation rate of glucose from its original content in the microbial fuel cell (bioagent- the preparation "Dr. Robic 109K"; electrodes - carbon cloth).

Thus, a comparison of the data with the results of studying the electrical parameters of microbial fuel cells showed that electricity generation is accompanied by intensive elimination of the substrate.

One of the integral indicators of the wastewater purification quality is the index of the COD. Series COD measurements in MFC was confirmed by the use of complex microbial preparations for wastewater purification from organic substances with the simultaneous generation of electricity. As a control in these experiments we used the MFC inoculated with inactivated microorganisms of the preparation "Baikal EM-1".

At the initial moment COD was 634.2 mg O2 / dm3 after 25 hours - 595.4 mg O2 / dm3. At the same time, the control MFC containing preparation, inactivated by autoclaving, COD decrease of 25 hours is less than the statistical error experiment (Fig. 5).

![Figure 5](image_url)

**Figure 5.** COD content dynamics of microbial fuel cell anode compartment (native and autoclaved preparation «Baykal EM-1," medium – a model wastewater, substrate – peptone 0.5 g / dm³).
4. Conclusion
Studies have shown that the use of commercial microbial preparations "Vostok EM-1" and "Dr. Robic 109K" to generate electricity at the recycling of the various components wastewater into the MFC.

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Acknowledgments
The authors thank V. Ya Severina for providing preparation "Vostok EM-1", the company "SvetogorskKhimVolokno" (Belarus) for the carbon cloth. The authors are grateful to Krasavtseva M. S., Borohoev N. D. for their participation in the research. The work was supported by the Ministry of Education and Science of the Russian Federation (project RFMEFI58317X0060 «Bioremediation and bioconversion of waste with the help of complex photosynthetic organisms and heterotrophic in aerobic and anaerobic conditions with generating of bioenergy»). The studies were carried out using the equipment of the Center for Collective Use of Analytical Equipment of the Irkutsk State University.