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COMPARATIVE STUDIES ON ELECTRODES FOR THE CONSTRUCTION OF MICROBIAL FUEL CELL

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ABSTRACT:

The main objective of this paper is to study the performance of the various combinations of electrodes which plays an important role in the microbial fuel cells for the generation of electricity. The present work is an experimented investigation concerned with selection of the electrodes for the best performance of a microbial fuel cell. The various combinations of anode/cathode materials like copper, zinc, aluminum, carbon, stainless steel, mild steel for MFCs has been systematically studied and out of which Cu/Zn, Al/SS, C/C and SS/SS gave higher voltage output.

Keywords: Microbial fuel cell (MFC); Membranes; Mediators; cow dung; Electrodes.

[I] NTRODUCTION

A microbial fuel cell (MFC) is a device that uses microorganisms as the biocatalysts for the oxidation of the organic matter to generate electricity [1]. The electrodes used in the construction of microbial fuel cells should have a good electrical conductivity, more surface area, less resistance, and should be non-corrosive, biocompatible, chemically and mechanically stable to obtain a reproducible result. The anode materials such as graphite rod, graphite fiber brush, carbon cloth, carbon paper, carbon felt and RVC have been used in the microbial fuel cells [2]. The higher current was obtained when the platinum – coated graphite was used in the place of fresh graphite cathode. The distance between the electrode is also plays an important role the performance of the microbial fuel cell so the distance should be as close as possible to overcome the electrical leakage and to have a more internal resistance [3]. One of the critical challenges in microbial fuel cell is selecting proper electrodes (cathode and anode) which affect the power output [4]. The basic components of MFC include anode, cathode, ion exchange membrane and electrode catalyst. The anode materials such as stainless steel mesh, graphite plates, rods, granules, carbon felt, carbon paper, carbon cloth, carbon foam, glassy carbon,

Pt, Pt black, reticulated vitreous carbon; cathode materials such as graphite, carbon felt, carbon paper, carbon cloth, carbon form, glassy carbon, Pt, Pt black, reticulated vitreous carbon; ion exchange membranes includes cathode exchange membrabes (Nafion, Ultrex), salt bridge, anion exchange membrane and electrode catalyst includes Pt, Pt black, MnO_2, polyaniline, electron mediator immobilized on anode are used in MFC [5]. One of the limiting factors to use MFC is the high cost of materials which are used in the construction of MFC such as electrodes and proton exchange membrane which is nafion membrane so attempts are made to replace these costly membranes with the low cost earthen pots, cheaper stainless steel mesh as a cathode material and graphite plate as anode [6]. Microbial fuel cell is an ideal way of producing electricity as it uses renewable source as a substrate and treats the waste [7].

In this study various combinations of electrodes were used for the best perofmance of a microbial fuel cell using cowdung as a substrate, nylon as proton exchange membrane and methylene blue as a mediator.

[II] MATERIALS AND METHODS

2.1. Chemicals (reagents): Methyl red (PH range- 4.5-6.2, G D fine Chem limited); Ethanol(Assay-99.99%, ChangshuYangyuan Chemical, China); Zinc sulphate (Assay -99.0%, PH Range- 4-6,S D fine Chem limited); Copper sulphate (Assay ≥ 99%,M.W-249.68,Merck limited).

2.2. Substrate

The cow dung slurry was prepared by diluting the cow dung with distilled water in the ratio of 1:1(ratio optimized). The MFC was constructed using the cow dung slurry as the substrate. The electrodes used were zinc as anode and copper as cathode, the nylon membrane of area 25cm^2 of thickness 0.1 mm was used. The mediator used was methyl red of concentration 0.1gm/100ml. The voltage was recorded at the regular interval of 24 hours for 21 days.

2.3. Studies on electrode materials

The different metals used in our studies are Copper(Cu), aluminum(Al) ,stainless steel(SS), Zinc(Zn), Carbon(C),mild steel(MS).All the anodes and the cathodes used in set of 8 MFC system have the same surface area so that they will allow to grow the microbes or have capability to take same electrons.

Different combinations of anode and cathode electrode materials have been carried out and are shown below in the table.

electrodes		**Cu**	**Zn**	**Al**	**Ms**	**C**
Cu	Cu/Cu	Cu/Zn	Cu/Al	Cu/MS	Cu/C	Cu/SS
Zn		Zn/Zn	Zn/Al	Zn/MS	Zn/C	Zn/SS
Al			Al/Al	Al/MS	Al/C	Al/SS
Ms				MS/MS	MS/C	MS/SS
C					C/C	C/SS
SS						SS/SS

Table 1: Shows different combination of electrodes used in MFC

The electrode materials were collected and pretreated before constructing MFC. The electrodes selected should have same surface area. Pretreatment of electrode involves initially washing the electrodes with distilled water and later dipped in the ethanol for 10 mins, finally the electrodes were dried by keeping it in the hot air oven for 5 mins. Conducting wires were soldered on to the electrode surface using soldering gun. 21 combinations of electrodes were used for the construction of MFC in the similar procedure.

2.4. Nylon Membrane

Nylon membranes are micro porous, positively charged, pure nylon, bound to a polyester support. They are cationic and maintain their positive charge over a wide pH range. These membranes therefore have a high binding capacity. In MFC it is used for transferring H^+ ions from anionic chamber to cationic chamber and blocking the diffusion of oxygen back to anionic chamber.

2.5. Construction of MFC

A rectangular plastic box with dimensions 23.5cms ×12.5cms was taken along with lid to develop a microbial fuel cell. Set of 8 tubes with capacity 30ml each with dimensions 10cm length and 2cm diameter were taken to place into the rectangular plastic box. These tubes were arranged in two rows containing 4 test tubes in each row. Another set of 8 centrifuge tubes were arranged similarly in same rectangular box which were separated by thermocol. Each of the centrifuge tube was filled with 25ml of 1:1 substrate and two drops of methyl red as a mediator.

The anode and cathode are basically a metal rods or sheets which were soldered to a conducting wire using a soldering gun. The anode was wound by nylon cloth to separate from cathode; these electrodes were tied together by rubber band by ensuring the distance between them is zero. These electrode setups were introduced into each tube. Each tube acts a single MFC. Set of 8 MFCs were connected in series (the +ve terminal of the first cell was connected to the –ve terminal of the second cell and so on). Two holes of same diameters of conducting wire were made on the lid of the rectangular box to insert the conducting wire along with electrodes and the terminals of the conducting wire were connected to multimeter to measure voltage. The system was closed with lid and packed with cellophane tape and the holes were sealed with mseal. The voltage was measured and recorded at regular intervals.

Fig 1: Shows the experimental set up of MFC

[III] RESULTS

3.1. Substrate used

Study of cowdung as a substrate was carried out and the output voltage is plotted bellow.

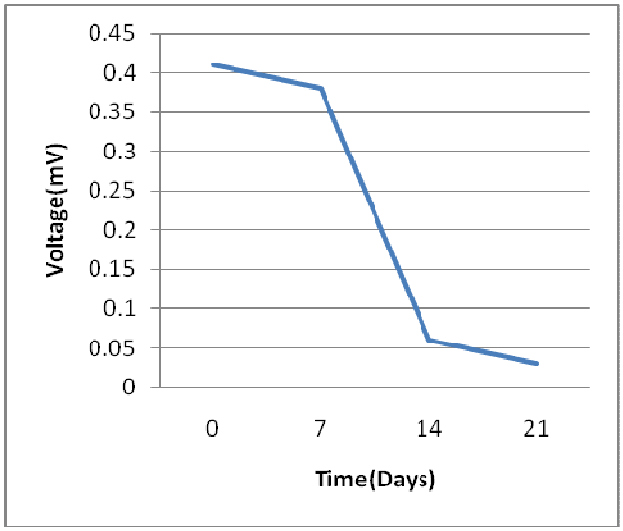

Fig 2: voltage generated using cowdung as a substrate

3.2. Studies on electrode materials

21 different combinations of electrodes were used for the power generation and voltage generated was tabulated in set of 7 combinations.

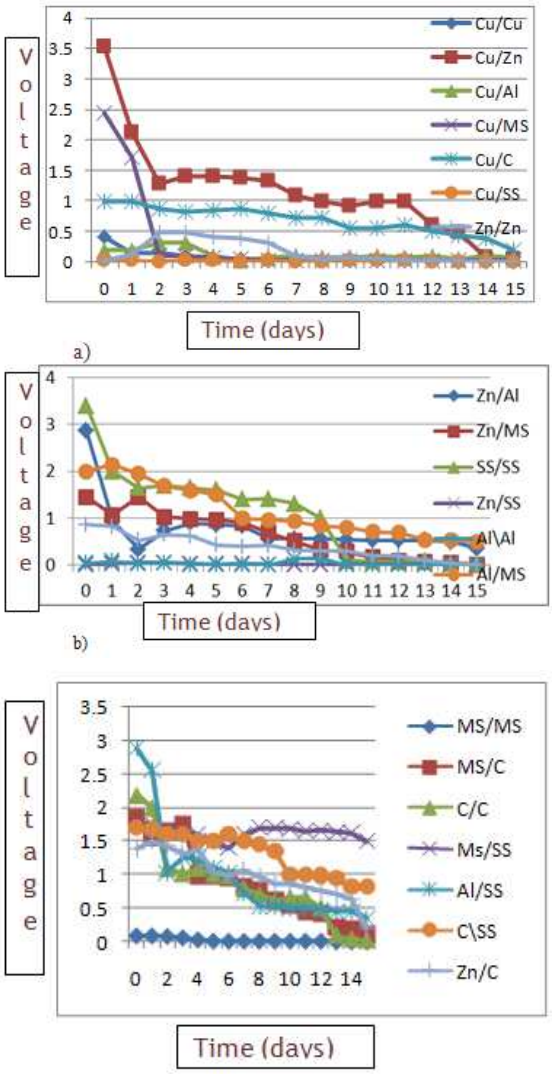

Fig 3: the above figures (a, b, & c) shows comparison of voltage (mv) generated by different combination of electrodes.

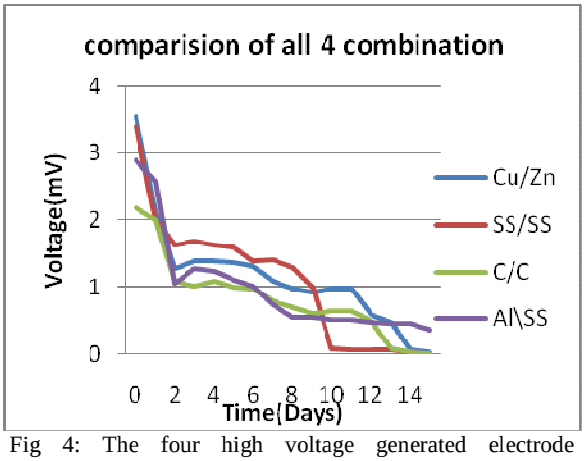

Fig 4: The four high voltage generated electrode combinations.

IV] DISCUSSION

Cow dung has high concentration of organic matter and other trace elements which are required for growth of mixed culture of organisms. It contains around 60 species of bacteria some of them are *bacillus, cornynebacterium, lactobacillus, streptococcus, pseudomonas, Nacordia, Mucor,* and *rhizopus*. After 14 days there is a sudden decrease in voltage probably due to combined effect of depletion of nutrients, interaction and release of toxins from other species (Figure - 2).

As shown in figure - 3, four combinations of electrodes i.e., Cu/Zn, Al/SS, C/C, and SS/SS, gave the higher voltage compared to other combination of electrodes which we have studied. From the above observations (Figure – 4) 4 high voltage producing combination of electrodes were selected and these showed initially a high voltage and gradually decreased to zero because of depletion in nutrients and interaction in mixed cultures by producing some sort of toxins which may prevent the growth of microbes responsible for electron generation. From this study Cu/Zn was selected as the most efficient and consistent electrode and will be used in our further studies which is on modifications of the electrode surface to enhance the voltage generated.

[V] CONCLUSION

Cow dung gave the best results, since the cowdung has high concentration of organic matter and other trace elements which are required for growth of mixed culture of organisms. The different combinations of electrodes were used and found that Cu/Zn gave the best and consistent results. It demonstrated that different electrodes exhibited different behaviors. From the perspective of current development, the exploration of electrode materials will be more important and attractive as a reasonable price and excellent performance will greatly expand the application of MFCs. MFC technology can be used to treat organic-rich soluble wastewater while producing electricity.

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