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Influence of IOT in Microbial Fuel Cell for Mass Production of Electricity

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ABSTRACT

Nowadays the major problem to be concerned is the energy crisis. By incorporating the emerging advancements in technologies in the electricity production we can increase the rate of production at reasonable cost. As the cost of electricity production is reaching its peak value, Microbial fuel cell is an effective technique from which we can obtain electricity at lower cost. Application of Microbial fuel cells towards environment is highly advantageous that can be applied in different sectors of industrial and agricultural waste management. Here we are using a digitalized approach to measure and maintain conductivity and pH of the sewage water that we use to generate electricity. The initial efficiency of power generation in MFC's was low. but incorporating the recent modification in its construction and components we can get the power output to a significant level. We can use household wastewater for the generation of electricity with adding some substrates and the whole system connected to the IOT technology. For the practical applications to increase their potential and efficiency, we can use the recent developments in the world of bio-technology and organic chemistry. This paper provides an outline and overview of the requirements, modifications and applications of MFC technology for various research areas and industrial needs.

Index Terms—Microbial fuel cell, IOT, AT mega controller, bio electrochemical system, Bio-electrodes, Reticulated polymeric coating, Hydrophobic polymers.

I. INTRODUCTION

IOT is an emerging technology which connects physical objects that are embedded with sensors, microcontrollers and some software that allows us the real time analysis of data and to exchange data with other devices and over the internet. IOT comprises various fields such as embedded systems, wireless sensor networks, automations and control system that perform together to achieve a function.

Microbial fuel cell is a bio-electrochemical system that converts organic substrates into electrical energy through redox reaction that are facilitated by microorganisms. It utilizes the energy present in the chemical bonds to generate current. Microbial fuel cell serves the best way for both the treatment of wastewater in eco-friendly way and production of electricity. This IOT connected MFC system allows the user to view the sewage water parameters which are collected by sensors, processed by microcontrollers, displayed on LCD display and also to store and process it in the cloud server. This type of IOT connected system yields more advantage when a greater number of MFC's are built for energy production.

II. DESCRIPTION

The Microbial fuel cell uses the organic substrates present in the wastewater to generate electricity with the help of anaerobic microbes. For the eco-friendly way, bio-electrodes are used instead of conventional electrodes. The bioanode is placed in the anode compartment (where oxidation occurs), biocathode placed in the cathode compartment (where reduction occurs) that are separated by cationic specific membrane.

The organic substrates present in the anode compartment consist of electron donor compounds such as hydrogen or sulphur. This helps for oxidation process and generates large number of protons, electrons and carbon dioxide. Even though some microorganisms will be present in the wastewater, anaerobic microorganism such as Escherichia coli, Geobacter sulfurenducens, Bacillus cereus, Clostridium butyricum are added for fast oxidation in the anode.

A. Electrodes and Electrically Conductivity Material

Compared to conventional electrodes, as bioelectrodes are coated with reticulated polymeric coating, that actively enhances the movement of ions which results in the increased production of electricity. Also has some pores which helps to reduce the flow through resistance thereby increasing the movement of electrons.

The bioelectrodes used in this process are enclosed by some electrically conductive material, either they are chemically bonded or attached to bioelectrode by a binder so that it provides electrically conductive surface for operation. These materials used to increase the electrical conductivity and do not harm the microorganisms as they are compatible to microbes.

Examples of such compounds are titanium, granular powdered carbon, graphene and even carbon nanotubes can be employed as they are enriched with carbon.

B. Microbial Fuel Cell and its Representations

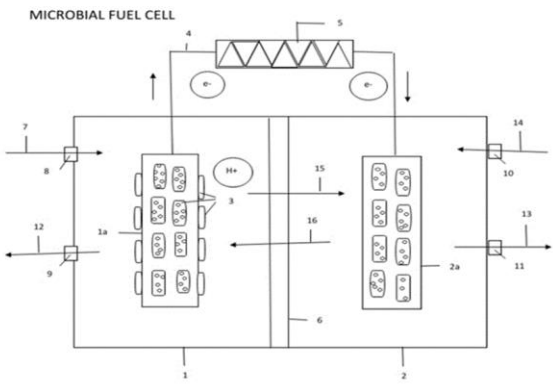
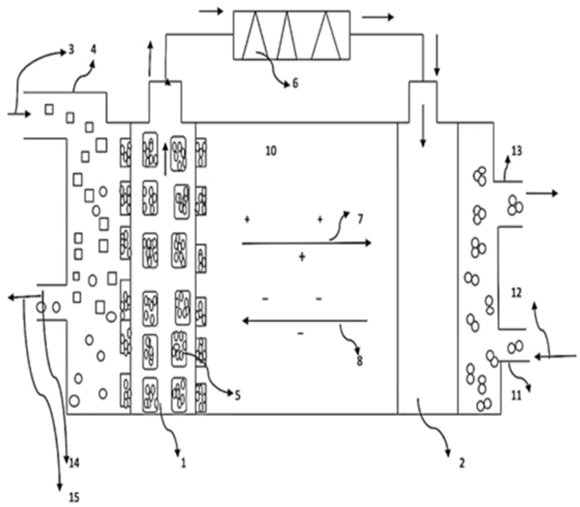


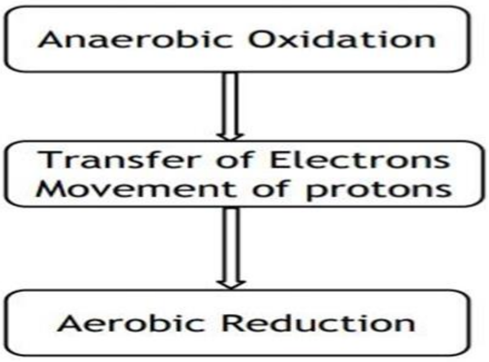
DIAGRAM REPRESENTATIONS

1 - Anode compartment
2 - Cathode compartment
3 - Bio-film
4 - Electrons
5 - External circuit
6 - Cation specific membrane
7 - Incoming fuel waste water
8 - Waste water inlet
9 - Anode outlet
10 – Electron receptor inlet
11 - Cathode outlet
12 - Treated waste water
13 - Hydrogen peroxide
14 - Oxygen
15 - Protons
16 - Hydrogen ions

C. Working of MFC

Organic matter from the wastewater is introduced into fuel inlet. Anode is set up, microorganisms and some substrates are added to anode compartment. Organic matter is anaerobically decomposed by microbes that result in the release of carbon dioxide and generation of protons and electrons. Carbon dioxide flows through the anode outlet. Electron flows through the external circuit by which current can be generated. Proton flows from anode chamber to cathode chamber through cation specific membrane. The electron reduces oxygen provided from oxygen supply inlet to water and hydrogen peroxide and flows out of the cathode compartment.



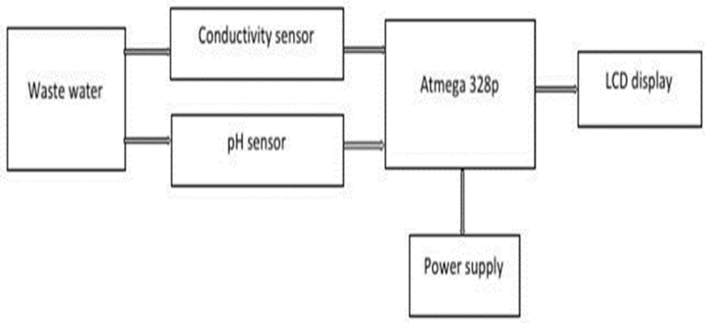


D. Polymeric Foam in the Substrate

The polymeric foam makes the substrate more porous for the movement of ions throughout the MFC. For best power output, hydrophobic polymers are employed. These polymers are prepared using polyether polyol by addition of hydrophobicity inducing surfactant such as polyalkylene polymers and polysiloxane. These polymers are stable in organic substrate and do not get degraded.

The usage of polymer enhances the lifespan and they are impermeable to water environment.

III. INFLUENCE OF MFC BY IOT



A. CONDUCTIVITY SENSOR

The conductivity sensor used is CS547. It measures the conductivity by three passivated stainless-steel electrodes having dc isolation capacitors using A547 and datalogger. It has pH range of 3 to 9 with conductivity of accuracy of +5% or -5%.

The operating temperature ranges between 0-50 degree Celsius. Its weight is about 0.3 kg with 3.05m cable. Requires one differential analog input, one single ended analog input and two excitation channels.

Code for Conductivity sensor

```
#include<LiquidCrystal.h>
LiquidCrystal display(2,3,4,5,11,12);

int pin=6;
int state=0;
int num;
void setup()
{
Serial.begin(4800);
display.begin(16,2);
pinMode(pin,INPUT):
}
void loop()
{
num=analogRead(A0);
int volt=num*(3/512);
display.setCursor(0,0)
display.print("The value of conductance is");
display.setCursor(0,1);
display.print(volt)
delay(25);
}
```

B. pH SENSOR

The pH sensor used is CS526. This pH sensor is more reliable and provides accurate value in aqueous solutions. It can be inserted in to the container containing the wastewater for production of electricity.

This pH sensor is manufactured under the stringent quality control condition in ISO 9001 environment. This sensor can be easily cleaned and more rugged than traditional sensor.

Code for pH Sensor

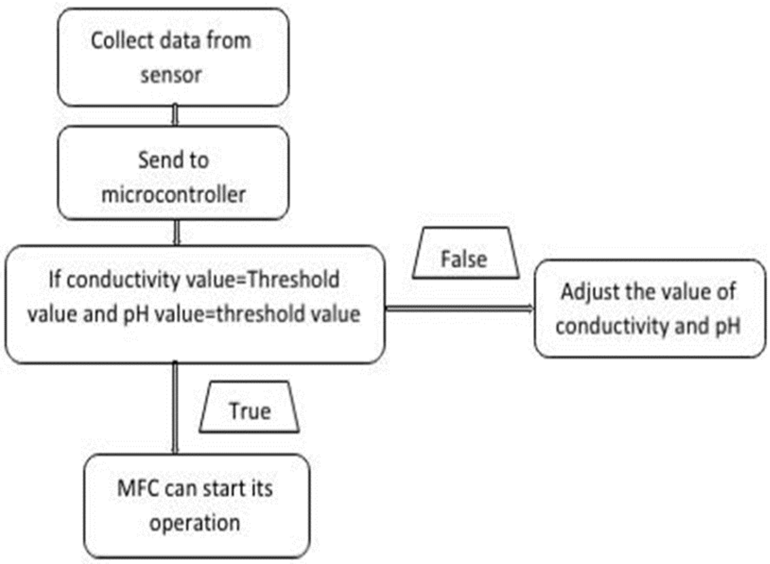
```
int Volt;
int pH;
void setup()
{
 Serial.begin(4800);
 pinMode(pH, INPUT);
}
void loop()
```

```
{
 pH = analogRead(A0);
 Voltage = pH* (3 / 512);
 Serial.println(Volt);
 delay(500);
}
```

IV. ALGORITHM

1. Measure the conductivity and pH of the water using conductivity sensor and pH sensor.
2. Send the data collected to Atmega 328p microcontroller.
3. Data processed in the microcontroller and required values are displayed on LCD.
4. Required values: -
   1.Conductivity of water
   2.pH of water
5. Conductivity value that can be added to increase conductivity of water to reach maximum threshold value.
6. Value of pH that should be increased or decreased to maintain threshold pH value.
7. If the value of conductivity and pH value equals to the threshold value, display “threshold conductivity and pH value obtained, MFC can start its operation”.
8. If the value of conductivity not equals threshold value, display “conductivity should be adjusted”.
9. If pH value not equals to threshold value display “pH value to be adjusted”.

V. FLOWCHART



VI. SURVEY AND INFERENCE

MFC S.NO	Information collected by pH sensor	Information collected by conductivity sensor (S/cm)	Indication on LCD	Inference from LCD
1	6.96	55.053	Increase pH by 1.44 Decrease conductivity by 5.053 S/cm	Adjusting pH and conductivity to threshold value
2	7.35	57.065	Increase pH by 1.05 Decrease conductivity by 7.065 S/cm	Adjusting pH and conductivity to threshold value
3	8.17	59.432	Increase pH by 0.23 Decrease conductivity by 9.432 S/cm	Adjusting pH and conductivity to threshold value
4	6.89	61.753	Increase pH by 1.51 Decrease conductivity by 11.753 S/cm	Adjusting pH and conductivity to threshold value
5	7.56	52.952	Increase pH by 0.84 Decrease conductivity by 2.952 S/cm	Adjusting pH and conductivity to threshold value
6	7.92	63.653	Increase pH by 0.48 Decrease conductivity by 3.653 S/cm	Adjusting pH and conductivity to threshold value

CONCLUSION

Performance characteristics of Microbial Fuel cell at different pH values and different conductivity values are obtained. Maximum current density and power density is obtained at pH value of 8.4 and conductivity of around 50 S/cm. The main theme of this research work is to obtain information for the operation of Microbial fuel cell for the practical application towards the contribution for eco-friendly management of wastewater in a best way. Best output can be obtained when large number of MFC are built for mass production of electricity.

VII. ACKNOWLEGEMENT

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