Parametric Effect of Distillery Effluent as Substrate in Microbial Fuel Cell for Power Generation

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Abstract

Depletion of fossil fuel increased direction towards renewalable energy sources. Microbial Fuel Cell substitute technology for converting waste water from industry effluent as well meet the requirement for environmental problem. Study was made to treat the distillery effluent as substrate in mfc for bio-energy considering effect of oxygen flow rate, pH and substrate concentration. Different organic load were used in mfc for power generation and different oxygen flowrate for oxidation of proton coming from anode chamber effect of pH also keep consideration regading microbial growth of saccharomyces as a biocatalyst. The maximum power generation were observed at optimized condition of oxygen flow rate 250rpm, pH6 and substrate 60% (in form of organic load) at 0.9114 mW and current density 82.48 mA/m²$^{}$.

Keywords: Distillery; Effluent; Substrate; Power Generation; MFC

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INTRODUCTION

The growing demand for energy, depletion of fossil fuels and increasing concerns of environmental issues have challenged researchers to develop new technological processes to generate clean and sustainable energy mainly through the utilization of renewable energy sources (Cai et al., 2013; Jatoi et al., 2016c; Jatoi et al., 2018; Liu et al., 2014; Logan et al., 2006). Recently, microbial fuel cell (MFC) technology has emerged as a promising sustainable technology to meet increasing energy demand that can utilize organic materials as a fuel (Pant et al., 2010; Yusoff et al., 2013) . MFCs are bio-electrochemical devices capable of converting biochemical energy into electricalenergy through the catalytic reaction of microorganisms (Yusoff et al., 2013). MFCs have remarkable electron-donor versatility as the microbes usewastewater as substrates to generate electricity and simultaneously accomplish wastewater treatment (Jatoi et al., 2016a; Jatoi et al., 2016b; Lu et al., 2009; Oh and Logan, 2005; Pant et al., 2010; Parkash et al., 2015; Soomro et al., 2016). Production of unmanageable quantity of sewage sludge from wastewater treatment plants is the major issue in terms of capitaland environmental burden. This costs 60% of the total plant capital cost, and its disposal has become problematic due to stringent sludge disposal laws (Canales et al., 1994; Pilli et al., 2011; Xiao et al., 2013). MFC technology provides new opportunities for the sustainable wastewater treatment by converting waste into energy, which may offset the operational costs of wastewater treatment plant (Lu et al., 2009). High concentrations of organic matter, mainly protein and carbohydrate can be found in sewage sludge (Wang et al., 2006; Xiao et al., 2013). Wang et al. (2006) reported the total protein and carbohydrate in sludge to be 12,036 mg/L and 2109 mg/L respectively. However, it is known that generation of power during the MFC process might be influenced by the efficient degradation of biomass in MFCs (Bougrier et al., 2008). In this study distillery effluent used as substrate in mfc for power generation.

MATERIALS AND METHODS

Microorganism

Yeast S.cerevisiae M-9 (Shah et al., 2010) were purchase from local market with analytical grade.

Inoculums of yeast were preperad from following composition with 250 ml medium which contained in g.l-1: glucose, 10; $(NH^4)^2$ HPO^4, 0.64 , and yeast extract 2.5; at pH 5.5 and incubated for 18 h on an orbital shaker at 150 rpm at 30°C.

Distillery effluent characteristic

Distillery effluent were collected from al abbas distillery plant and analyzed given in table 1.

Table 1: Characteristic of distillery waste water

Characteristic	Average value
pH	3.99
Colour	Dark Brown
BOD3 (mg/L)	36666
COD (mg/L)	89833
Total Solids(mg/L)	74033
Dissolved Solids (mg/L)	59733
Chlorides (mg/L)	6933
Conductivity (mS/cm)	20.2

Configuration of MFC

The H-shaped MFCs were fabricated with two polycarbonate bottles (500 mL) as chambers and a PVC pipe (5 cm × 1 cm) for preparing a salt bridge. The slat bridges were prepared by filling boiled sodium chloride (10 %) solution containing 5 % agar. The salt bridges were fixed to the bottles with the aid of epoxy adhesive. The electrodes were inserted into respective chambers while circuit connections were set with the copper wires fixed into the drilled holes of the electrodes and sealed with epoxy resin to avoid corrosion of copper wire (Jatoi et al., 2018). The fabricated MFCs were sterilized with Ethanol (70 %) and irradiated with UV for 15 min. The electrolytes were added up to the brim of the respective chambers to maintained air free conditions.

Figure 1: Typical MFC Camera View

Preparation of anode and cathode chamber

Two chamber were prepared with carbon electrodes, aerobic condition were maintained in cathode and anaerobic in anode. The air fish pump were used for oxidation of proton coming from anode to cathode chamber for water formation. Under different ph of anode chamber were maintained for power generation to make best condition for microbial growth in MFC. Cathode chamber were maintained with aerobic condition for promoting proton coming from anode chamber for oxidation.

Preperation of salt bridge

Salt bridge was prepared from different salt such are NaCL KCL and agar salt for making gel like membrane for transferring of proton from anode to cathode chamber.

Running of MFC

Distillery effluent were added in anode chamber under anaerobic condition with inoculums prepared for growth of *saccharomyces servisae* as biocatalyst for utilizing organic matter for bio-generation of electricity. Cathode chamber were maintained by salt water under aerobic condition with addition of oxygen by fish pump to promote oxidation of proton coming from anode chamber.

Electron transferred occur with installing carobon electrode through external resistance.

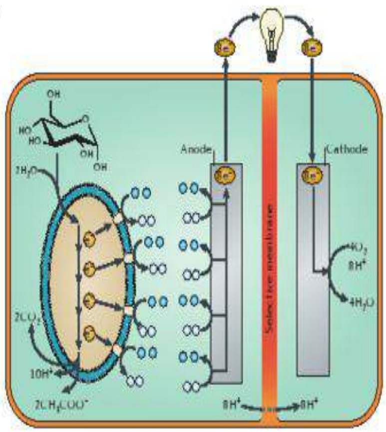

Figure 2: Basic operation of MFC

Analysis of MFC

In MFC different parameter were analysed during experimental work on it .

pH

pH were analysed using pH meter to set the desired condition for microbial growth, because if the pH increases above the 8.5 and below the 6 there will be effect on microbial growth in MFC.

Oxygen flowrate

Oxygen flow rate were analysed with the help of flow meter to know about the oxygen enter in the MFC cathodic chamber,because we make cathodic chmber aerobic condition .

Voltage Generated

Current was analysed by using multimeter, different concentration and pH were used to saw the behavior of the system ,at what concentration and pH had maximum output of power generation. Voltage was continuously measured by a multimeter with a data acquisition system. Current (I) was calculated from the voltage (V) by I=V/Re, where Re is the external resistance. Power (P) was calculated as P=IV (Wei et al., 2012).

RESULTS AND DISCUSSION

During running of MFC different process parameter effect on electrcity generation. Different parameter of mfc were tested and analysed. Voltage generation from MFC were measured by volt meter and current, current density, power, power density were calculated by following relation.

P=VI

Power density = power/ area of anode

Current density = current generated/ area of anode
In table 02 current and power genartion were listed with different oxygen flowrate and ph ranges the maximum electrcity were observed at 250ml/min of oxygen flowrate 0.98mA and for ph the maximum generation of bioenergy at 6 with voltage generation 0.82Volts.

Table 2: Current, Voltage, Power, Power Density and Current Density at various parameter

Parameter	Oxygenflowrate (ml/min)				pH value				Substrate % w/v		
	100	150	200	250	4.5	5	5.5	6	20	40	60
Current (mA)	0.81	0.89	0.94	0.98	0.79	0.83	0.86	0.89	0.75	0.79	0.83
Voltage (volts)	0.77	0.86	0.95	0.97	0.75	0.79	0.82	0.85	0.72	0.74	0.77
Power (mW)	0.62 37	0.7654	0.893	0.911 4	0.59 25	0.6557	0.70 52	0.75 65	0.54	0.58 46	0.639 1
Power density (mW/m2)	50.4 3	61.53	71.98	78.42	49.3 75	54.641 67	58.7 667	63.0 4167	45	48.7 1667	53.25 833
Current density (mA/m2)	67.2 9	73.98	78.97	82.48	65.8 333	69.166 7	71.6 7	74.1 67	62.5	65.8 33	69.16 6

Effect of oxygen flowrate on power generation
In mfc operation were successful with addition of air in proper into cathode chamber for oxidation proton coming through salt bridge from anode chamber. Different ranges of oxygen were under investigation for promoting energy generation from distillery effluent. From 100-250ml/min of air flowrate tested and analyzed the maximum voltage generated at 250ml/min with 0.98 v/l. in fig 03 it highlights after 56 hour the line in decreasing way due to the changing in dissolved oxygen, because during running of mfc different parameter effect regarding dissolve oxygen becuas at that time temperature of cathode chamber increasing it decease the voltage generation.

Effect of pH on power generation
Acidic and basic nature had importance regarding microbial growth in MFC, regaring biocatalyst *saccharomyces specii* for their nature it active in acidic nature of the solution and could serviveph ranges from 4-6.5. highlighting this problem effect of ph under consideration for maximing the activity of biocatalyst. For power generation from distillery effluent the maximum power production observed at pH6 about 0.85 v/l as shown in figure 04. It colud helpful for meeting environmental condition for generating power from distillery effluent and decrease the percentage of waste water promoting renewlable energy.pH is a significant factor that affecting the activity of microbes. Growth and development of microbe's maximum at optimum pH. The experiments show that at pH 6 and below, activities of microbes minimum when compared with the result recorded at higher pH. This is by the neutralization of proteins or active sites under acidity. These results demonstrate that there is also impact of pH on voltage Generation (Shah et al., 2010).

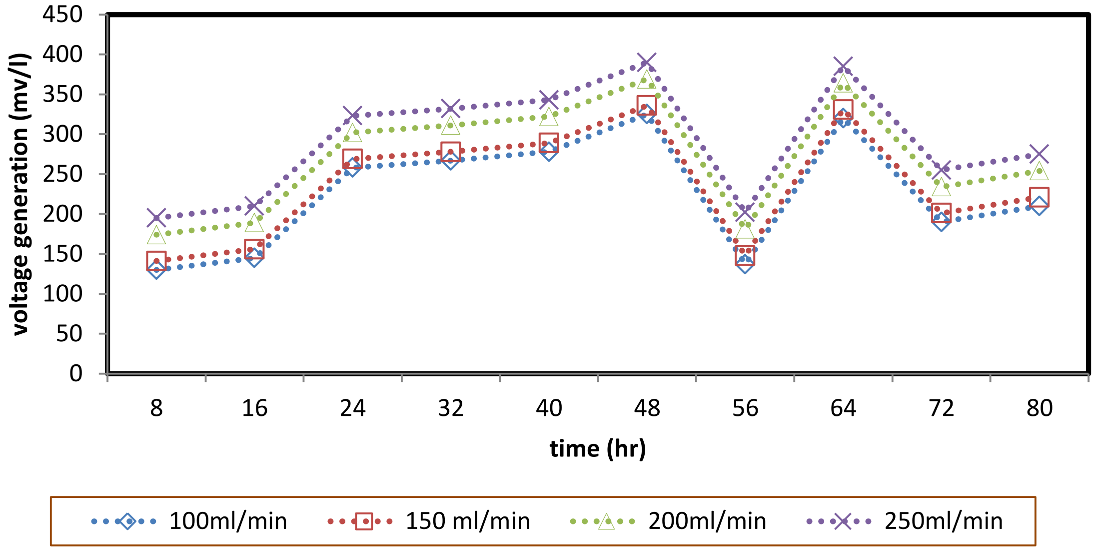

Figure 3: Effect of oxygen flow rate on power generation from MFC

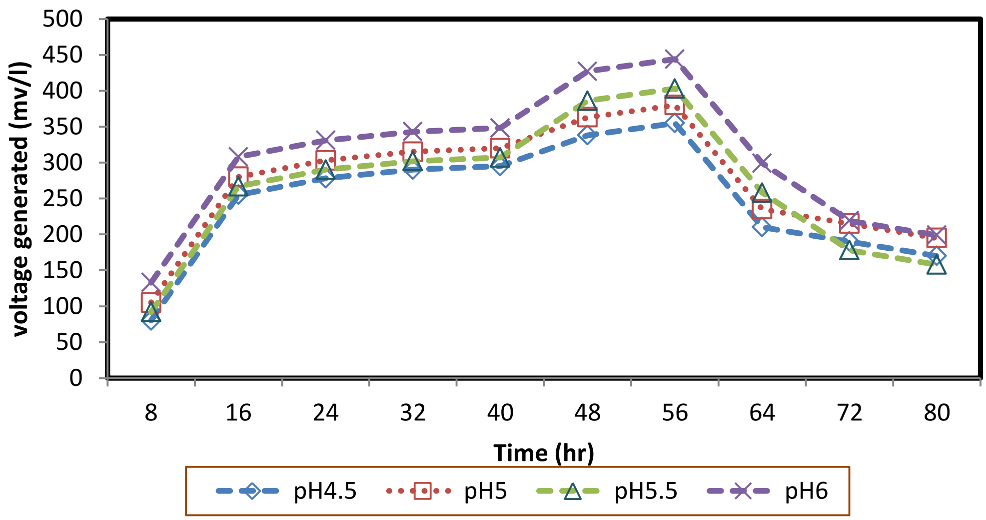

Figure 4: Effect of pH on power generation from MF

Effect of substrate concentration

Different Substrate concentration were tested in MFC for power generation by utilizing distillery effluent as substrate. From 20-60%w/v of substrate were used in MFC for identifying the range where maximum power production maximum from fig 05 observation suggest when concentration of distillery effluent increases upto 60% power generation maximum, this could be due to the decreasing organic compound present in distillery effluent and microbial activity could inhbit by changing the concentration of substrate and maximum power generation observed when substrate concentration 60% about 0.82mA.

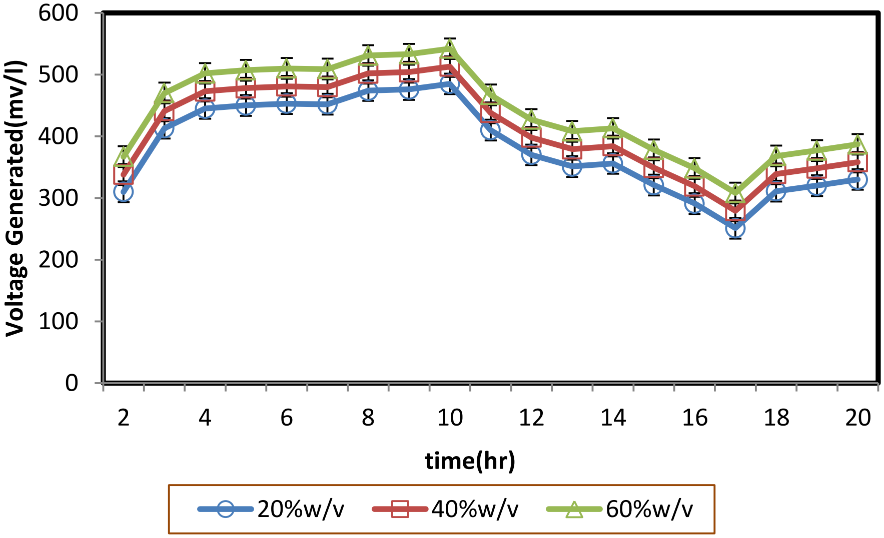

Figure 5: Effect of Substrate Concentration on power generation from MFC

CONCLUSION

The double chamber MFC using *Saccharomyces cerevisiae* with various substrate concentrations and oxygen flowrate for the performance and process optimized. The suitable substrate concentration of distillery where maximum voltage 0.97V and maximum current 0.98 mA is at 60 %w/v. Internal resistance resist the generation of voltages as a higher grade of polymerization of the gel, internal resistance build up inside the cell. The maximum power generation were optimized at pH6 , 250ml/min of oxygen flow rate and 60%w/v of distillery effluent gave maximum power generation 0.9114 mW. It could be say that mfc could help to improve the utilization waste material into energy generation.

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