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Investigating The Potentials of Wood Charcoal, Groundnut Shell Charcoal and used Toner in Microbial Fuel Cell Electrode Power Generation

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Abstract **– This research is on the potentials of wood, groundnut shell and toner charcoals are investigated to ascertain the best material for microbial cell electrodes. To investigate this, wood, groundnut shell and toner charcoal were used to produce electrodes after mixing each of them in cement in the ratio of 1:1. Agar concentration of 20g/500ml was mixed with 3.5g salt for the production of the Proton Exchange membrane. Voltage and current of the cells were measured three times daily using digital multi-meter and the average was recorded. After 20 days of study the result obtained showed that wood charcoal electrode in close circuit has maximum current, voltage, power and current density of 0.17mA, 0.15V, 2.2024mW/m2, and 14.683mA/m2 respectively. For groundnut shell charcoal the following results were obtained for close circuit- maximum current, voltage, power and current density were 0.07mA, 0.13V, 0.7859mW/m2, and 10.3644mA/m2 respectively, for toner charcoal the results are maximum current, voltage,power and current density 0.1mA, 0.11V, 0.7773mW/m2, and 7.7733mA/m2 respectively. For open circuit, maximum values of wood charcoal for current, voltage, power and current density were 0.017mA, 0.15V, 0.216mW/m2, and 1.445mA/m2respectively. Groundnut shell in open circuit gives the following result, 0.007mA, 0.14V, 0.0833mW/m2, and 0.595mA/m2 for maximum current, voltage, power and current density respectively, toner charcoal in open circuit gives 0.011mA, 0.013V, 0.1216mW/m2, and 1.1056mA/m2for maximum current, voltage, power and current density respectively. All result obtained from the experiment shows that wood charcoal base electrode has the highest potential among the tested materials, thus, would produce more power and has more efficiency than the other materials.**

Keywords **– produced water, charcoal, power generation, electrodes, water treatment, cruel oil, microbial cell.**

I. INTRODUCTION

The deleterious effect of crude oil pollution on animal lives is enhanced by the fact that the crude oil contains high level of aromatic hydrocarbons which alter the normal biochemical processes in animal life. There are different operations in the petroleum industry in the onshore as well as in the offshore that can cause soil pollution and aquifer contamination with petroleum products such as drilling operations, leakages from well heads and pipe lines, overflows at gathering stations, improper disposal of petroleum waste and leakages from underground tanks (Argonne National Laboratory, 2009, Arthur et al, 2005).

In addition, increasing human activities is mounting pressures on natural energy sources leading to the depletion of fossil fuel. Therefore, the need for alternate fuel has made researchers to identify a potential, cheap and renewable source of energy production. The building of a sustainable society will require reduction of dependency on fossil fuels and reducing the amount of pollution that is generated and also, about climate and global warming requires developing new methods of energy production using renewable and carbon-neutral sources.

This microbial fuel cell (MFC) technology can be the ultimate solution for these problems as it has recently drawn the world's interest as a new method of directly generating electricity from the oxidation of organic matter in wastewater while simultaneously treating the waste water of its contaminants (Aelterman et al., 2006, Alzate-Gavira et al., 2007). Microbial fuel cells are devices that use bacteria which serve as catalyst in the cells to oxidize organic and inorganic mater and also generate electricity (Aelterman et al., 2008, Alzate-Gavira et al., 2008, Ahn and Logan, 2010). The major advantage the system offers is no energy requirement for oxygen supply, less sludge production, and recovery of methane gas. While treating sewage, particularly in small capacity treatment plant recovery of methane may not be attractive, because most of the methane produced in the reactor is lost through effluent of the reactor (Alzate-Gavira, 2011). Treating low strength wastewater major fraction of the methane gas may be lost through effluents, reducing the energy recovery. Electricity can be produced in different types of power plant systems, batteries or fuel cells. Fuel cells, if used for wastewater treatment, can provide clean energy for people, apart from effective treatment of wastewater (Chang et al., 2004). The benefits of using fuel cells include: clean, safe, quiet performance; high energy efficiency; low emissions; and ease in operating (Debabov, 2008, Kumar and Signh, 2008).

Produced water is defined as the water that exists in subsurface formations and is brought to the surface during oil and gas production(Aurthur et al, 2005). This water is generated from conventional oil and gas production, as well as the production of unconventional sources such as coal bed methane, tight sands, and gas shale. The concentration of constituents and the volume of produced water differ dramatically depending on the type and location of the petroleum product. Produced water accounts for the largest waste stream volume associated with oil and gas production (Argonne National laboratory, 2009). This research is aimed at investigating the potentials of wood charcoal, groundnut shell charcoal and used toner in microbial fuel cell electrode power generation. The objectives will include.

II. METHODOLOGY

1. Electrode Preparation Procedure

The groundnut shells charcoal, wood ash charcoal and tonner charcoal, were ground to fine powder after (groundnut shells and wood ash) the burning at a temperature of about 4000C in Oven(see Figure 1). Method used by Oji et al., 2012 is applied in this methodology procedure.

Fig.1. Biomass before and after burning for use as electrode construction material.

- The charcoal fine powders was mixed with cement in the ratio of 1:1 (that is, 50g of groundnut shell charcoal to 50g of cement, 50g of wood ash charcoal to 50g of cement, and 50g of tonner charcoal to 50 of cement) as seen in figure 1.
- Add a small quantity of water of about 100ml.
- Cut the PVC trunking to the desired length (24.2cm)
- Lubricate the inside of the PVC trunking with oil (vegetable oil) to allow the easy removal of the electrode when it solidifies.
- Pour the cement/charcoal mixture into the mould (PVC trunking) and insert a flexible wire into it and allow it for about 2days to get strong.
- Test the electrodes with a multi-meter; there should be a small amount of resistance between a point on the electrode and the end of the wire opposite the electrode (see figure 2).

Fig.2. Electrodes after been produced.

Proton Exchange Membrane (PEM) Preparation Procedure

- Cut 1 inch diameter PVC pipe into 3 pieces with length of 0.08m each.
- Fix the PVC flanges on the PVC pipe with epoxy at both ends thereby giving it a total length of 0.105m.
- Sterilize each of the pipes with ethanol in order to free the internal surface of the pipe from microorganism.
- Seal the open ends with a masking tape(See figure 3) to prevent microorganism from acting on the internal surface after sterilization.
- Dissolve Agar Agar into distilled water (concentration of 20g/500ml).
- Add salt to the agar (3.5g of salt in 20g of agar).
- Autoclave the agar/salt mixture to about 1210C for 15minutes.
- Open one end of the PVC pipe and pour the agar/salt mixture into the pipe while it is still warm and before it solidifies.
- Allow the agar/salt mixture to cool and solidifies for 45minutes.

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Fig.3.Produced PEM.

1. Connect the Proton Exchange Membrane (PEM)

- Cut open the sides of the plastic bottle to the desired diameter
- Fix the membrane into the holes of the bottle
- Epoxy the plastic pipe to the sides of the plastic bottle
- Allow to harden.

2. Connection of the Tap

- Cut open the side of the plastic bottle
- Connect the tap
- Epoxy the tap to the side of the plastic bottle
- Allow to harden

3. Assembling the MFC

The plastics with lids for anode and cathode respectively were drilled from the side with about 1inch diameter of the hole. Ion exchange membrane was fixed with one end connected to the anode chamber and the other connected to the cathode chamber. Epoxy was used to seal and firmly fix the ion exchange membrane to the chambers. The taps was also connected to the plastic bottle with epoxy. After about 4hours, water was used to check for leakages. Holes of about 0.015m were made on the lids for the electrodes.

4. Running the MFC

The produce water was added to the anode chamber
250g of salt was dissolved in 15liters of water which was poured into the cathode chamber as a conductive solution.
Insert the electrodes into the anode and cathode chambers.
After all preparations were done, the high strength produce water was poured into the 5litres anode chamber of each set-up. The anode was covered and sealed to prevent oxygen from entering. The anode chamber must be anaerobic. The cathode chamber (the oxidant) was filled with the catholyte (brine) and was not sealed but partially covered to allow enough oxygen which helps in oxidation.

5. Microbial Fuel Cell Set Up

The anode chamber containing high strength produce water was connected through flexible wires to the cathode chamber containing brine. The two chambers were linked with salt bridge inter-connection (see Figure 4). The microbial fuel cell voltage for each set-up was monitored three times daily using a digital multi-meter. Reading of voltage and current was done few minutes after stabilization.

Fig.4. MFC set-up.

6. Important Hints for Operating your MFC

- Oxygen must be kept out of the anode chamber
- Power can be significantly increased by using a catalyst (typically platinum) on the cathode side. Note: platinum is expensive.
- For long term operation, electrodes should be constructed in a way that limits corrosion of copper wire due to contact with liquid.

Calculation of Charcoal Electrode Surface Area
Applying the Formula for surface area = 2πrh+ 2πr^2 = 2πr(h+ r)
But,
Diameter = 1.5cm = 0.015m
Radius = 0.075cm = 0.0075m
Length = 24.2cm = 0.242m
Therefore, surface area = 2*3.142*0.0075(0.242+0.0075)
Surface Area = 11.758*10-3m2

III. RESULTS AND DISCUSSION

1. Power Generation

This experimental work was observed for 20days as stated above; Readings of voltage and current were also recorded using a multi-meter for both closed and open circuit. Three readings were taken daily and an average of all three readings was recorded.

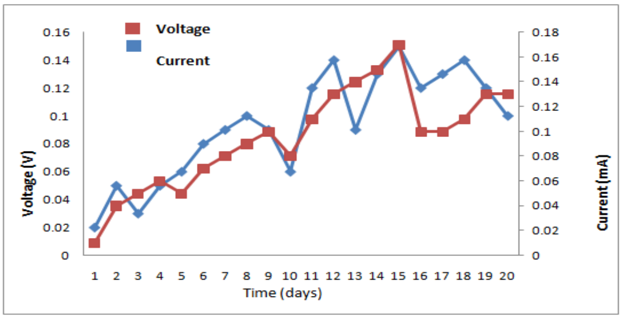

Fig.5. Voltage and current against time for wood ash cell for a closed circuit.

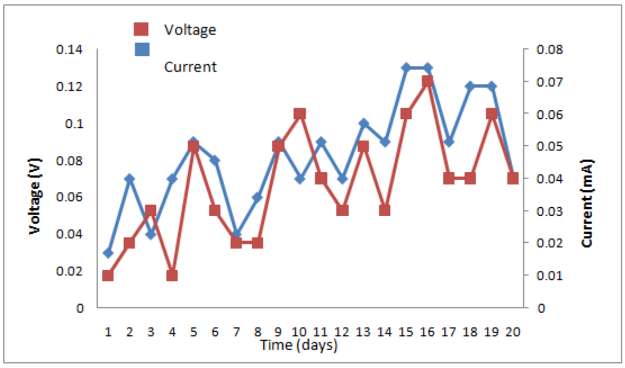

Fig.6. Voltage and current against time for groundnut shell cell for a closed circuit.

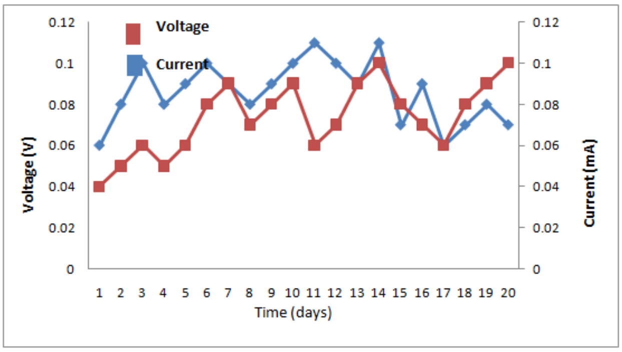

Fig.7. Voltage and current against time for tonner cell for a closed circuit.

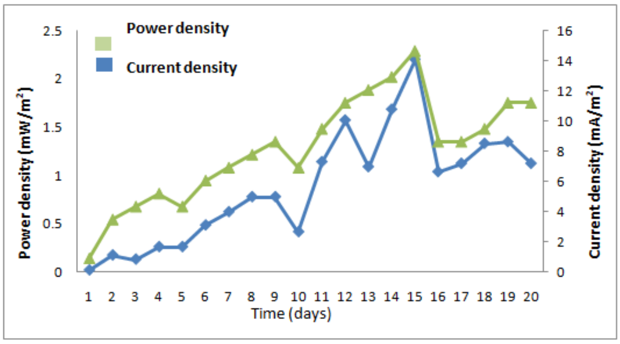

Fig.8. Power density and current density against time for wood ash cell for a closed circuit.

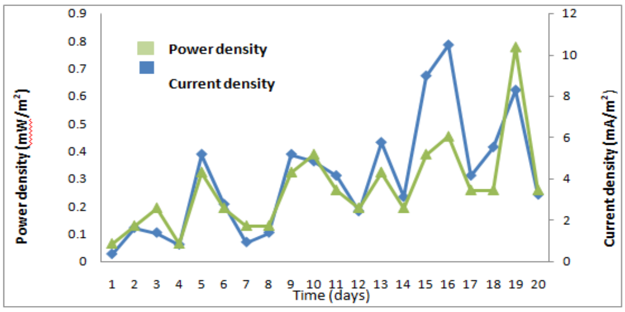

Fig.9. Power density and current density against time for groundnut shell cell for a closed circuit.

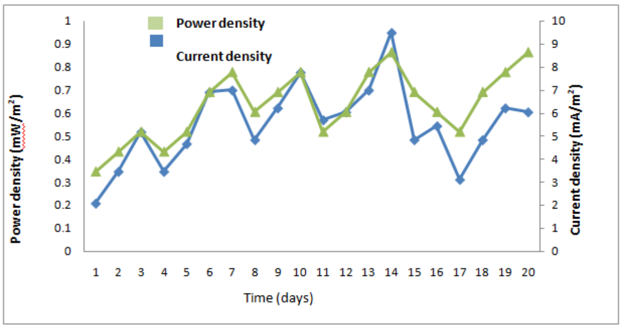

Fig.10. Power density and current density against time Tonner cell for a closed circuit.

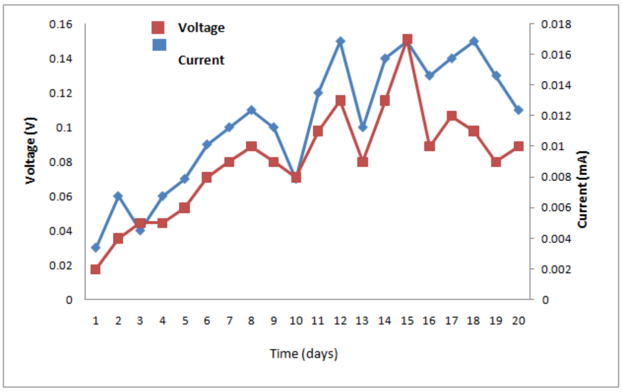

Fig.11. Voltage and current against time for wood ash cell for an open circuit.

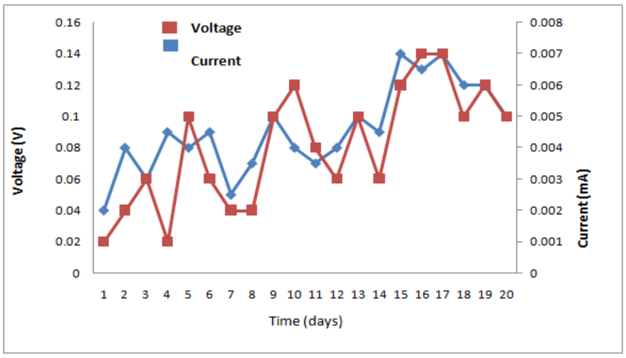

Fig.12. Voltage and current against time for groundnut shell cell for an open circuit.

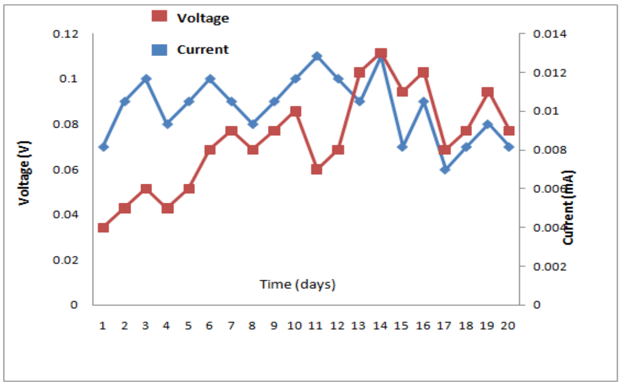

Fig.13. Voltage and current against time for tonner cell for an open circuit.

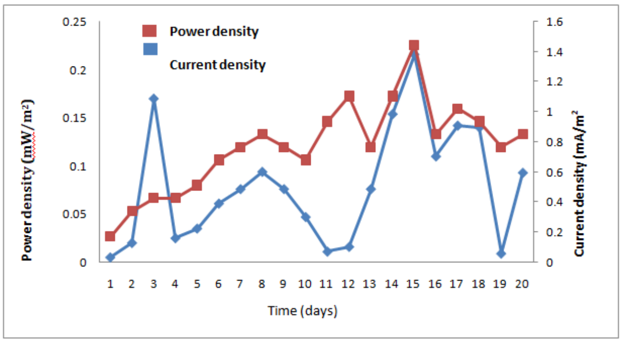

Fig.14. Power density and current density against time for wood ash cell for an open circuit.

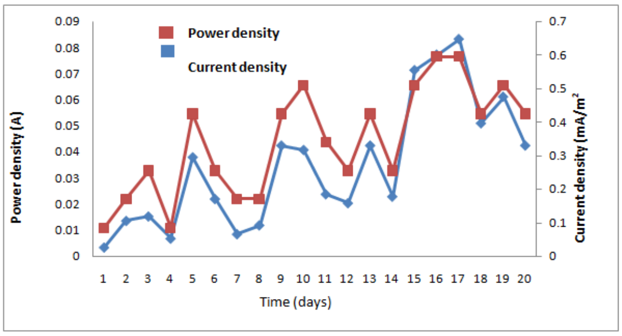

Fig.15. Power density and current density against time for groundnut shell cell for an open circuit.

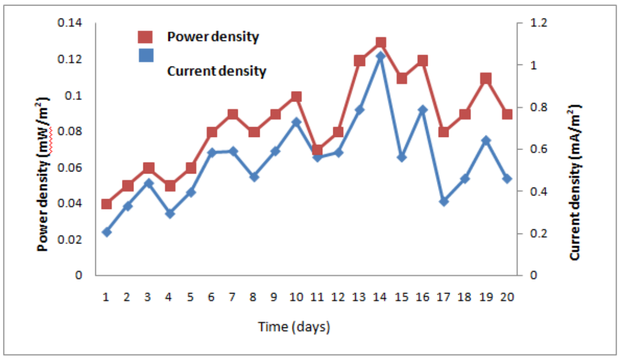

Fig.16. plot of power density and current density against time for Tonner cell for an open circuit.

2. Close circuit

2.1 Wood ash close circuit

For the wood ash closed cell, the minimum current and voltage produced were 0.01mA and 0.02V and its corresponding power and current densities are 0.8637mW/m2 and 0.0172mA/m2respectively. Also the maximum current, voltage and its corresponding power and current density are 0.17mA, 0.15V, 2.2024mW/m2, and 14.683mA/m2

2.2 Groundnut shell close circuit

For the groundnut shell closed cell, the minimum current and voltage produced were 0.01mA and 0.03V and its corresponding power and current densities are 0.0259mW/m2 and 0.8637mA/m2 respectively. Also the maximum current, voltage and its corresponding power and current density are 0.07mA, 0.13V, 0.7859mW/m2, and 10.3644mA/m2

2.3 Tonner close circuit

For the tonner closed cell, the minimum current and voltage produced were 0.04mA and 0.06V and its corresponding power and current densities are 0.2072mW/m2 and 3.4548mA/m2 respectively. Also the maximum current, voltage and its corresponding power and current density are 0.1mA, 0.11V, 0.7773mW/m2, and 7.7733mA/m2

3. Open circuit

3.1 Wood ash open circuit

For the wood ash open cell, the minimum current and voltage produced were 0.002mA and 0.03V and its corresponding power and current densities are 0.005mW/m2 and 0.17mA/m2 respectively. Also the maximum current, voltage and its corresponding power and current density are 0.017mA, 0.15V, 0.216mW/m2, and 1.445mA/m2

3.2 Groundnut shell open circuit

For the groundnut shell open cell, the minimum current and voltage produced were 0.001mA and 0.04V and its corresponding power and current densities are 0.0034mW/m2 and 0.085mA/m2respectively. Also the maximum current, voltage and its corresponding power and current density are 0.007mA, 0.14V, 0.0833mW/m2, and 0.595mA/m2

3.3 Tonner open circuit

For the Tonner open cell, the minimum current and voltage produced were 0.004mA and 0.07V and its corresponding power and current densities are 0.0238mW/m2 and 0.3401mA/m2respectively. Also the maximum current, voltage and its corresponding power and current density are 0.011mA, 0.013V, 0.1216mW/m2, and 1.1056mA/m2.

IV. CONCLUSIONS

Microbial fuel cells are evolving to become a simple, robust technology, as alternative source of power generation. It is also observed that MFC can be applied as a wastewater treatment method especially for produced wastewater treatment or for the modification of current conventional treatment plants. It also shows that the composition/source of the locally prepared electrodes (that is, source of charcoal) used in MFC, also contributes greatly to the efficiency of the cell. In this case the wood ash, groundnut shell and Tonner charcoals are explored and it's observed from the results above that the wood ash cell has a higher efficiency of power generation when compared to the other charcoals used as electrodes. And MFCs can also serve as an alternative renewable source of energy through bio-energy production. Over the years, microbial fuel cell has gained the world attention because of its integrated wastewater treatment and bio-energy production, thus it is a promising alternative for power generation when require attention is given.

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