Salt Removal for Recycling Hydraulic Fracturing Fluid Using the Microbial Fuel Cell

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Abstract: In this study, the potential of using two-chamber Microbial Fuel Cell (MFC) to remove salt for recycling the hydraulic fracturing fluid was investigated. In the anode chamber used vegetable oil was used with bacteria to produce biosurfactant in the anode chamber and very high concentration of salt solution representing the contaminated fracturing fluid was used in the cathode chamber. In two hour of MFC operation there was 8.28 mW/m2 power production, bio surfactant production in the anode chamber and the 17.5% salt content in the cathode chamber was reduced by 2.5 g/L/hr. Based on the literature review, the rate of salt removal in this study was very high.

1. Introduction: Removal of salt from hydraulic fracturing fluid is one of the challenging process because of very high concentration of salts (Olmstead et al., 2012) One method used to remove salt from waste water is by reverse osmosis and this process requires external power supply (Elimelech et al., 2011). Sea water reverse osmosis plants can remove nearly 99% of sodium and chloride (Greenlee et al., 2009). Microbial Fuel Cell is one of the energy efficient processes which can be used to treat waste water (He 2005; Vipulanandan et al. 2011). In recent years, MFC has been used to remove salt by using three chambers (Cao et al., 2009).

2. Objective: Investigate the potential of two-chamber microbial fuel cell to remove high concentration of sodium chloride from hydraulic fracturing fluid using only two chambers.

3. Materials and Methods: Two chamber MFC method was used where anode chamber was filled with 500 mL wastewater with used vegetable oil and the cathode chamber was filled with 17.5% NaCl solution. Carbon fiber brush was used as anode electrode and carbon mesh with basalt fiber was used as the cathode electrode. This MFC was connected with 1 kilo ohm external resistance and the voltage was monitored at half an hour interval. Changes in electrical resistivity of solutions in both chambers were also monitored. Gravimetric method was used to measure the salt content in the cathode chamber.

4. Results and Analysis

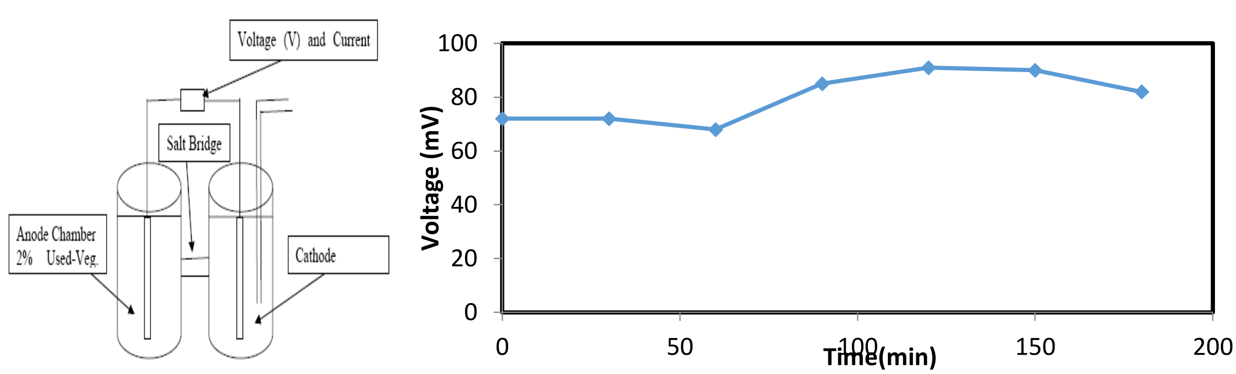

Figure 1. Microbial Fuel Cell (a) Schematic and (b) Variation of Voltage with time

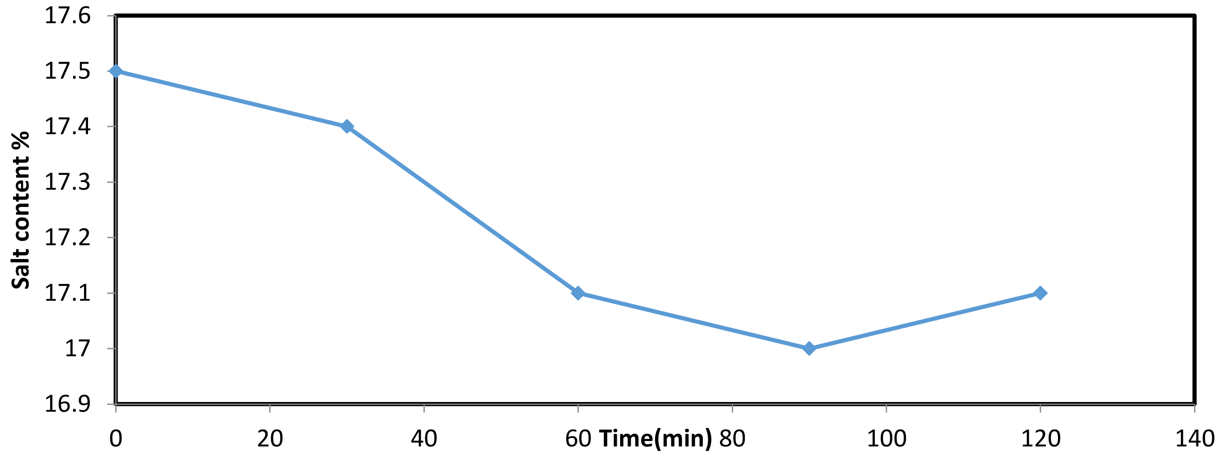

Figure 2. Variation of Salt Content in the cathode chamber

The MFC voltage varied from 70 to 90 mv (Fig. 1). Bacteria in the anode chamber oxidized the used vegetable oil substrate producing biosurfactants and electrons. These electrons were delivered to the cathode solution (closed circuit) resulting in the following reaction:

Na^{+} + electron → Na (1)

$4Cl^{-} + 2\,H_2O + O_2$ → 4HOCl (2)

Salt in the cathode solution was reduced from 17.5 % to 17 % after two hour of operation, rate of removal was 2.5 g/L/hour, considered to be one of the higher side of value reported in the literature (Fig. 2). In two hour of MFC operation produced 8.28 mW/m2 power.

5. Conclusion: Very high Salt content in the cathode chamber was reduced at the rate of 2.5g/L/hr. Maximum power production was 8.28 mW/m2. Also biosurfactant was produced in the anode chamber.

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7. References

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