# CHAPTER 7

# *APPLICATION*

# 7 APPLICATION

## 7.1 Electrochemical Cell Fabrication

From the results of room temperature electrical conductivity measurements and supporting characterization techniques, it is clear that the composition of AC + 0.4 g EC + 0.2 g $AgCF_3SO_3$ has the highest electrical conductivity and thus used as an electrolyte in the electrochemical cell fabrication. Here AC is used to designate chitosan. The anode and cathode materials used were as mentioned in section 2.10. The cathode also consists of carbon to ensure adequate electronic conductivity [94]. The cell configuration can be illustrated as follows:

Ag | AC + 0.4g EC + 0.2g $AgCF_3SO_3$ | AgI

This configuration is a modification of Liang's cell [6] Li/LiI/AgI where both the electrolyte and cathode are exclusively cationic conductors and the electrode may contain the electroactive material only. In Liang's cell, the discharge process involves the production of LiI at the anode-LiI electrolyte interface and the deposition of Ag at the interface of the cathode and the cathode current collector. In the present configuration, the electrolyte and the active material in the cathode are also cationic conductors. The discharge process therefore involves the production of AgI at the electrolyte-cathode interface and the reduction of silver ion at the interface of the cathode and the cathode current collector. Thus, the cell reaction still involves the production of AgI. Therefore, the maximum theoretical OCV is still expected to be

0.687 V. In order to investigate the performance of the cell, more than one cell were fabricated to study the open circuit voltage, self-discharge, internal resistance and discharge characteristics.

### 7.2 The Open Circuit Voltage (OCV)

The open circuit voltage is the voltage of the cell when no current is drawn from it. It is different from the potential difference of the cell, that is the voltage of the cell when a certain current has been drained out of the cell [95]. Since the electrolyte, exhibiting the highest conductivity is used to fabricate the cell and its bulk resistance is ≈ 900 Ω (Figure 4.1), the multimeter which has an internal impedance of several MΩ is suitable for the OCV measurement. Table 7.1 gives the value of OCV for each fabricated cell. These voltages are the result of half-cell reaction [96] between the anode and the cathode at equilibrium. The ions travel through the solid electrolyte of AC + 0.4 g EC + 0.2 g $AgCF_3SO_3$ complexes. From Table 7.1, it is observed that the average OCV of the fabricated cell is about 0.557 V.

Table 7.1: Open circuit potential values using AC + 0.4 g EC + 0.2 g $AgCF_3SO_3$ film.

| **Fabricated cell** | **OCV (V)** |
|---|---|
| C1 | 0.5024 |
| C2 | 0.5432 |
| C3 | 0.5148 |
| C4 | 0.5940 |
| C5 | 0.6284 |
| Average OCV (V) | 0.5566 |

### 7.3 The Internal Resistance

The internal resistance for the fabricated cells can be calculated using the equation in section 2.10.2. The internal resistance of the fabricated cell can be attributed to the impedance of the materials used and the interfacial electrode-electrolyte resistance. Usually, the internal resistance of the battery should be comparable with the impedance of the electrolytes used [97]. In this study, it was found that the internal resistance for a single cell (C1) is 1.2 kΩ and for cell connected in parallel (C4//C5), the value is still 1.2 kΩ. From the result of impedance spectroscopy the bulk resistance of electrolyte used is ~ 900 Ω. It is clear that the impedance of electrolytes used is lower than internal resistance of fabricated cell at room temperature. The difference of around 40% in value shows that the fabricated cells suffer from electrode-electrolyte interfacial resistance.

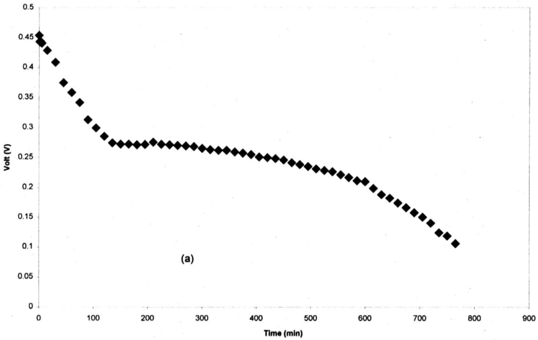
### 7.4 Discharge Characteristics

The discharge characteristics of an electrochemical cell can be described as the variation of the terminal voltage against discharge time at a constant load from which the lifetime or operating time of the cell can be determined. Figures 7.1 to 7.3 depict the discharge characteristics for the fabricated cells at a constant load, i.e. 11 MΩ. It can be observed that the voltage of each cell drops quite tremendously at the beginning of the discharge. As the discharge proceeds and current is drawn out of the cell, the voltage seems to be quite stable for many hours at the plateau region before it decreases again. This may be due to the buildup of the internal resistance in the cell [97] due to the low conductivity discharge product.

Referring to the V-t and I-t plots, the current density, discharge capacity, power density and energy density can be calculated. These parameters are depicted in Table 7.2 and it is obvious that cells connected in series and parallel show reasonably good discharge capacity, as well as better energy and power densities compared to the single cell. A 64 K microprocessor needs a cell of 100 μAh to last for several years. If these cells can maintain their charge and undergo very little self discharge, they can last longer than the cell with 100 μAh discharge capacity that could run the microprocessor.

**7.5 Summary**

We have shown that the highest conducting sample can be used to make a silver solid state polymer battery. When connected in series our result shows that the Ag | AC + 0.4g EC + 0.2g $AgCF_3SO_3$ | AgI battery has a capacity of ~1 mA-h.



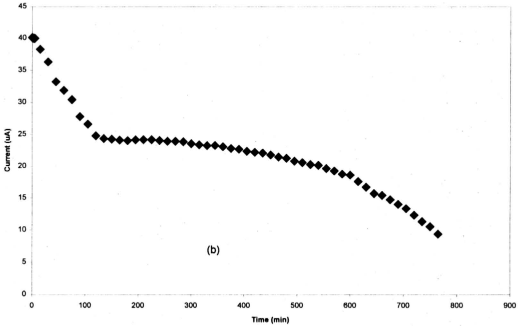




Figure 7.1: (a) Voltage and (b) current variant with time under a load of 11 MΩ for a single cell.

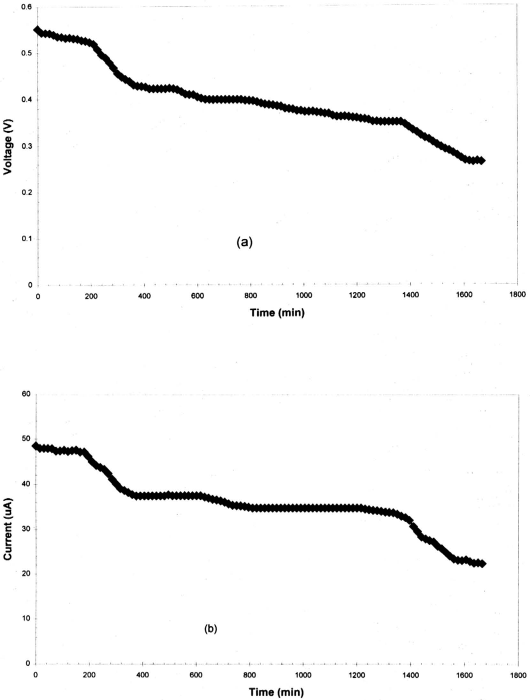



Figure 7.2: (a) Voltage and (b) current variant with time under a load of 11 MΩ for a cell connected in parallel.

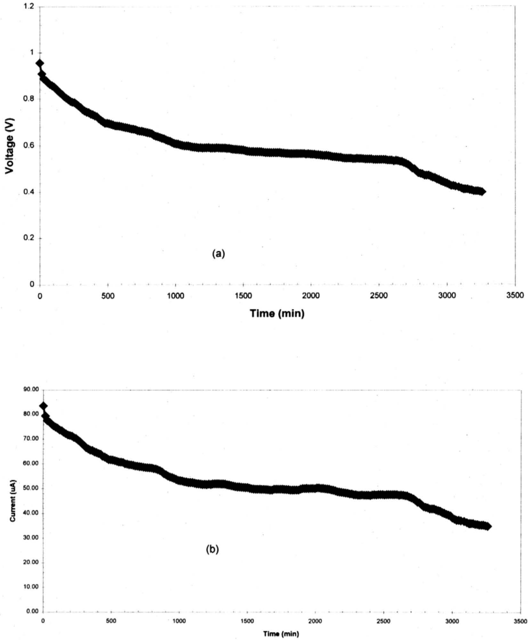



Figure 7.3: (a) Voltage and (b) current variation with time under a load of 11MΩ for a cell connected in series.

Table 7.2: Some parameters of the cells fabricated using the film with containing AC + 0.4 g EC + 0.2 g $AgCF_3SO_3$ and connected in series and parallel.

| Cell | Plateau Voltage (v) | Plateau current (μA) | Discharge time (h) | Weight of cell (g) | Current density ($\mu A/cm^2$) | Discharge capacity (μA-h) | Power density (W/kg $x10^{-3}$) | Energy density (J/kg) |
|---|---|---|---|---|---|---|---|---|
| Single (C1) | 0.3 | 24 | 6.00 | 2.4126 | 4.00 | 144.00 | 2.98 | 64.37 |
| Series (C2 & C3) | 0.6 | 50 | 22.75 | 5.0167 | 8.33 | 1137.50 | 5.98 | 489.76 |
| Parallel (C4 & C5) | 0.4 | 37 | 17.75 | 2.6728 | 6.17 | 656.75 | 5.54 | 354.01 |