Characterization of Iron Phthalocyanine as the Cathode Active Material for High Capacity Lithium-ion Batteries

Mohammed Albader
Advisor: Dr. Sarwan Sandhu

Introduction

The research/ development work presented here is on the characterization of iron phthalocyanine (FePc) as cathode active material to be used in higher specific lithium storage and energy density lithium-ion cells/batteries. Theoretical work suggested the control of the active material particle size for its optimum utilization during the discharge of lithium-ion cells. Also, the experimental work reported the lithium storage in FePc is equivalent to 2050 mAh/g FePc. This prompted us to further characterize FePc as a potential cathode active material for its application in the development of lithium-ion batteries to be employed for extended discharge periods.

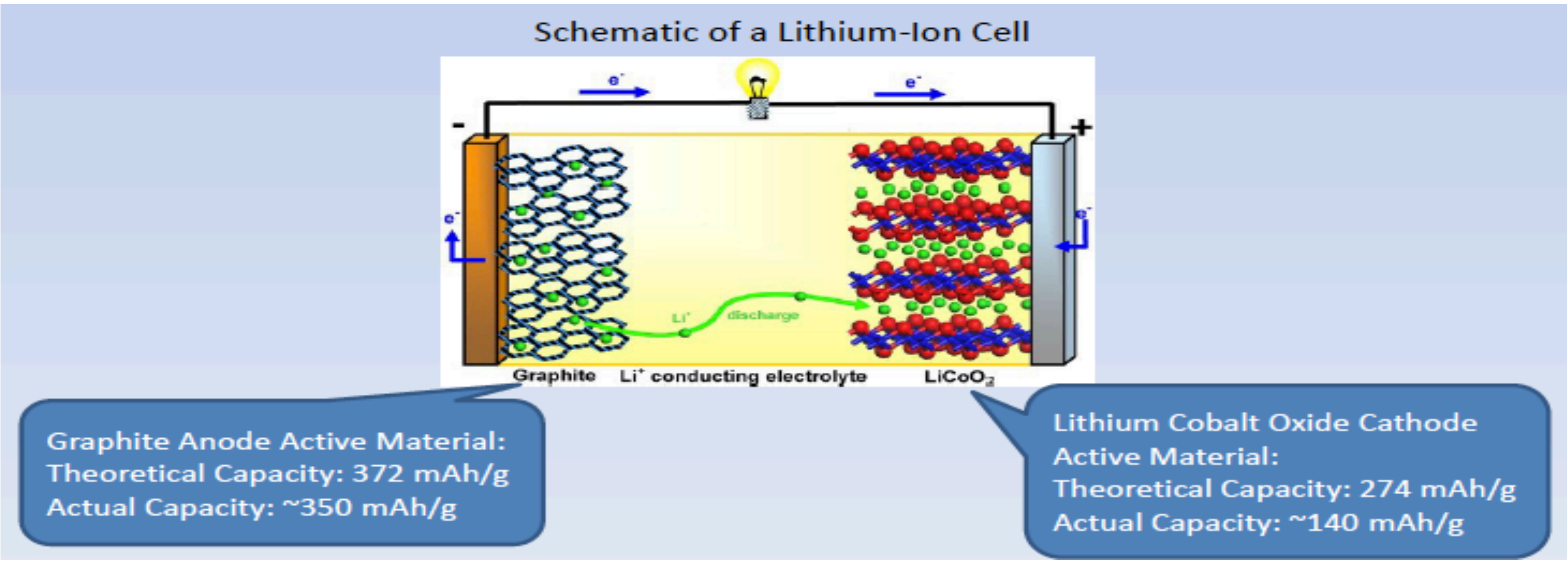

Figure 1: Schematic of a Lithium-ion Cell.

Experimental

Two types of cells were tested: 1) high temperature polyethylene oxide electrolyte-based lithium/FePc (HT FePc) cells and 2) room temperature organic liquid electrolyte-based lithium/FePc (RT FePc) cells. Both types of cells were assembled into cylindrical coin cells and then placed into a coin cell holder for testing. The HT FePc cells were tested at temperatures ranging from 80-100°C. The RT FePc cells were tested on the benchtop at room temperature (~20°C).

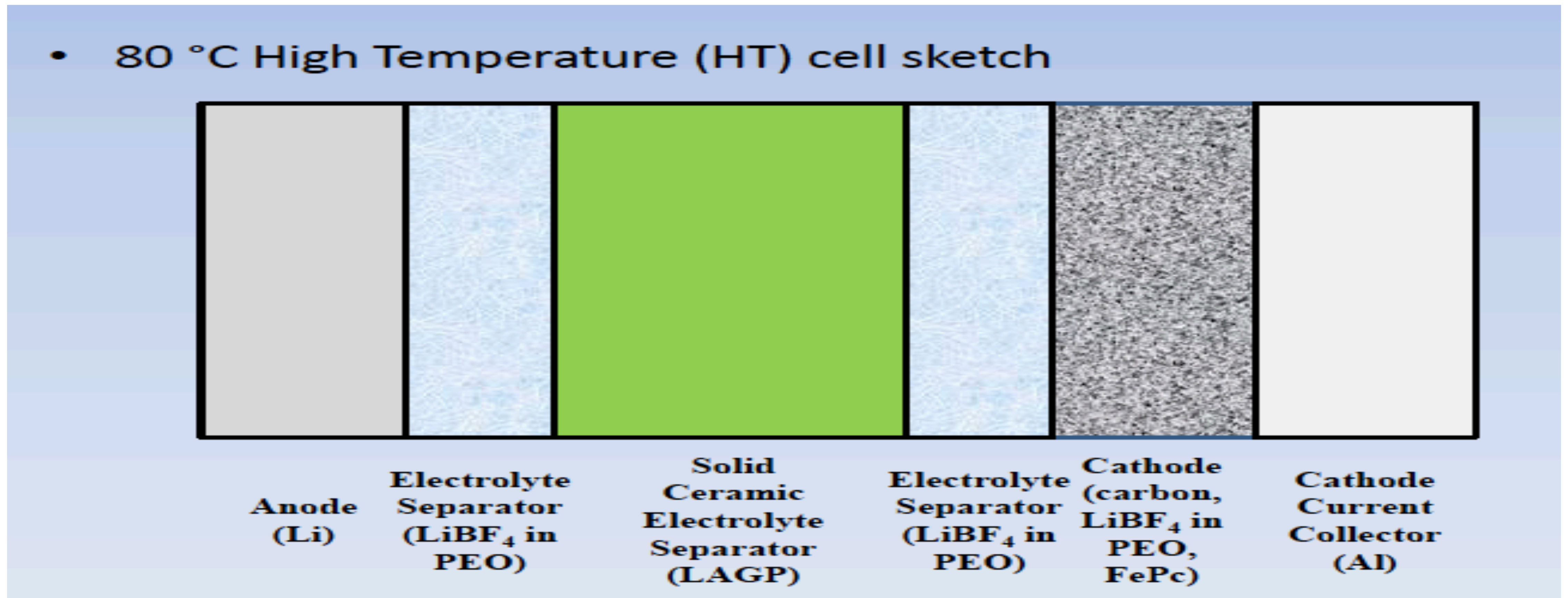

Figure 2: High Temperature (HT) cell sketch.

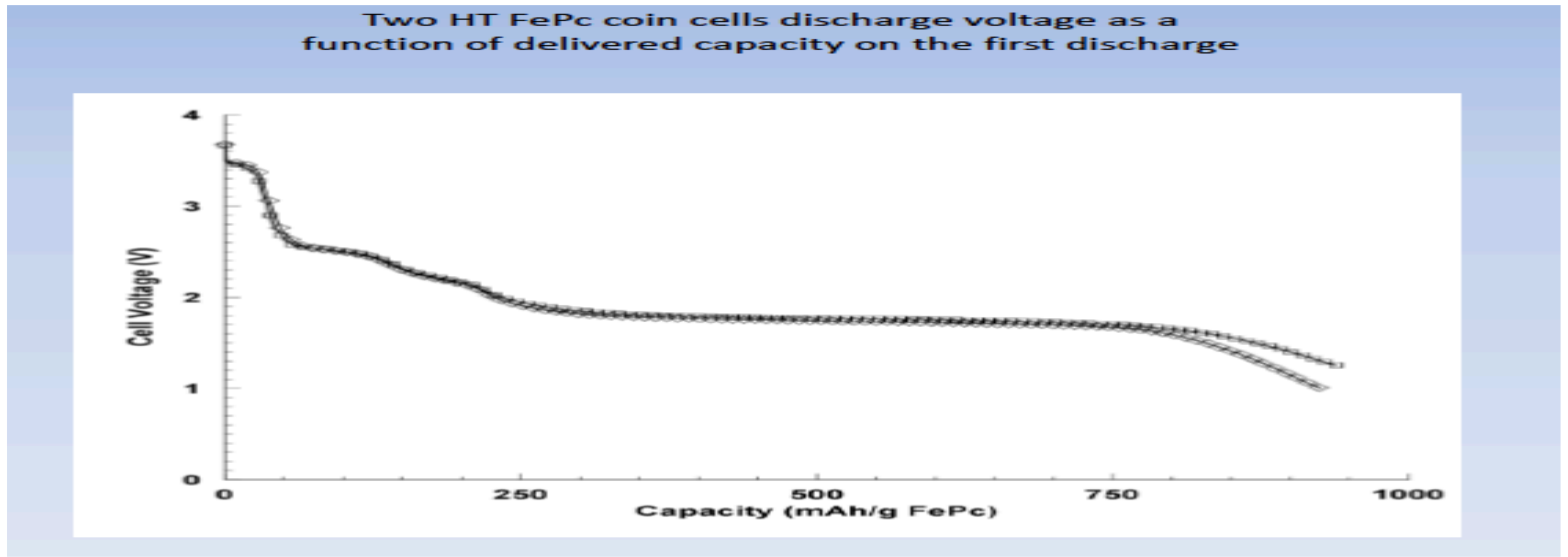

Figure 3: Two LT FePc cells discharge voltage as a function of delivered capacity on the first discharge.

Conclusion

Experimental data on the cell voltage versus capacity for a high temperature FePc cell at 80°C and a low temperature FePc cell at 20°C acquired at approximately 40 μA (~C/100 rate) in the presence and absence of FePc were presented. The data shows that the charge/lithium storage capacity of acetylene black is relatively much smaller than the total capacity of the cell. The lithium/FePc cell impedance experimental data in the form of Nyquist plots were employed to evaluate the lithium diffusion coefficients in the cell cathode active material FePc. The experimentally determined diffusion coefficients for the lithium ion penetration into the cathode active material are:

$80^\circ C,\ D = 7.74 \text{x} 10^{-12} cm^2/s$

$100^\circ C,\ D = 3.08 x 10^{-11} cm^2/s$

Diffusion activation energy= 75.7 kJ/mol-K

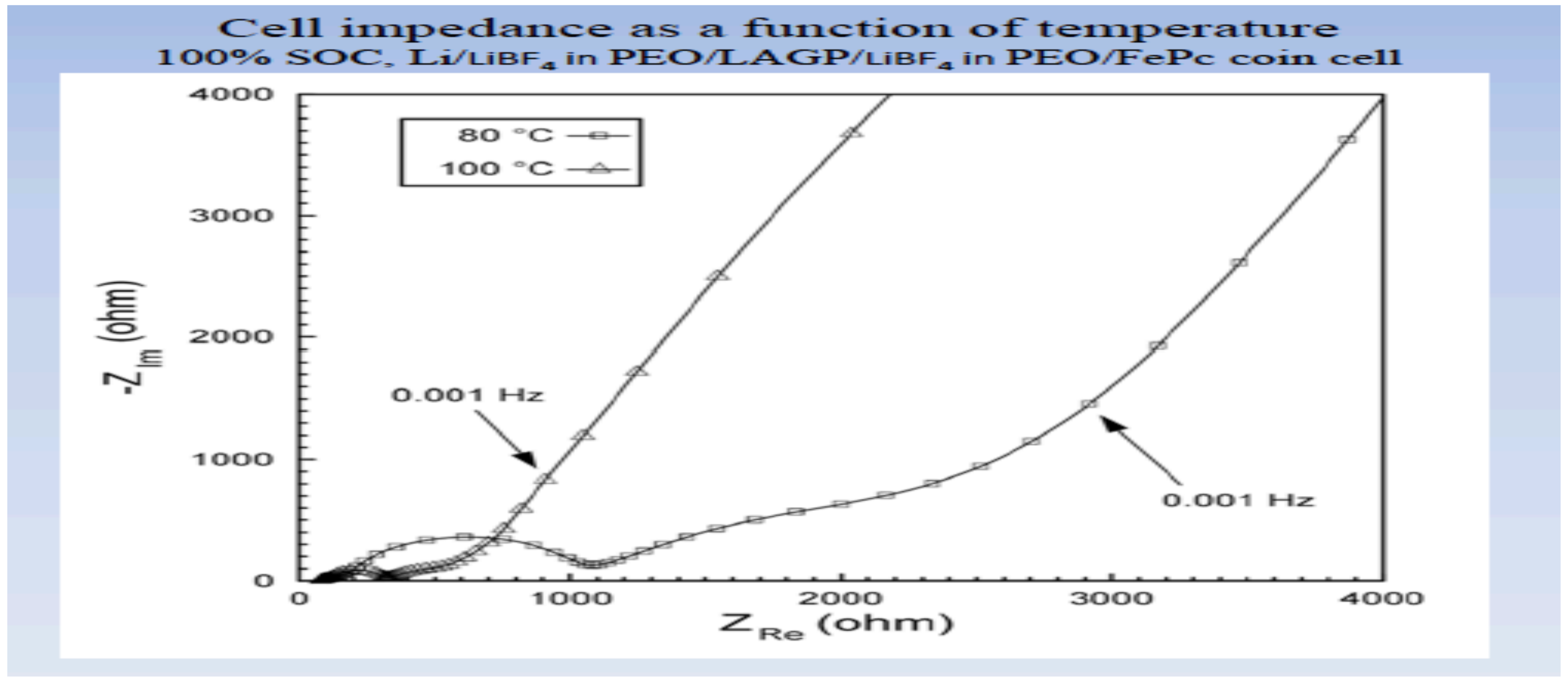

Figure 4: Cell impedance as a function of temperature for a HT FePc cell.

Acknowledgment

I thank Dr. Sandhu from the chemical engineering department for his support.