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Electrochemical double layer capacitors with PEO and Sri Lankan natural graphite

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Abstract. Electrochemical double layer capacitors (EDLCs) have received a tremendous interest due to their suitability for diverse applications. They have been fabricated using different carbon based electrodes including activated carbons, single walled/multi walled carbon nano tubes. But, graphite which is one of the natural resources in Sri Lanka has not been given a considerable attention towards using for EDLCs though it is a famous carbon material. On the other hand, EDLCs are well reported with various liquid electrolytes which are associated with numerous drawbacks. Gel polymer electrolytes (GPE) are well known alternative for liquid electrolytes. In this paper, it is reported about an EDLC fabricated with a nano composite polyethylene oxide based GPE and two Sri Lankan graphite based electrodes. The composition of the GPE was [{(10PEO: $NaClO_4$) molar ratio}: 75wt.% PC] : 5 wt.% TiO_2. GPE was prepared using the solvent casting method. Two graphite electrodes were prepared by mixing 85% graphite and 15% polyvinylidenefluoride (PVdF) in acetone and casting n fluorine doped tin oxide glass plates. GPE film was sandwiched in between the two graphite electrodes. A non faradaic charge discharge mechanism was observed from the Cyclic Voltammetry study. GPE was stable in the potential windows from (-0.8 V-0.8 V) to (-1.5 V-1.5 V). By increasing the width of the potential window, single electrode specific capacity increased. Impedance plots confirmed the capacitive behavior at low frequency region. Galvanostatic charge discharge test yielded an average discharge capacity of 0.60 Fg^{-1}.

Keywords: gel polymer electrolyte; graphite; electrochemical double layer capacitors; cyclic voltammetry; electrochemical impedance spectroscopy; galvanostatic charge discharge; nyquist plots; super capacitors

1. Introduction

Super capacitors, a kind of promising, uninterruptable power sources, have received an enormous attention during the last few years in a wide range of applications. They combine the high energy storage capability of batteries and high power delivery capability of conventional capacitors (Hashmi 2004). They are projected as power sources for high power applications such as hybrid/electric automobiles, military devices, utility load maintenance and medical applications.

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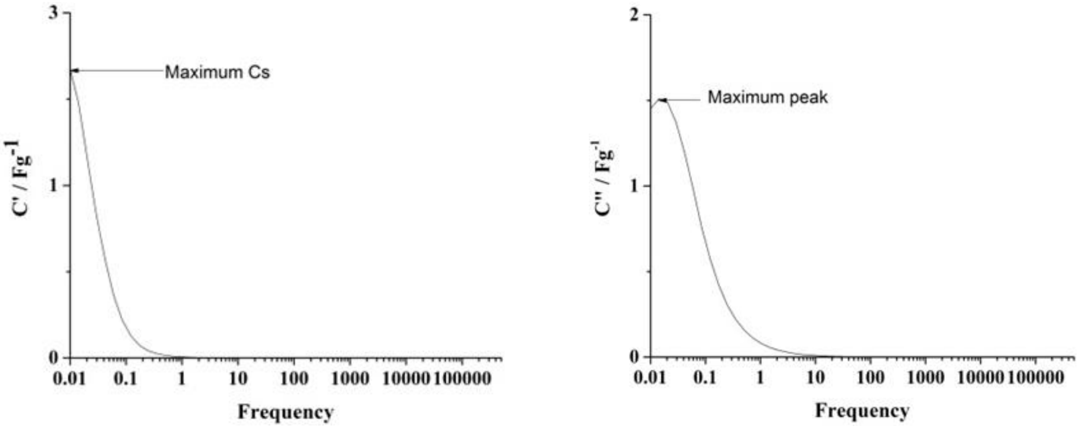
frequencies. This implies the attaining pure capacitive behavior at low frequencies. When the frequency is lowered, ion movement becomes higher and as a result, resistive nature vanishes allowing capacitive features to become dominant (Natalia *et al.* 2013). For ideal capacitors, this spike is perfectly parallel to the imaginary axis. In this study, it was not possible to obtain such a parallel line due to some surface roughness problems in the electrodes .

Fig. 3(a) and 3(b) show the variations of real and imaginary capacitances with frequency respectively. At lower frequencies in Fig. 3(a), the capacitive behavior is dominant but with increasing frequency, capacitive behavior tends to vanish and resistive behavior becomes dominant. The calculated single electrode specific capacitance is 2.1 F/g. The value of the relaxation time is found to be 11 s which is slightly higher for an EDLCs. This may be due to low rate of movement of molecules.



(a) (b)

Fig. 3 Variation of (a) real capacitance and (b) imaginary capacitance with the frequency

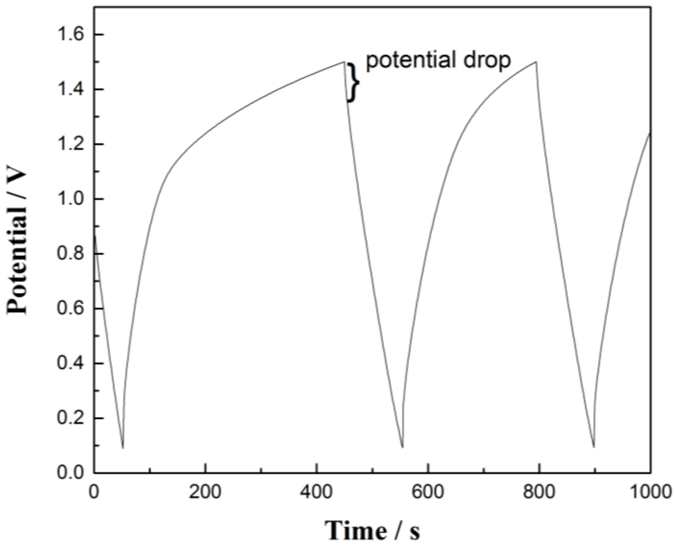


Fig. 4 The charge discharge profile of the EDLC

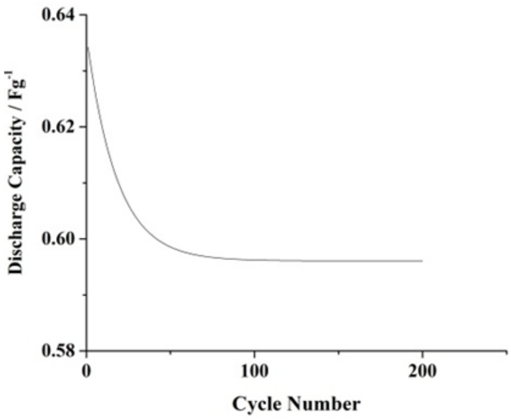


Fig. 5 Variation of C_d with time for EDLC

3.3 Galvanostatic charge discharge test

Fig. 4 illustrates the charge discharge profile of the EDLC.

Variation of C_d with time is shown in Fig. 5. Decrease in discharge capacity is observable initially but upon continuous cycling, it has attained a constant value of 0.60 Fg^{-1}.This proves the stable charge discharge processes in the EDLC (Li *et al*. 2008). C_s obtained from cyclic voltammetry test refers to the complete charge available for charge and discharge process whereas C_d refers only the charge available for discharge process. If the charge discharge processes are identical to each other, the amount of total charge should be twice the charge involved in each individual process. C_s and C_d values result from the present study prove the above fact very well.

4. Conclusions

An EDLC with a PEO based nano composite GPE and Sri Lankan natural graphite electrodes was fabricated successfully. The performance of EDLC was evaluated using Cyclic Voltammetry, Electrochemical Impedance Spectroscopy and Galvanostatic Charge Discharge Test. Single electrode specific capacity was in the range 1.28 Fg^{-1} to 2.06 Fg^{-1}when cycled in different potential windows. GPE was stable in a wider potential window like -1.8 V-1.8 V. The charge storage mechanism is of non-faradaic nature. Impedance data proves the dominant capacitive nature at low frequencies. Charge discharge profile obtained for 230 cycles gives an average discharge capacity of 0.6 Fg^{-1}. EDLC becomes stable and maintains a near equal discharge capacity after few initial charge discharge cycles. Further studies are being continued to improve the performance and thereby to provide a value to a Sri Lankan natural resource and also to initiate steps to fabricate low cost, environmental friendly EDLCs for future energy storage requirements.

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