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Glass wool material as alternative separator for higher rating electric double layer capacitor

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1. Introduction

Electric double layer capacitor (EDLC) has been widely applied in various modern practical applications due to its high cyclability, high power capability and adequate energy capacity [1]. There are two types of electrolyte that have been employed in EDLC construction; 1) aqueous electrolyte, which is relatively cheap but low energy density, and 2) organic electrolyte that has higher energy capacity but expensive. One way to achieve superior capacity and cheap EDLC is by employing high concentration aqueous electrolyte [2, 3]. However, none of conventional separator materials are capable to withstand high acidic or basic solutions. The present study evaluates a non-corrosive and cheap material, glass wool as alternative separator for higher rating and cheap EDLC design.

2. Experimental

Cheap glass wool was purchased from Johns Manville Corporate and used without any prior treatment. Aqueous solution sulfuric acid (1M H_2SO_4) was used as the electrolyte. With the use of two-electrode cell system (HS Test Cell from Hohsen Corp.), a symmetrical cell was constructed by sandwiching the glass wool-containing electrolyte with two activated carbon sheets (thickness of 0.15mm and 0.17mg in mass) from Nippon Valqua Corp. Test cell with typically used conventional separator, cellulose (NKK Corp.) was also constructed.

Cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS) and galvanostatic measurements were performed on each test cell. The CV and EIS measurements were carried out using an electrochemical system, HZ5000 (Hokuto Denko Corp.); while the galvanostatic measurement was conducted using a potentiostat, VersaStat4 (Princeton Applied Research).

3. Results and Discussion

As shown in Fig. 1, it can be seen that both tested cells have good capacitive behavior (nearly rectangular shape curve) with better behavior belongs to the glass wool-based cell (112F/g compared to 106F/g for cellulose separator).

Referring to the Nyquist plot of impedance data

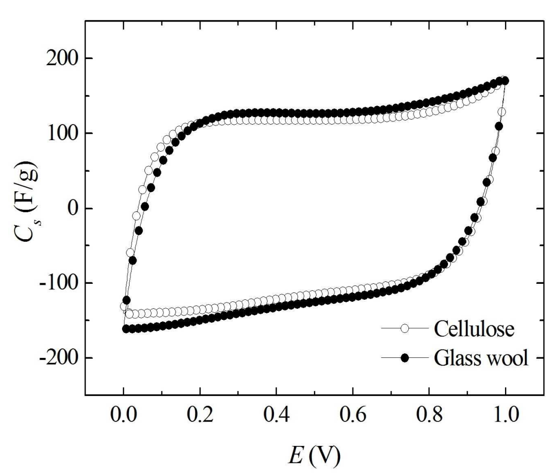

Fig. 1. Cyclic voltammogram (2mV/s) for cellulose- and glass wool-based test cells with 1M H_2SO_4.

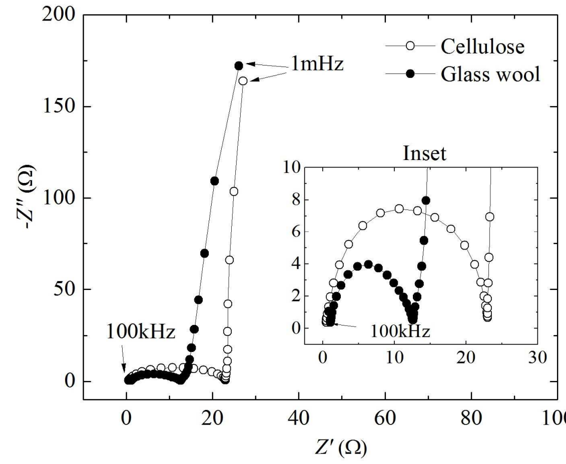

Fig. 2. Nyquist plot for cellulose- and glass wool-based test cell with 1M H_2SO_4 (Inset: High frequency region).

from EIS measurement (Fig. 2), both tested cells exhibit typical EDLC impedance behavior. Close-view to high frequency region reveals (inset in Fig. 2) that the glass wool-based cell has improved overall cell resistance (intersection of nearly-vertical lines to the x-axis) of 13Ω compared to cellulose separator (23Ω).

Fig. 3 indicates that the tested cell with glass wool as the separator has higher capacitance behavior compared to cellulose-based cell with specific capacitance of 131F/g and 120F/g respectively. From IR drop analysis, the glass wool-based cell has lower internal resistance of 13Ω compared to cellulose separator (19Ω). Interestingly, both parameters are in a good agreement with results obtained from CV and EIS measurements.

4. Conclusion

Compared to conventional separator material, significant performance improvement of the cell with glass wool separator suggests its high potential as alternative separator materials that may lead to higher rating EDLC design (utilizing high concentration electrolyte) at relatively low cost (compared to organic solution-based EDLC).

5. References

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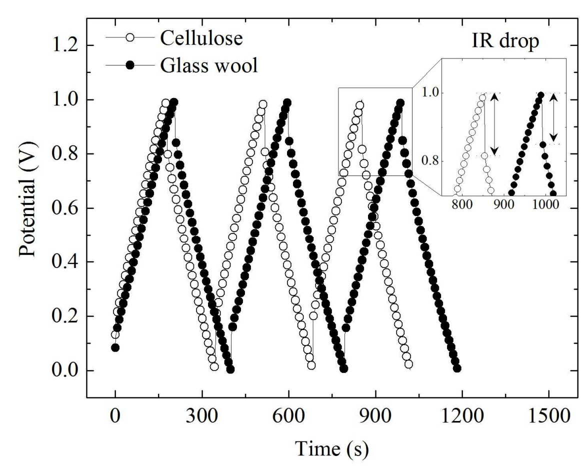

Fig. 3. Galvanostatic response for cellulose- and glass wool-based test cells with 1M H_2SO_4.