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The effect of Polytetrafluorethylene (PTFE) as binder of Carbon Electrochemical Double-Layer Capacitors (EDLCs)

In the 21st century, our global world faces with the consequence of our actions such as excessive use of fossil fuels and indiscriminate development. So in recent years, much interest in alternative energy along with powerful energy storage devices such as lithium ion batteries and supercapacitors have been paid due to their stable energy density and high power density to overcome serious global warming. The electrochemical double-layer capacitors (EDLCs) called as supercapacitor of ultra-capacitor can be applied to various applications, portable electronic devices and electric automobile car, particularly to the field of high-rate charge/discharge. EDLCs can be mostly used in energy storage systems (ESS) and electric-vehicles (EVs). The operating temperature of these applications ranges from -25 to 70℃. However, a great deal of research for EDLCs performance has been studied at room temperature (25℃). The components of EDLCs electrodes are activated carbon, conductive material, electrolyte, separator and binder. To maintain high capacitance at high temperature, all ingredients of electrode should endure this condition. So far, a variety of research have been carried out on electrode active material, separator, and electrolyte, however, much less analysis on binder have been conducted. In this study, we analyze the effect of Polytetrafluorethylene (PTFE) which has superior thermal stability as binder for EDLCs by utilizing FE-SEM, TGA, BET, Cycling, High rate capability, EIS, CV for physical and electrochemical characteristics. A few of commercial binder such as polyvinylidene (PVDF), styrene-butadiene rubber (SBR), sodium-carboxymethyl cellulose (CMC) and PTFE for EDLCs are available. Among these, PTFE has the highest thermal stability and we do experiment about the performance of EDLCs as compared to SBR. Figure 1 shows the thermal stability of SBR and PTFE by using thermogravimetric analysis (TGA). The decomposition temperature of each binder has a big gap that SBR decompose its structure around 390℃ but PTFE can tolerate heat disturbance over 550℃. To see the high rate of charge/discharge, we perform the rate capability test at 45℃. As you know that, EDLCs have advantages with fast charge/discharge so we can see the large amount of PTFE EDLC cell, which has high specific capacitance through this test with different current densities at high temperature in Figure 2. In electrochemical impedance spectroscopy (EIS), resistances significantly exist depending on the binder. The diameter of semi-circle indicates the charge-transfer resistance, R_{CT}. From the R_{CT}, it is enough to expect how much EDLCs have the internal resistance. By conducting diverse analysis, we try to inspect the characteristic of PTFE as binder of EDLCs.

References

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Figures

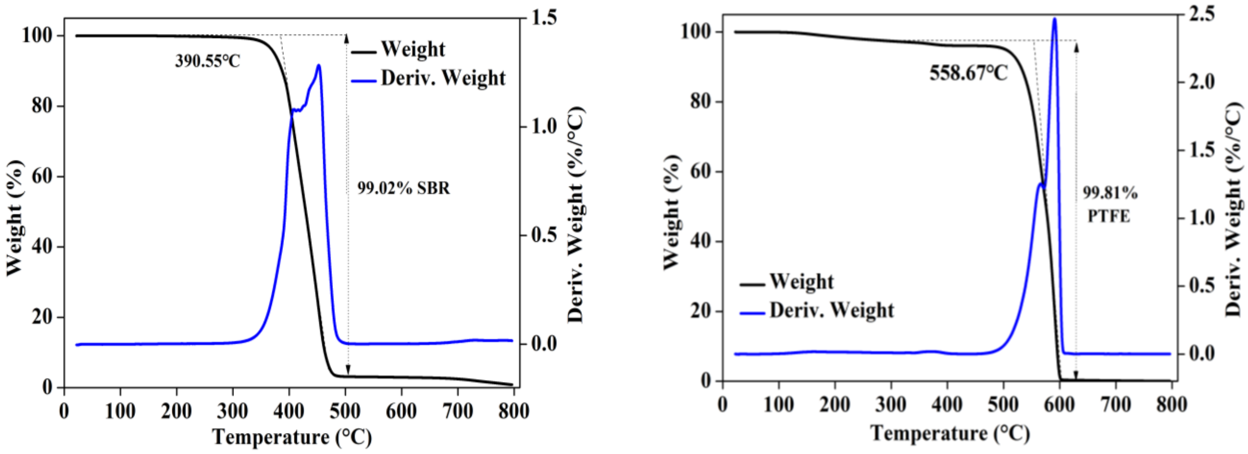

Figure 1: TGA result of SBR and PTFE with temperature range from room temp to 800℃

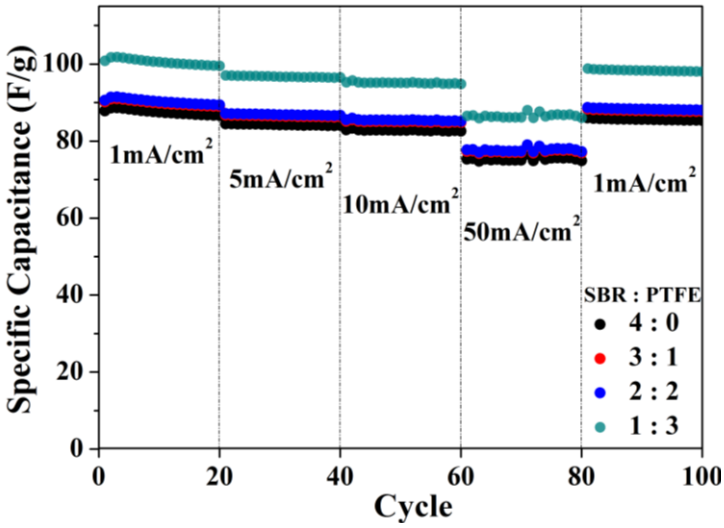

Figure 2: Performance of rate capability test with different currnt density for 20 cycles and voltage range from 0.1V to 2.7V at 45℃

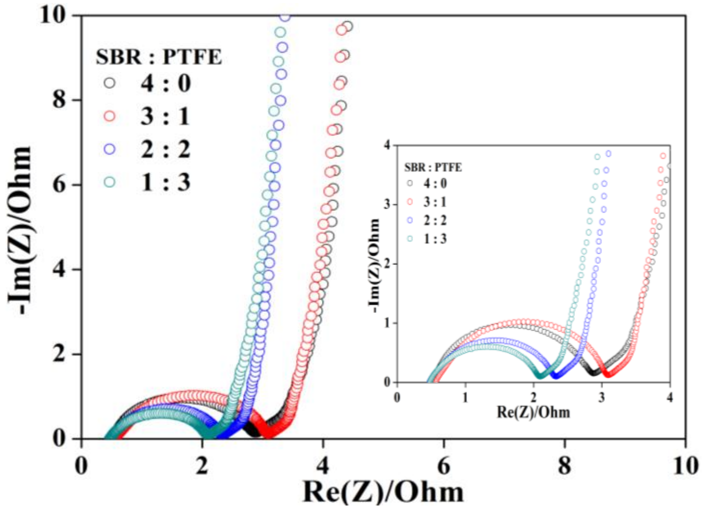

Figure 3: EIS data expressed as Nyquist plot with the frequency range from 10^{-2} to 10^{6} Hz, after rate capability test