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Influence of Electrode Mass Ratio on Capacitance of Electrochemical Double-Layer Capacitors

Introduction

Symmetric electric double-layer capacitors (EDLCs) use equal masses of the same active material in both electrodes. However, when the size of the hydrated electrolyte anions differs from the size of the hydrated electrolyte cations, an identical electrode weight will not result in the largest possible specific capacitance. In this case, the available electrode material and the electrolyte are not fully exploited. We show that one can increase the capacitance of EDLCs by adjusting the electrode masses to the size of the electrolyte ions.

Materials

- *electrode composition:* 50% batterygraphite + 50% activated carbon + additional 10% cellulose nanofibers
- *electrolytes:* 1M H_2SO_4, 1M KOH, 1M NaOH, 1M Na_2SO_4
- *separator:* greaseproof paper

Preparation of electrodes

- vacuum filtration on Millipore Durapore membrane filters
- same material in all electrodes, but different electrode weights
- theoretical electrode mass ratio $emr_{th}=(y \bullet r_B)/(x \bullet r_A)$ for electrolyte molecule A_xB_y

Testing of EDLCs

- stack of 2 electrodes+separator
- components were wet with electrolyte prior to assembly
- various emr were tested
- galvanostatic cycling between 0 and 1V at charge/discharge currents of 8mA/-8mA
- measured electrode mass ratio $emr_m=m_+/m_-$

Results

Table 1: Theoretical and measured electrode mass ratio (emr_{th}, emr_m), highest specific capacitance C_{sp} and specific capacitance increase C_{incr}.

Electrolyte	emr_{th}	emr_m	C_{sp}/Fg^{-1}	$C_{incr}/\%$
Na_2SO_4	0.53	0.75	49.28	3.66
H_2SO_4	0.67	0.75	89.71	1.53
NaOH	0.84	0.86	66.82	8.62
KOH	0.91	1	67.59	0

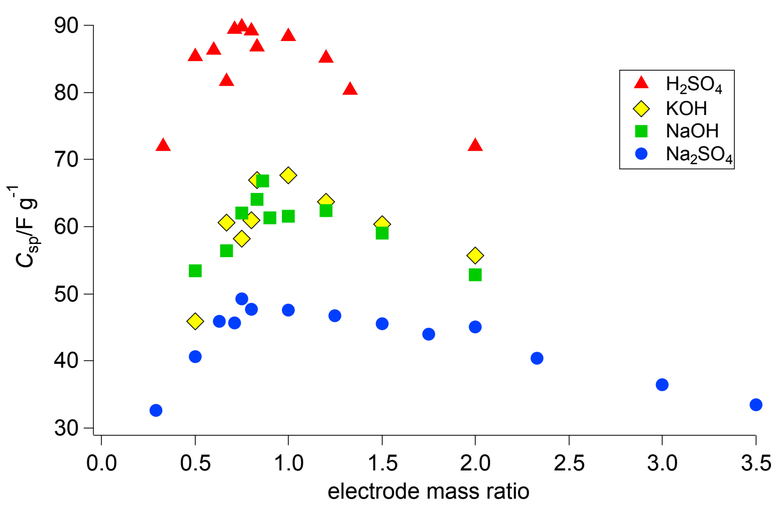

Fig.1: Influence of electrode mass ratio on specific capacitance of supercapacitors with various aqueous electrolytes.

Conclusion

We showed that the capacitance of EDLCs can be increased if the electrode mass ratio is adjusted to the ion size ratio. This optimization is favorable for improving the EDLC's performance, reducing the amount of unused electrode material and thus decreasing the cell weight and volume. The highest increase in specific capacitance could be achieved for EDLCs using sodium hydroxide as electrolyte. An increase of 8.6% was obtained by shifting the electrode mass ratio from 1 to 0.86. The highest specific capacitance was obtained with EDLCs using sulfuric acid as electrolyte. By changing from a symmetric electrode configuration to the optimal electrode mass ratio of 0.75, only a small increase in specific capacitance of 1.5% could be obtained for sulfuric acid.