# 移動式電源之可充式鋅-空氣電池與超高電容器之關鍵技術開發與整合

## Development and integration of key technologies in rechargeable Zn-air batteries and supercapacitors for the mobile powers

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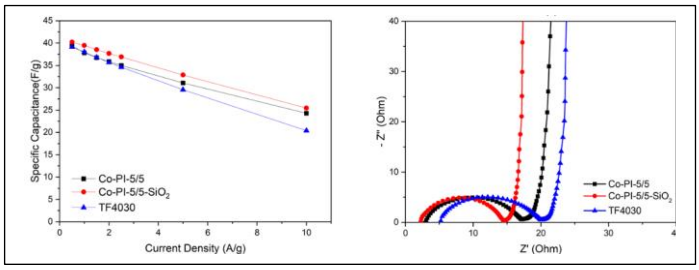
This project focuses on the development and integration of key materials and techniques for the rechargeable zinc-air batteries and supercapacitors as the power sources of mobile systems. There are five co-PIs in this project and the five topics under investigations in this 2-year project include (1) gas diffusion layer, (2) positive air electrode, (3) negative zinc electrode, (4) binders, electrolytes, and additives, and (5) supercapacitors.

For the organic supercapacitor part, functionalised PI separators with high electrolyte wettability and good thermo-dimensional stability provide high ionic conductivity for EDLCs.[1] The mechanical strength of PI separators can be further improved by a factor of 3 via the optimisation of ratio of soft and hard segments, and the introduction of 5% $SiO_2$ NPs. We also focus on the alleviation of the water-induced self-discharge process in non-aqueous EDLCs through the utilization of a PI separator coated with the PUPAA copolymer (denoted as PI@PUPAA).[2] The trace water in the non-aqueous electrolytes is effectively absorbed by the copolymer, leading to the obvious suppression of self-discharge in the EDLC cells. The introduction of $Al_2O_3$ nanoparticles into PI to form a PI+$Al_2O_3$@PUPAA composite separator substantially improves the electrochemical responses of EDLCs. Also, PVdF, carboxymethyl cellulose, and half-sodiated poly-(acrylic acid) are examined to find the influences of polymeric binders on the charge storage performances of expanded mesocarbon microbeads (EMCMB) as the positive electrode in the lithium-ion capacitors.[3] In comparison with the electrode using PVdF, EMCMB electrodes with the aqueous binders show a lower onset potential of electrochemical activation and a lower contact resistance. Both aqueous binders can increase the micro- porosity and specific capacitance of EMCMBs, confirmed by the EIS test.

For the Zn-air battery part, a simple method for preparing the gel electrolyte is reported to maintain a high water content within the gel, which is the key factor facilitating the high discharge rate of flexible zinc-air batteries.[4] The optimal flexible battery can be discharged at a large current density of 50 mA $cm^{-2}$ for 5 minutes and reaches a capacity of 37 mAh $cm^{-2}$ and a maximum power density of 64 mW $cm^{-2}$. ZnO precipitation is considered the main reason for the decay of both zinc and air electrodes. Furthermore, the binary (Ru-Sn)$O_2$ has been confirmed to be an excellent bifunctional electrocatalysts for the rechargeable Zn-air batteries and the rechargeable aprotic Li-$O_2$ batteries.[5] The Ru-enriched (Ru-Sn)$O_2$@GNW possessed high activity for complete oxidation of the discharge products, avoiding the accumulation and providing the accommodation space for discharge products, leading to the excellent discharge-charge stability.

Figure 1. (L) Specific capacitance-*i* curves, and (R) Nyquist plots of the EDLC with (1) Co-PI-5/5, (2) Co-PI-5/5-$SiO_2$, and (3) TF4030 separators.



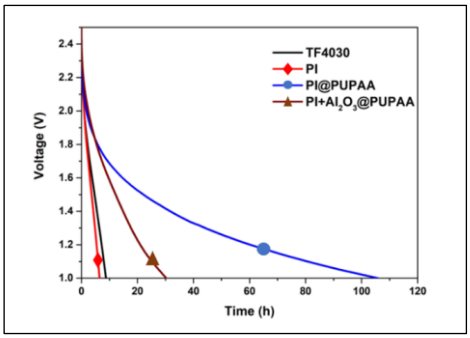
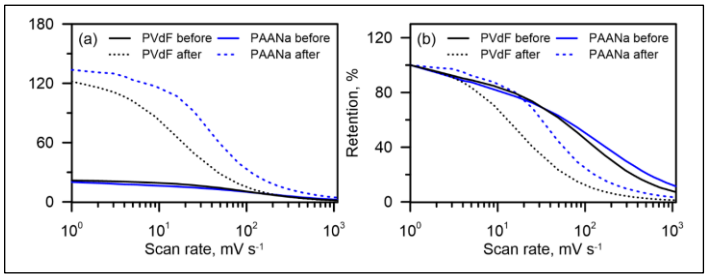
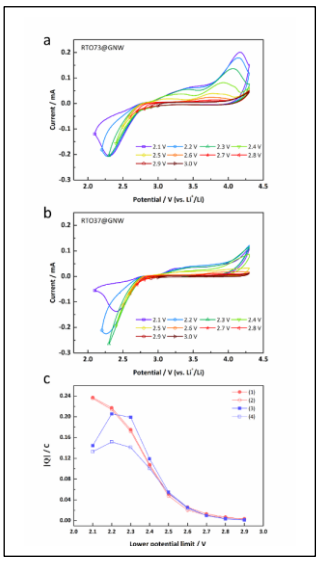




Figure 2. Self-discharge curves of EDLCs using (1, —) TF4030, (2, —) PI, (3, —) PI@PUPAA, and (4, —) PI+$Al_2O_3$@PUPAA separators in 1 M $TEABF_4$/PC containing 200 ppm water.

Figure 3. Dependence of (a) specific C and (b) capacitance retention on the scan rate of CV of EMCMB-PAANa and EMCMB-PVdF before and after activation at 3 V (vs. $Li^+$/Li).



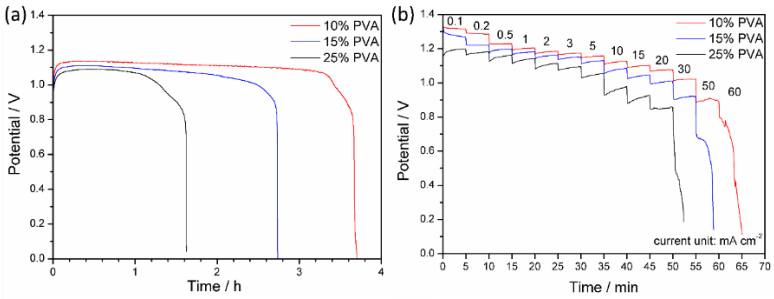




Figure 4. (a) Galvanostatic discharge curves at 10 mA $cm^{-2}$ and (b) quasi-steady-state discharge curves at various current densities for flexible ZABs using 10% PVA, 15% PVA, and 25% PVA gel electrolytes.

Figure 5. (a, b) CV curves at 0.5 $mV \cdot s^{-1}$ with $E_{SL}$ = (1) 3.0, (2) 2.9, (3) 2.8, (4) 2.7, (5) 2.6, (6) 2.5, (7) 2.4, (8) 2.3, (9) 2.2, and (10) 2.1 V. (c) Cathodic (1, 3) and anodic (2, 4) charges against $E_{SL}$ of CV for a Li-$O_2$ cell using (a, c1, c2) RTO73@GNW and (b, c3, c4) RTO37@GNW air electrodes.

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