A Comparative Study of Solid Pseudocapacitive Electrochemical Capacitors

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Polymer electrolytes are enablers for solid energy storage devices with high specific energy and power densities and thin, flexible form factors. They are not subject to liquid leakage, which can enhance the safety of the devices. Solid proton conducting polymer electrolytes, such as polyvinyl alcohol (PVA)-heteropolyacid(HPA)-H_3PO_4 have demonstrated ultrahigh rate capabilities and good stability for solid electrochemical double layer capacitors (EDLC) [1,2]. In addition to the solid EDLCs, solid pseudocapacitive devices also warrant a systematic investigation for their enhanced energy density without sacrificing their power density. In this study, we focus on solid pseudocapacitive capacitors enabled by the PVA- HPA-H_3PO_4 electrolytes.

A solid polymer electrolyte comprised of PVA-silicotungstic acid (SiWA)-H_3PO_4 with a proton conductivity around 0.02 S/cm was developed. Utilizing this polymer electrolyte, we assembled solid EC cells using pseudocapacitive electrodes such as RuO_2, polyaniline, and polypyrrole. These solid pseudocapacitive devices were tested together with their respective liquid electrolyte counterparts in 1 M H_2SO_4.

The electrochemical performance of the solid and liquid pseudocapacitive device is compared in Fig. 1. The solid and liquid devices demonstrated very identical CV profiles indicating an equivalent performance of solid and liquid electrolytes and a very good ionic accessibility for the PVA-SiWA-H_3PO_4 electrolyte. The CVs were obtained at a sweep rate of 1V/s, which demonstrated a high rate capability of the polymer electrolyte. Due to the electrochemical oxidation and reduction reactions, the areal specific capacitances of these devices were higher than that of the solid EDLC cells reported before [2]. Although the electrochemical reactions for each pseudocapacitive electrode are all different, their overall responses in the PVA-SiWA-H_3PO_4 electrolyte cells are similar. A more detailed analysis and comparison will be given.

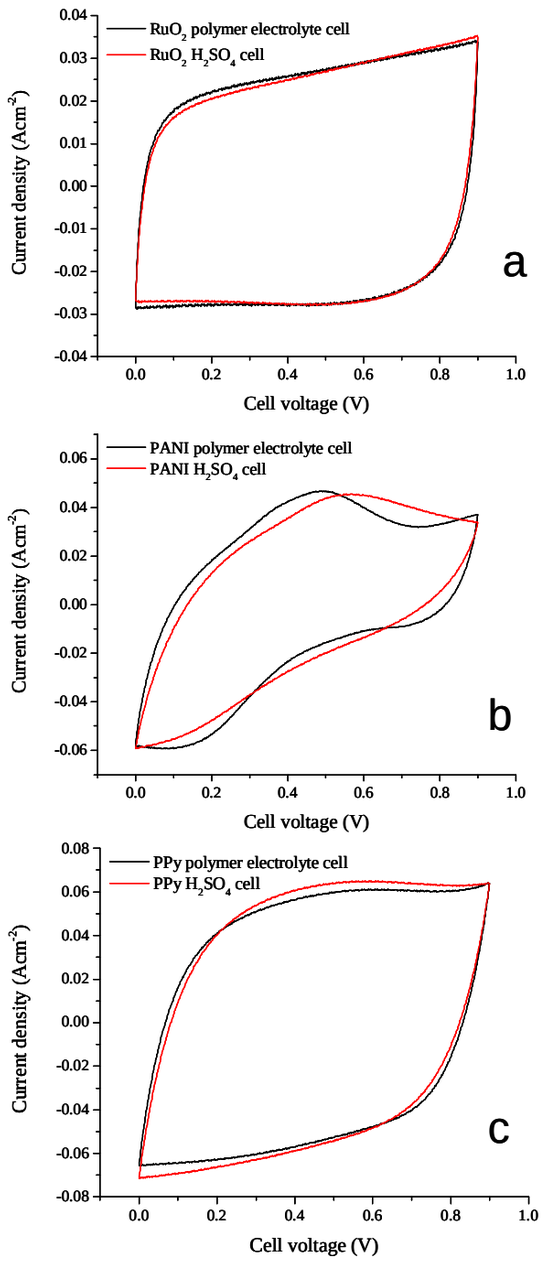

Fig. 1: CVs of some solid pseudocapacitive devices and their respective liquid electrolyte based devices; a) RuO_2, b) polyaniline, and c) polypyrrole. All devices were tested at a sweep rate of 1 V/s.

Reference:

1. H. Gao, H. Wu, and K. Lian, Electrochem. Comm. 17, 48, 2012.
2. H. Gao and K. Lian, J. Mater. Chem. 22, 21272-21278, 2012.