Yanchunxiao Qi
Minh Hien Thi Nguyen, Seul Lee, Eun-Suok Oh*
School of Chemical Engineering University of Ulsan, Ulsan 44610, Republic of Korea
esoh1@ulsan.ac.kr

The poly(styrene-pyrrole- acrylonitrile/butylacrylate)core-shell binder and its performance in anodes of Lithium-ion batteries

Nowadays, Lithium-ion battery (LIB) with high energy density becomes more and more popular because of the increase in demand of energy storage systems for portable electronic devices such as cell phones, laptops, cameras, electric vehicles, etc. In the matter of battery performance, one of the key factors for improving LIB's cycle life-time is improving the characteristics of its binder. With an effective binder, the connection between active materials and current collector after charge, discharge processes should be guaranteed and lead to a good performance. Besides, it's conductivity is also important. However, most of the polymeric binders we are using in Lithium-ion batteries are non-conductive. In recent years, much efforts have been done with several types of binders to enhance its adhesion strength, processability, or environmental friendliness, e.g. high adhesive polyvinylidenefluoride, polyacrylonitrile, polyvinylacohol, water-soluble carboxylmethyl cellulose, styrene-butadiene rubber, alginate, and so on. Less effort was paid on improving conductivity of binder, especially water-based binders. Therefore, in this study, we introduce a new conducting poly(styrene-pyrrole-acrylonitrile/butylacrylate) water-based binder with core-shell structure synthesized via catalytic oxidative polymerization of pyrrole and emulsion polymerization of styrene monomers, and acrylonitrile/butylacrylate monomers. And the poly(styrene-pyrrole-acrylonitrile/butylacrylate) particles size is around 50nm-70nm by the Transmission electron microscope(TEM) measurement (Figure1). As you may know, polypyrrole is one among the conducting polymers such as polyaniline, polyacetylene, polypyrene, polythiopene, polyphenylene, etc. and unfortunately, they are not able to dissolve in water but organic solvents. As a matter of fact, in LIBs the use of organic solvents is the cause of environmental problems and high cost. With the modification from polypyrroles to core-shell structure poly(styrene-pyrrole-acrylonitrile/butylacrylate) nanoparticles we hope to develop a new conducting and environmentally friendly binder for anodes of lithium-ion batteries.In this research, we use a small amount of ferric chloride ($FeCl_3$) and hydrogen peroxide (H_2O_2) to catalyze the oxidation of pyrrole. Sodium p-styrene sulfonate (NaSS), potassium persulfate (KPS) and sodium bicarbonate ($NaHCO_3$) were used as emulsifier, initiator and buffer, respectively for the emulsion polymerization of styrene core. We also use KPS and sodium dodecyl sulfate (SDS, Sigma-Aldrich) as initiator and emulsifier respectively for the emulsion polymerization of acrylonitrile/butylacrylate. Physical and electrochemical properties of poly(styrene-pyrrole-acrylonitrile/butylacrylate) were carefully examined to confirm the promise of using it as a conducting water-based binder for anodes of lithium-ion batteries.

Keywords: pyrrole; styrene; acrylonitrile/butylacrylate; conducting polymers; water-based binder.

References

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Figures

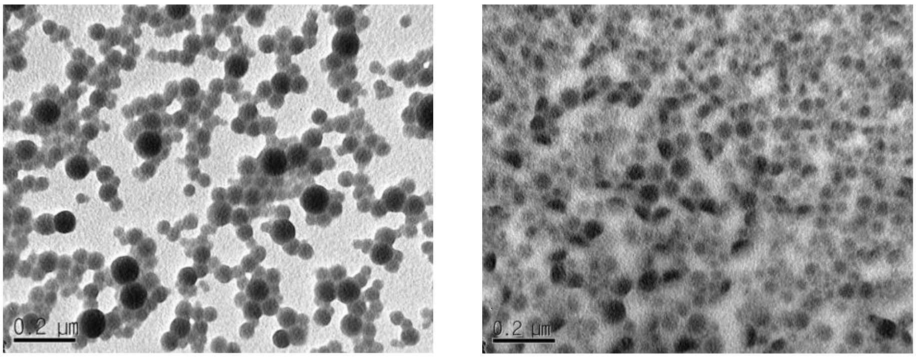

Figure 1: Morphology of PS-PPy5% (left) and PS-PPy5%-P(AN-BA) (right).

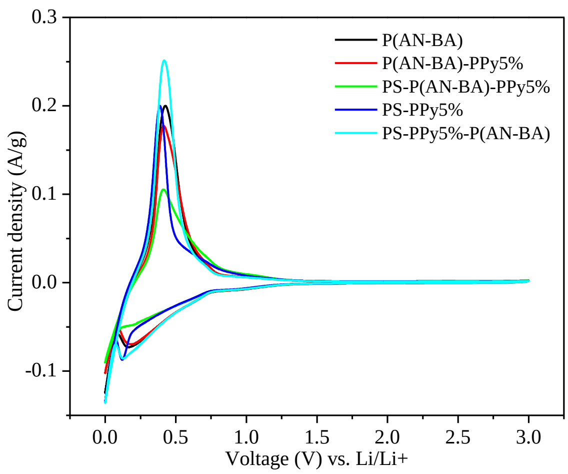

Figure 2: Cyclic voltammogram of the graphite electrodes of P(AN-BA) reference binder and our synthesized binders between 0 and 3V after charged and discharged for 2 cycles.

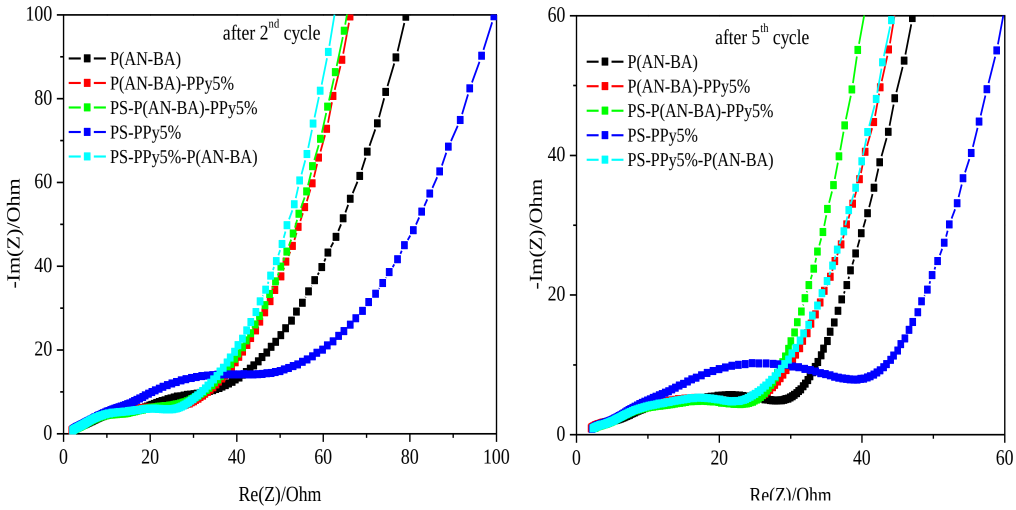

Figure 3: EIS results of the graphite electrodes containing our conducting polymeric binders measured after charged and discharged at 0.1C for two cycles (left) and then 0.5C for 3 cycles (right).