

Polypyrrole-Polyimide Composite for application in solid state Li⁺ ion battery

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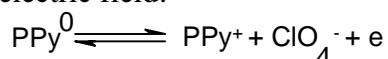
Application of intrinsically conducting polymers in solid-state Li⁺ ion polymer batteries has generated a lot of interest during the past few years. Polypyrrole (PPy) film was found to be switchable between the anion- and cation-exchanger states. Polyimides (PI) were chosen as a matrix for polymer filled conducting composites because it possesses electroactivity and excellent mechanical properties. PPy/PI conducting composite is studied for application as a solid polymer electrolyte for Li⁺ ion batteries, and under certain modifications as an active polymer anode.

Polyimide matrix was synthesized by casting and drying the poly(amic acid) (Pyralin) on the surface of stainless steel working electrode. PPy/PI Composite was prepared by electrochemical oxidative polymerization in a solution containing pyrrole monomer and potassium hexafluorophosphate electrolyte. Potential step amperometry was carried out and the current response after switching the potential between the charging and discharging values was recorded.

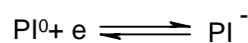
Cyclic voltammetry and potential step amperometry of the PPy/PI composite shows that PI matrix significantly increases the charge storage properties of PPy possibly because of the formation of complexes and charge transfer between PPy and PI.

The discharging behavior of free standing PPy films, and of the PPy/PI composites gives evidence of two processes: discharge of the double electric layer (faradic process) and dedoping (nernstian process). Faradic process does not require either oxidation or reduction of the polymer. Doping/dedoping involves change in the oxidation state. Transition between these two types of behavior at different amounts of charge passed is clearly indicated for the PPy/PI composite.

Charge and discharge behavior of polypyrrole/polyimide composite can be explained by a model shown below: during the first step of the reaction, PPy becomes doped. At this stage electron is drawn by applying of the external electric field:



where ClO₄ denotes a dopant. In the second step, electron is trapped by polyimide:



In the third step, electrostatic coupling occurs in the composite.



The electrochemical impedance spectroscopy of the PPy/PI composite shows presence of a time constant due to the PPy layer which forms a double electric layer with PI and stores a polarization charge. This time constant is not observable in freestanding PI. Application of a constant potential results in the appearing the new time constant possibly because of doping. At the same time diffusive behavior (Warburg part) becomes more capacitive that may be caused by ion depletion in polarized samples. Electrochemical impedance spectroscopy shows evidence of a double electric layer in the composite due to polarization of doped molecules.

Study of PPy/PI composite has shown its promising properties and potential for use in supercapacitors and polymer Li⁺ ion batteries.