Journal Article Volume 30, Issue 3 Cellulose Pages 1637 – 1656

One-pot preparation of highly porous paddy waste derived-cellulose-silica nanocomposite membrane separator for advanced performances of supercapacitor

Abstract

A new strategy was demonstrated to produce cellulose nanofibril-silica (CNF–SiO2) nanocomposite membrane separator for supercapacitor by one-pot synthesis of silica (SiO2) nanoparticles using different contents of tetraethyl orthosilicate (TEOS) precursor (0.9, 1.8, 2.7, 3.6 wt%). With the SiO2 nanoparticles acting as the disassembling agent, a highly porous CNF–SiO2 nanocomposite membrane was prepared using a simple solvent casting method. The CNF–SiO2 nanocomposite membrane with 1.8 wt% TEOS content (CNF-C2), exhibited the best properties with high porosity of 61%, electrolyte uptake ability of 260% and ionic conductivity of 5.0 mS cm− 1. Besides, the maximum thermal degradation temperature (Tmax) of the CNF–SiO2 nanocomposite membrane increased from 300 ℃ to 322 ℃, making it suitable for use within the operating temperatures of a supercapacitor. A symmetric supercapacitor assembled with CNF-C2 separator achieved the highest specific capacitance of 179.0 F g− 1 at 0.1 A g− 1 and energy density of 35.8 Wh kg− 1 at a power density of 240.0 W kg− 1. This CNF–SiO2 nanocomposite membrane helped the supercapacitor to achieve excellent electrochemical stability after 10,000 charge-discharge cycles with a capacitance retention and coulombic efficiency of 98.3% and 95.0%, respectively. The presented results proved that the CNF–SiO2 nanocomposite membrane is a good alternative separator in the supercapacitor application.

Keywords

Cellulose nanofibrils; Nanocomposites; Separators; Silica nanoparticles; Supercapacitors