Composite materials for supercapacitor electrodes utilizing polypyrrole nanotubes, reduced graphene oxides and metal–organic framework

Rudolf Kiefer[1], Irina Sapurina[2], Constantin Bubulinca[2], Lukas Munster[2], Ahmad Reshad Delawary[2], Nikola Bugarova[3], Matej Mičušík[3], Maria Omastova[3], Natalia E. Kazantseva[2], Petr Saha[2] and Quoc Bao Le[1,*]

[1]Conducting Polymers in Composites and Applications Research Group, Faculty of Applied Sciences, Ton Duc Thang University, Ho Chi Minh City 700000, Vietnam
[2]University Institute, Tomas Bata University in Zlin, Nad Ovčírnou 3685, 760 01, Zlin, Czech Republic
[3]Polymer Institute, Slovak Academy of Science, Dubravska Cesta, 9, 845 41 Bratislava, Slovakia

Polypyrrole (PPy) is favoured in energy storage for its high pseudo-capacitive performance, notably as polypyrrole nanotubes (PPyNTs) due to their easy synthesis, cost-effectiveness and electrochemical solid properties. Metal–organic frameworks (MOFs) have also gained attention for enhancing supercapacitors (SCs). In this study, we fabricated aerogel composites with PPyNTs, MOFs and reduced graphene oxide (rGO) as SC electrode materials. Varying concentrations of PPyNTs and rGO were explored, with MOFs added to assess their impact. Electrochemical tests revealed that the composite with PPyNTs and Zn-MOF achieved the highest specific capacitance of approximately 270 F/g at 0.5 A/g.

Keywords: Electrochemical devices, metal–organic framework, polypyrrole nanotubes, reduced graphene oxide, supercapacitor electrodes.

NOWADAYS, technological advancement with regard to traditional electric double-layer capacitors based on carbon materials have specific capacitance and energy storage limitations[4–6].

To overcome these limitations, conductive polymers like polypyrrole (PPy) have been utilized for their pseudo-capacitance properties, with PPy nanotubes (PPyNTs) showing promise due to their large specific area and charge transportability[7]. Moreover, metal–organic frameworks (MOFs) have shown exciting results when integrated into SC devices, enhancing energy storage capacitance through their electrochemical behaviour[8–10].

The present study evaluates the effect of one-dimensional PPyNT concentration in composites with rGO and MOFs on the performance of SCs. The composites were synthesized via a one-step hydrothermal method, with rGO as the matrix and PPyNTs and MOFs as reinforcements to improve their electrical properties. The resulting composites were evaluated as electrode materials for symmetrical SCs. Based on