Rational design of iron nitride/carbon cloth electrode as an anode for asymmetric supercapacitors

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It is essential to develop novel materials for batteries and supercapacitors in order to boost the effectiveness of energy storage systems and ease the switch from non-renewable to green and sustainable energy sources. Among them, asymmetric electrochemical capacitors and hybrid capacitors are strongly investigated to meet current performance expectations [1]. However, the device's electrochemical performance is directly correlated with the morphology and structural characteristics of the electrode material. Electrochemical capacitors can be divided into two distinct groups: electric double-layer capacitors (EDLC) and pseudocapacitors, of which the former consist of redox-active electrode materials like transition metal-based (Fe, Mn, Ru, Co) oxides, hydroxides, sulfides, or nitrides [2,3]. Iron compounds, including oxides and nitrides, are among the different materials utilized for negative electrodes and are regarded as a viable choice because of their electrochemical performance, wide working potential window, low cost, and natural abundance [4].

In this study, we investigated environmentally friendly synthesis protocol for iron oxide/carbon cloth (Fe_2O_3@CC) composite electrodes. Iron oxide was used as the precursor for the formation of iron nitride and was electrochemically deposited on hydrophilic carbon fabric using a typical three-electrode setup at a constant potential of -1.4 V vs. Ag/AgCl and an electrolyte of 0.02 M $FeCl_3$. The conversion of iron oxide to iron nitride was performed using high temperature annealing in ammonia atmosphere.

According to the obtained results, iron nitride-carbon cloth electrodes exhibit battery-like behavior, showing both visible peaks at the desired potential and a clear plateau during galvanostatic charge and discharge experiments. Due to the increased electrical conductivity of the nitrides, flexible electrodes with deposited iron nitride demonstrated significantly greater capacity retention with increasing current loads compared to their iron oxide counterparts. XRD measurements revealed that electrochemical deposition protocol yields an amorphous inorganic phase, which can provide electroactive sites for redox reaction. Finally, the iron nitride-carbon cloth electrode was used as the anode of an asymmetric system, combined with an Mn-based cathode.

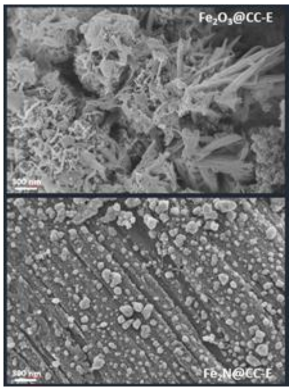

Figure 1. FESEM images presenting morphology of the flexible iron-based electrodes.

The findings show the possibility of flexible iron-based electrodes for use in supercapacitors or hybrid capacitor applications.

Acknowledgements

The following research was financially supported by the Small Grant Scheme - NOR/SGS/DesignHyCap/0189/2020 funded by The National Centre for Research and Development, Poland.

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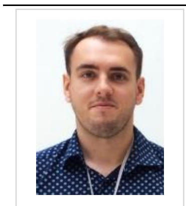

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