Report on the outcomes of a Short-Term Scientific Mission[1]

Action number: **E-COST-GRANT-CA20126-564bd979**

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Details of the STSM

Title: ***Development and characterization of composite electrodes based on porous graphene materials for energy storage devices***

Start and end date: 14/10/2022 to 24/10/2022

Description of the work carried out during the STSM

Composite single electrodes were prepared using six different materials based on reduced graphene oxide (rGO) in form of aerogels/powders and studied in the three-electrode system.

The following rGO-based materials were used:
- rGO_{FD}: rGO with sodium dodecyl sulfate (SDS) surfactant obtained by freeze-drying (FD) process and annealed at 180 ^{o}C for 5 h in vacuum;
- rGO_{HT}: rGO with SDS obtained by hydrothermal (HT) method at 160 ^{o}C for 10 h;
- $(rGO,Ti)_{FD}$: rGO with SDS and with titanium butoxide mixed to obtain the porous aerogel by the FD process and annealed at 180 ^{o}C for 5 h in vacuum;
- $(rGO,Ti)_{HT}$: rGO with SDS and with titanium butoxide mixed to obtain the porous material by the HT method at 160 ^{o}C for 10 h;
- $(rGO,Mn)_{FD}$: rGO with SDS and with Mn-based chemicals ($KMnO_3$+$Mn(NO_3)_2 \cdot 4H_2O$) mixed to obtain the porous aerogel by the FD process and annealed at 180 ^{o}C for 5 h in vacuum;
- $(rGO,Mn)_{HT}$: rGO with SDS and with Mn-based chemicals mixed to obtain the porous material by the HT method at 160 ^{o}C for 10 h.

[1] This report is submitted by the grantee to the Action MC for approval and for claiming payment of the awarded grant. The Grant Awarding Coordinator coordinates the evaluation of this report on behalf of the Action MC and instructs the GH for payment of the Grant.

The composite electrodes were prepared by mixing 80% of the active materials with 10% of carbon black (CB) and with 10 % of polytetrafluoroethylene (PTFE) and studied by the three-electrode system. A homogenous paste was obtained as a result of thorough mixing.

Freestanding electrodes were prepared by a screen-printing method and dried at ~60 °C in vacuum. Electrodes with 1 cm^2 area were cut and fixed by carbon glue on stainless steel support.

In addition, after several tests the samples with PTFE, several composite slurries were prepared from the corresponding components with polyvinylidene fluoride (PVDF) and were covered onto Ni foam, and dried in vacuum.

All samples were tested in three-electrode system and investigated by different electrochemical methods such as cyclic voltammetry (CV), galvanostatic charge and discharge (GCD) and impedance spectroscopy.

Description of the STSM main achievements and planned follow-up activities

Cyclic voltammetry (CV), galvanostatic charge and discharge (GCD) results obtained on composite single electrodes prepared using different materials based on rGO in form of aerogels/powders will be used to calculate the values of the specific capacitance for prepared and tested electrodes.

Based on impedance spectroscopy (Nyquist and Bode plots) all measured electrodes represented capacitive behaviour. However, the time of the discharge was found very short for all measured electrode. In addition the possible specific capacitance (approximated from GCD) could be not high probably due to low surface area of the initial materials.
Thus, the deep analyses of the obtained measurements and following discussion will be done.

Due to preliminary analysis shows that CV area of the electrodes with PVDF is larger than that with PTFE, corresponding composites with PVDF could be tested in the future.

Due to connection of the tested electrodes on stainless steel was found not optimal, the carbon paper can be used as support for the further measurements.

Moreover, the processing detail alterations to obtain materials with high surface area as well as the preparation of electrodes with improved electrochemical properties will be applied (to use a special conductive additives and polymer binders).