**EUROPEAN COMMISSION**

HORIZON 2020 PROGRAMME - TOPIC H2020-LC-BAT-2019
Affordable High-Performance Green Redox Flow Batteries

GRANT AGREEMENT No. 875613

# HIGREEW – Deliverable Report

## D2.3 – Electrode activation and surface modification protocols

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| **Deliverable No.** | HIGREEW D2.3 | |
| **Related WP** | 2 | |
| **Deliverable Title** | Electrode activation and surface modification protocols | |
| **Deliverable Date** | 2021-08-31 | |
| **Deliverable Type** | REPORT | |
| **Dissemination level** | Confidential – member only (CO) | |
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| **Approved by** | E. Sánchez (CICe) | 2021-08-31 |
| **Status** | Final | 2021-08-31 |

*Disclaimer/ Acknowledgment*



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875613. The information and views set out in this publication does not necessarily reflect the official opinion of the European Commission. Neither the European Union institutions and bodies nor any person acting on their behalf, may be held responsible for the use which may be made of the information contained therein.

## Publishable summary

HIGREEW project aims at the construction of pilot-scale redox flow battery stacks with new aqueous organic electrolytes: low cost organic molecules dissolved in aqueous supporting electrolytes and permitting reaching high power density. Electrodes suitable for this application are carbon and graphite felts, materials exhibiting tremendous porosity (>90%) and high specific surface area. However, these materials' electrochemical properties have been known to be extremely sensitive to their surface state, which is altered via activation treatments in order to enhance their wettability and the resulting heterogeneous charge transfer kinetics of redox couple used in the battery. These activations are often mere thermal treatments, but other physical-chemical steps have also been reported in literature, although rarely with molecules of interest to HIGREEW project. In order to target the best possible operating conditions for the batteries, it is therefore of interest to be able to thoroughly quantify and characterize the kinetics of redox couples promoted in HIGREEW project on a wide selection of carbon felts.

Unfortunately, determining intrinsic kinetic constants is often difficult with porous materials first due to their high surface area, and second to their porous structure which limit the number of electrochemical techniques applicable and require complex models to be applied for rigorous interpretation. In this part of the project, a selection of commercial felts was studied, along with their activation treatment carried out by the providers. Methods privileged were cyclic voltammetry and electrochemical impedance spectroscopy. A gradual analysis, starting from a simple equivalent circuit and finishing with a more complex physical model was undertaken. Apparent and intrinsic kinetic constants were obtained, specific surface area have been estimated from two different approaches: the physisorption measurements using BET method and non-faradaic current measurement method. These results were then compared to an analysis using electrochemical impedance spectroscopy on carbon fibre microelectrodes directly extracted from the felt, which was considered to be the most reliable and powerful technique to estimate kinetic constants of fast redox couples on such materials. Ultimately, different treatments were carried out, and their effect on redox reaction kinetics was determined with microelectrodes using first a semi-quantitative approach relying on cyclic voltammetry which was confirmed by EIS quantitative approach for the treatment giving the best results.