SUMMARY OF THE THESIS

In the following, the summary of the main results achieved during the PhD period is reported. Since it is possible to identify 3 main topics, this summary will be divided into 3 sections, each one for each single topic.

CAPMIX

In order to improve as much as possible the energy and power production of a Capmix device, it was decided to exploit a cation exchange membrane (CEM) and a functionalized graphene oxide (fGO) to modify the electrodes' surface. The aim was to induce inside the supercap a spontaneous potential able to already polarize the electrode and generate the electrical double layer required for the energy harvesting with this technology. The modification introduced affects the surface of carbon-based electrodes, since in both cases the CEM and the fGO are casted in liquid phase over the electrode and then dried under vacuum conditions to ensure a conformal coating. Results are reported in figure 1.

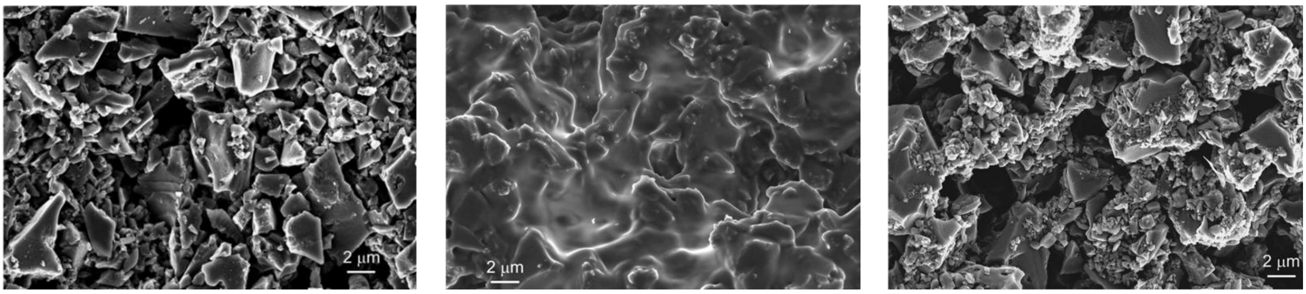

Figure 1. FESEM images of the obtained electrodes. From left to right: bare activated carbon (AC), AC coated with CEM, AC coated with fGO.

Exploiting this coating technique together with a proper optimization of the procedure, it was possible to obtain a net power output of 12 mW cm^{-2}, with good stability over prolonged measurements.

SUPERCAPACITIVE SWING ADSORPTION

The work on supercapacitive swing adsorption had the purpose to introduce and test the mass balancing concept. The final goal was to improve the adsorption capacity of the overall device, by enlarging the operative voltage window. As depicted in figure 2, this goal was achieved in the case of a bare activated carbon device with a mass ratio $m_+/m_-=0.8$ (red curve), which showed an adsorption capacity of about 100 mmol/kg, much higher than the generally used configuration (green curve, about 70 mmol/kg). However, a drawback arose: the energy spent by the mass balanced device is much higher than the energy spent by the unbalanced one (about 120 kJ/mol vs about 40 kJ/mol).

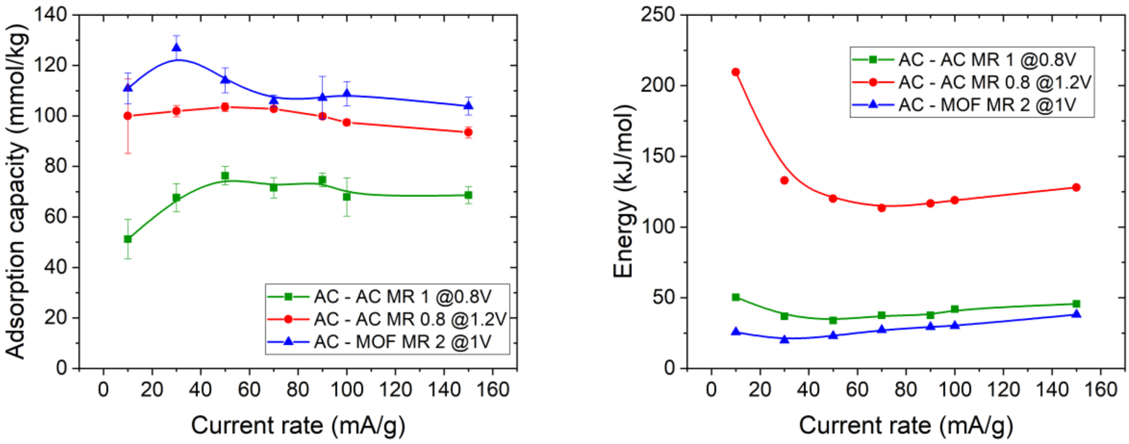

Figure 2. Comparison between adsorption capacity (on the left) and spent energy (on the right) of symmetric device.

Because of this, a different kind of material was tested in combination with activated carbon, namely the metal organic framework (MOF). This material was used in the electrode in direct contact with the gas reservoir. The benefits are evident, since the device with MOF shows the highest adsorption capacity (about 110 mmol/kg) and the lowest spent energy among all the tested devices.

CO2CAP

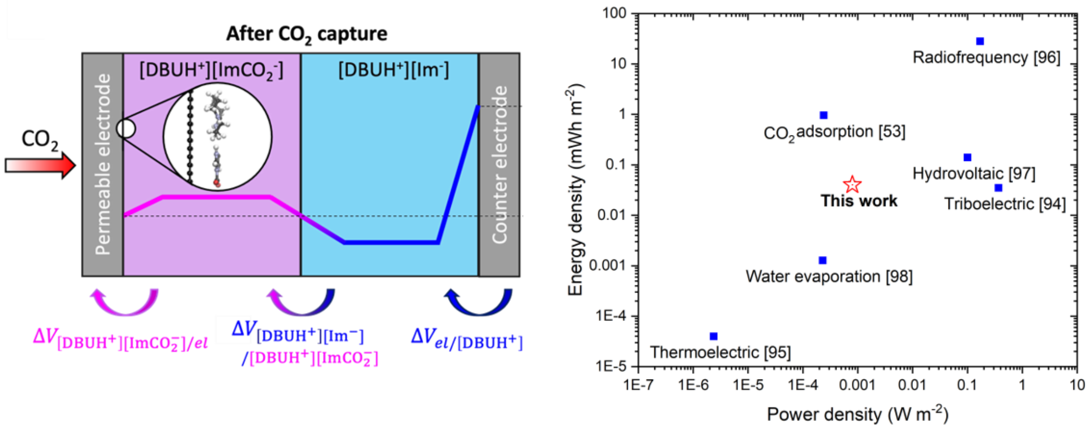

Figure 3. Results obtained from molecular dynamics simulations (left) and placement of CO2Cap (right).

Finally the above exposed approaches are merged in the CO2Cap technique, where the goal was to harvest energy from the carbon dioxide capture. To do this, a carbon-based supercapacitor with ionic liquid electrolyte was exploited. With the work of this thesis, the feasibility of this technology was proved, being able to be comparable with several other published energy harvester and moreover a new mechanism suitable for energy recovery based on the combined contribution of ion reorientation and the generation of a "bulk-interface" was unraveled.