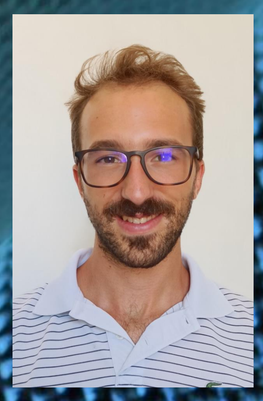
Novel infiltration method of membranes over activated carbons electrodes

# Novel infiltration method of membranes over activated carbons electrodes



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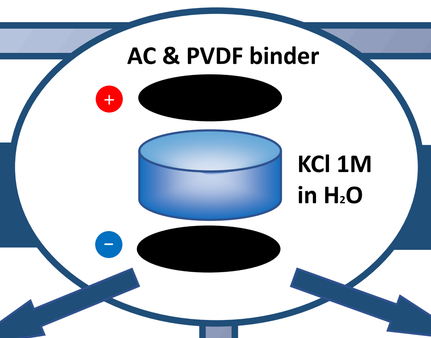
## Background

A novel method to modify **activated carbon electrodes** through addiction of **selective ion exchange polymers** (IEM) is presented. Nowadays the preferred method to self-polarize an electrode in an EDLC is to place a stand-alone membrane in proximity of the electrode itself [1, 2]. This technique produces some drawbacks brought about the dimension of the device: an increase of the internal series resistance and reduction of overall capacitance. With the propoesed methods, it is possible to use the IEM **directly in the production** of the slurry (instead of traditional binders) or in a **conformal contact** with the electrode.




## IEM as binder

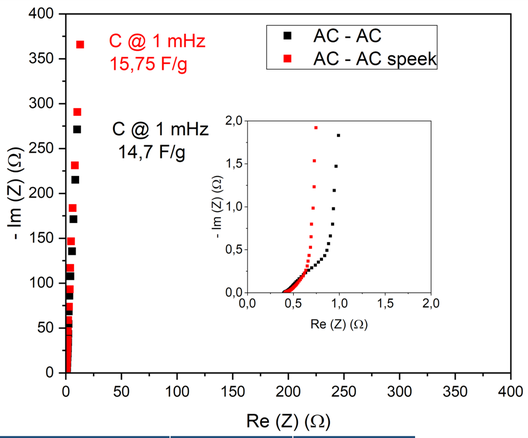
### Electrode fabrication

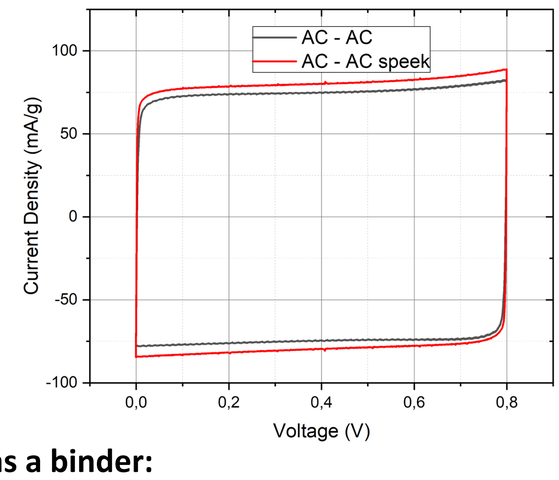
**Materials:**

- Activated carbon *90%*
- Sulphonated poly ether-ether ketone (SPEEK) *10%*
- DMSO *1 ml / 20 mg binder*
- Glass fiber separator

Electrodes are then laser cutted and placed inside a coin cell.

### Electrochemical characterization




| @ 0,8 V | PVDF binder | SPEEK binder |
|---|---|---|
| Mass loading [mg/cm²] | 9,27 | 6,3 |
| C [F/g] | 14,84 | 15,8 |
| Coul. Eff. | 99% | 99% |
| OCV [mV] | 23 | 110 |

**IEM as a binder:**

- invariated ESR
- Constant efficiency
- Much higher OCV
- Increase of specific capacitance

## IEM as conformal coating

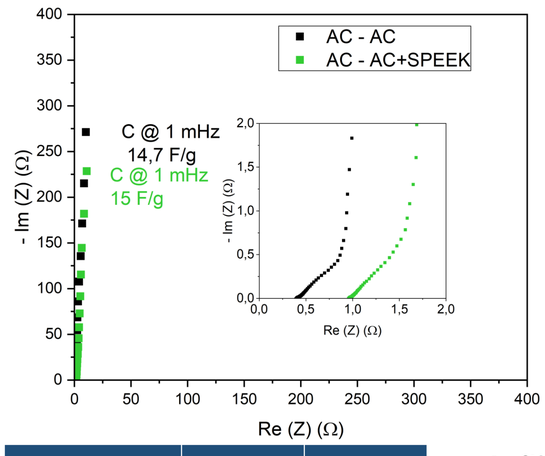
### Infiltration method

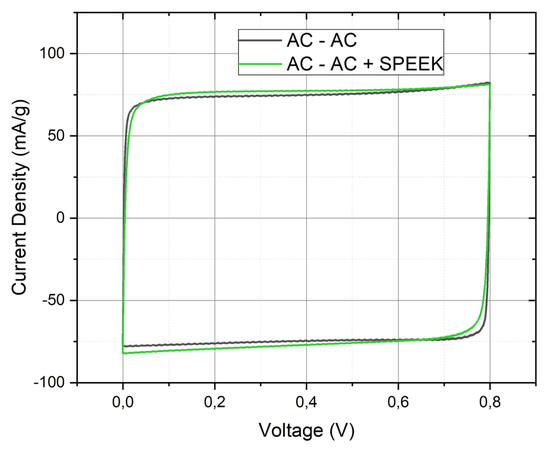
**Materials:**

- Activated carbons *90%*
- Poly vinyldene fluoride (PVDF) *10%*
- DMSO *1 ml / 20 mg binder*
- Glass fiber separator

Casting of SPEEK under vacuum over electrode to get a conformal membrane.
Electrodes are then laser cutted and placed inside a coin cell.

### Electrochemical characterization



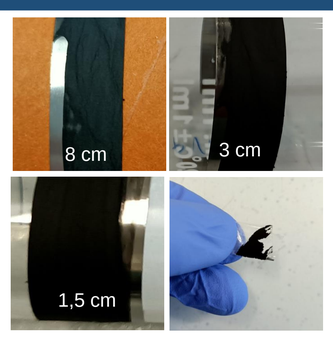




| @ 0,8 V | No IEM | Inf. IEM |
|---|---|---|
| Mass loading (slurry) [mg/cm²] | 9,27 | 10,7+2,48 |
| C [F/g] | 14,84 | 15,1 |
| Coul. Eff. | 99% | 99% |
| OCV [mV] | 23 | 458 |

**Infiltering process:**

- Invariated capacitance
- Same Coulombic efficiecy
- Highly increased OCV
- Direct contact electrolyte - membrane

## Adhesion test

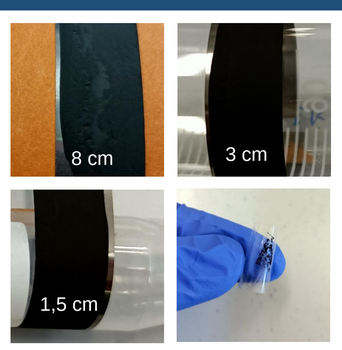



**PVDF binder**

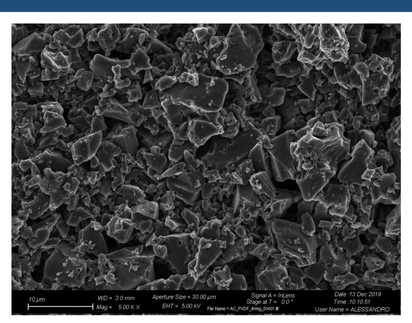
No delamination due to deformation of the substrate. Remotion of all the deposited material during peeling test.

**SPEEK binder**

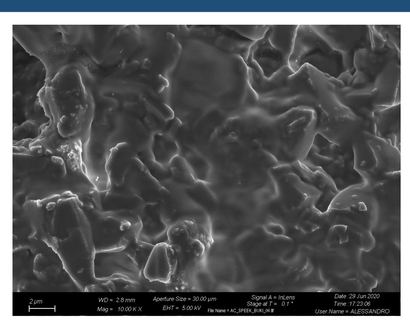
No delamination due to deformation of the substrate. Remotion only of all the upper layer of carbon during peeling test.




## SEM comparison

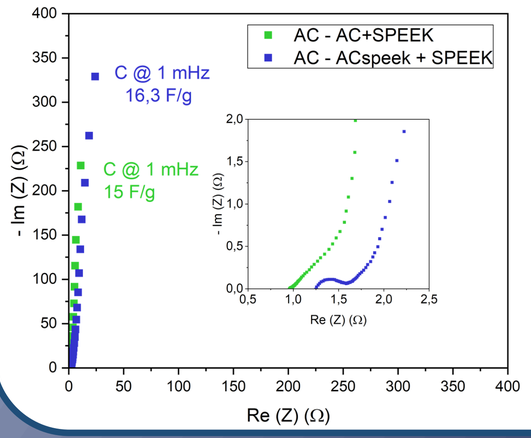


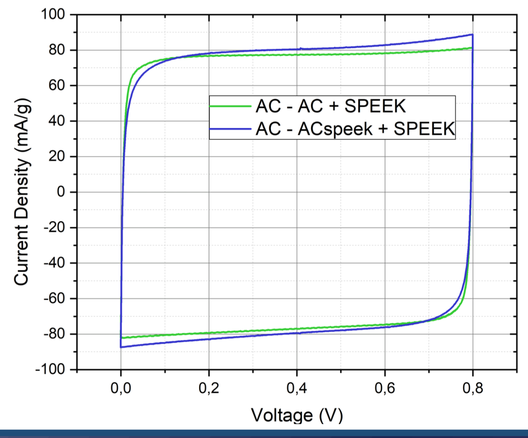
**No membrane**



**Vacuum infiltred membrane**

## Combination of binder + infiltred IEM




**Combination**:

- Invariate specific capacitance
- Invariate coulombic efficiency
- Comparable OCV

| @ 0,8 V | PVDF Binder + IEM inf | IEM binder + IEM inf |
|---|---|---|
| Mass loading [mg/cm²] | 10,7+2,48 | 6,7+3,98 |
| C [F/g] | 15,1 | 15,2 |
| Coul. Eff. | 99% | 99% |
| OCV [mV] | 458 | 442 |

## Conclusions

- Speek binder provides a better adhesion to Ti
- Infiltering process allows to maintain constant the ESR of the device, but highly increases its OCV
- It is possible to combine both approaches presented

## Future outlooks

- Repeat same tests with a anion exchange membrane and combine with SPEEK
- Test the obtained electrodes in a device built for capmix or RED

## Bibliography:

[1] Sales, Bruno B., et al. <<Electrochemical characterization of a supercapacitor flow cell for power production from salinity gradients>> *Electrochemica acta*, 86 (2012) 298-304

[2] Wang, Xingfeng, et al. <<A 1.8 V aqueous supercapacitor with a bipolar assembly of ion-exchange membranes as separator>> *Journal of The Electrochemical Society*, 163.9 (2016): A1853

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