Performance study of a thin cation exchange membrane for water based supercapacitor applications

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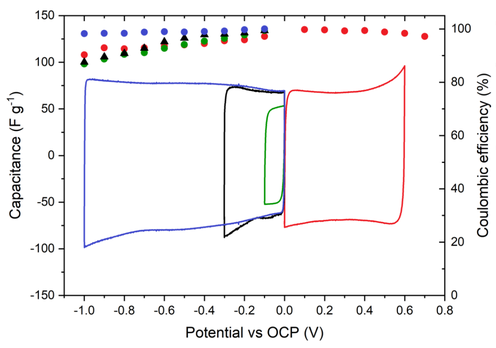
Background

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 proposed 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.

3 Electrodes measurements



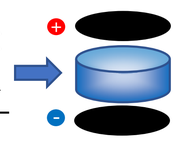
- **AC pvdf**
- **AC speek**
- **AC pvdf + SPEEK**
- **AC speek + SPEEK**

Maximum device operating voltage:

1.6V

Mass balancing:

$$m_+ C_+ V_+ = m_- C_- V_-$$

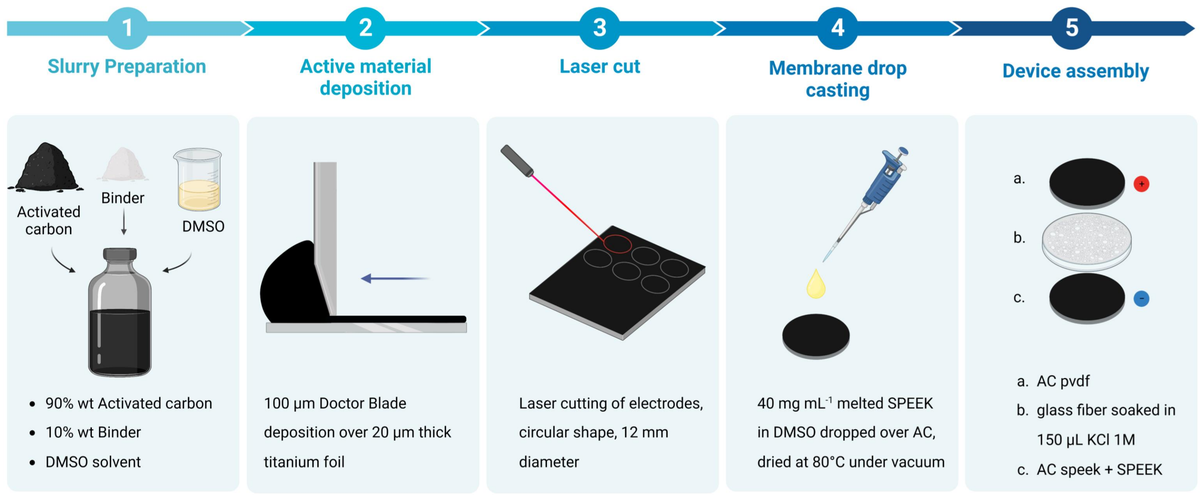


AC pvdf

$$\frac{m_+}{m_-} = \frac{9}{5}$$

Ac speek + SPEEK

Electrode fabrication



- 90% wt Activated carbon
- 10% wt Binder
- DMSO solvent

100 µm Doctor Blade deposition over 20 µm thick titanium foil

Laser cutting of electrodes, circular shape, 12 mm diameter

40 mg mL^{-1} melted SPEEK in DMSO dropped over AC, dried at 80°C under vacuum

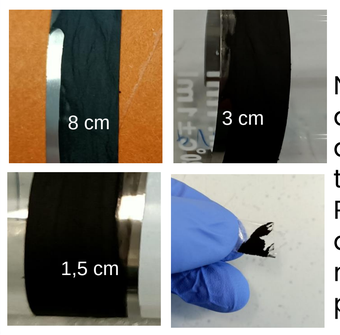
Negative electrode:

- SPEEK binder
- Melted SPEEK casted over AC, dried under vacuum

Positive electrode:

- PVDF binder
- No infiltered IEM

IEM as binder

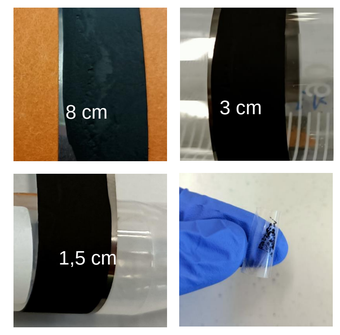


PVDF binder

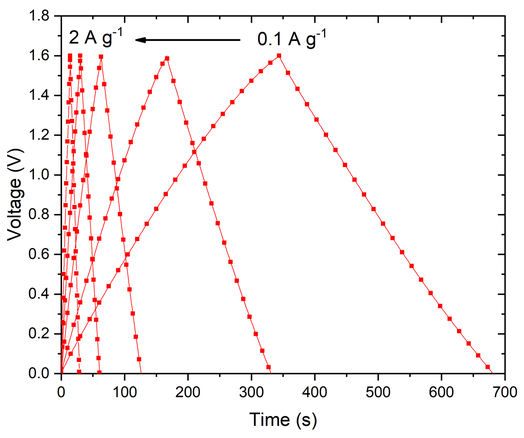
No delamination due to deformation of the substrate. Removal of all the deposited material during peeling test.

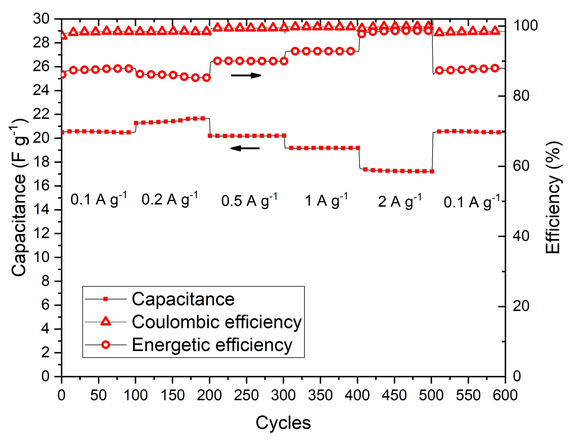
SPEEK binder

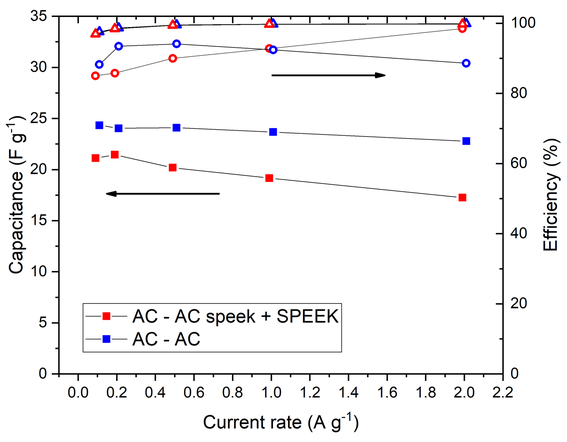
No delamination due to deformation of the substrate. Removal only of all the upper layer of carbon during peeling test.

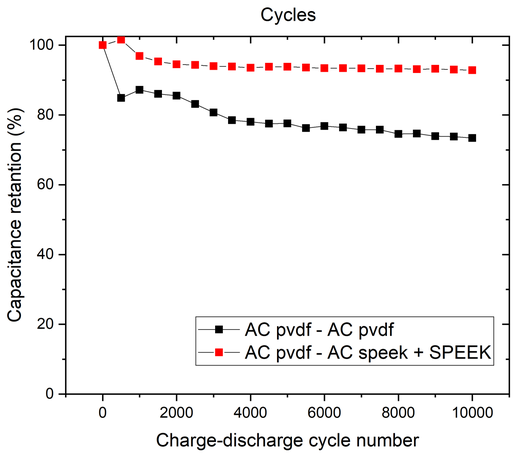


Device measurements

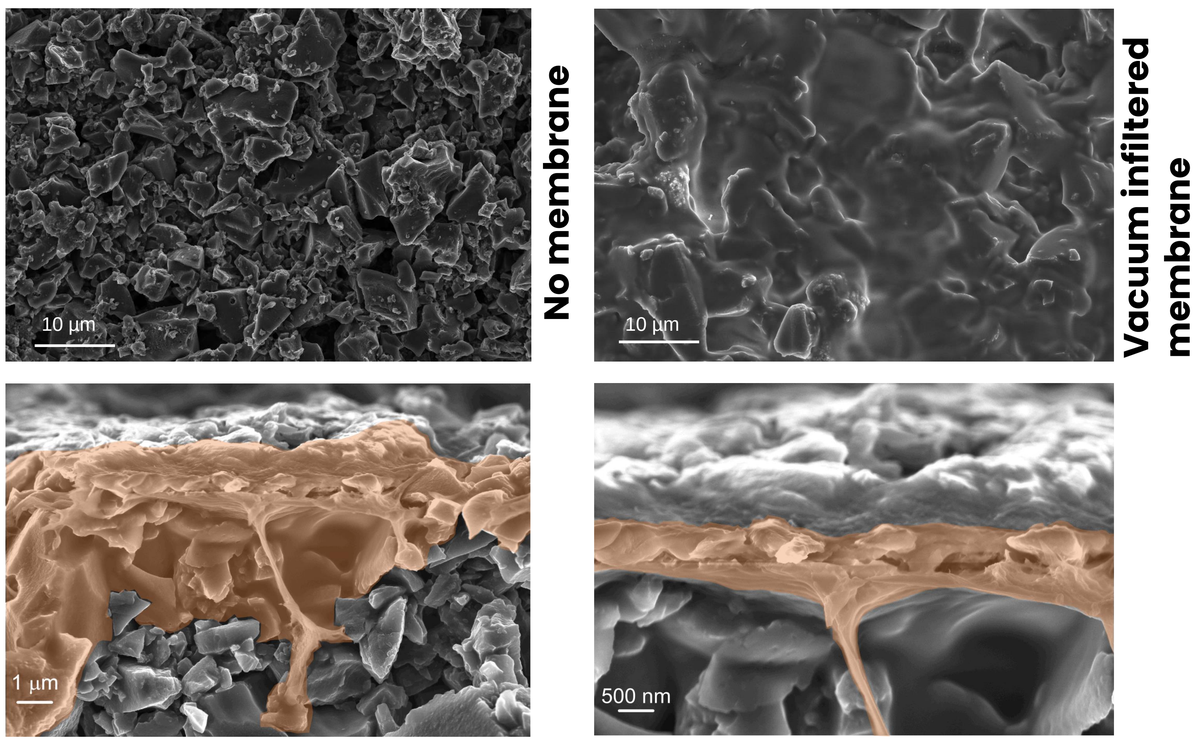








IEM as conformal coating



Cross-section

Conclusions

- Newly proposed coating procedure to obtain thin membrane over carbon based materials
- Substitution of standard binder and improvement of the adhesion performances for supercapacitor electrode application
- Use of CEM in thin film over a carbon based electrode resulting in an enlargement in operating voltage window, increase in coulombic efficiency and reduction of ESR

Future outlooks

- Combination of SPEEK modified electrode with a AEM modified electrode
- Test the device inside a Capmix or RED cell

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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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