Functionalized Paper and Nanocomposites for Application in Electrochromic Devices

P. Duarte[1,2,*], S. N. Fernandes[2], A. C. Marques[1], S. Pereira[1], A. Pimentel[1], L. Pereira[1], M. H. Godinho[2], E. Fortunato[1], R. Martins[1]

[1] *Materials for Electronics, Optoelectronics and Nanotechnologies* - CENIMAT/I3N [2] *Soft and Bifunctional Materials Group* - CENIMAT/I3N *e-mail: pauloduarte@fct.unl.pt*

Introduction

Paper based electronics is a new and very challenging field that aims the use of paper as an active part on electronic or electrochemical devices[1]. The main advantages of cellulose are the low environmental impact and low cost when compared with others materials. Moreover, flexibility, sustainability and recyclability are matters that are now in the front line of all scientific community[2].

In this work two different cellulose nanocomposites were designed and engineered, aiming the application in a broad range of electronic commodities such as electrochromic devices.

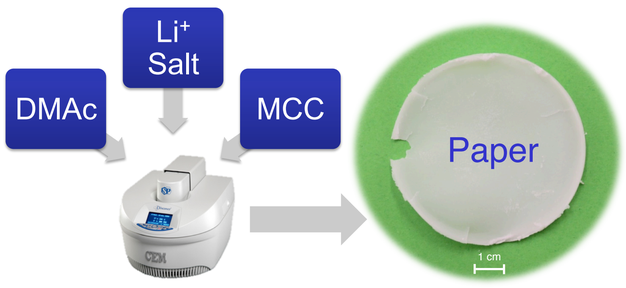
1. An 100% cellulose matrix solid electrolyte (CSE) from microcrystalline cellulose (MCC) was developed through an easy, fast and low cost synthesis route using microwave irradiation process.

2. An electrochromic paper, based on nanocrystalline cellulose (NCC) functionalized with WO_3 nanoparticles produced by hydrothermal synthesis, was synthesized by a chemical route (drop casting method).

Cellulose Solid Electrolyte *(CSE)*

Synthesis

Microwave Assisted Synthesis

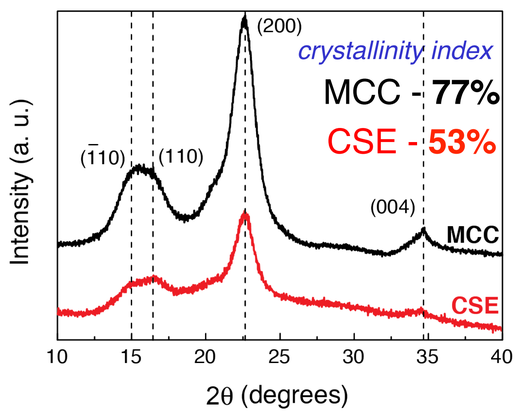


- mass ratio (DMAc:MCC:Li+) 1:0.33:0.1
- 65 ºC
- maximum power of 50 W
- less than 25 minutes
- dried at room temperature

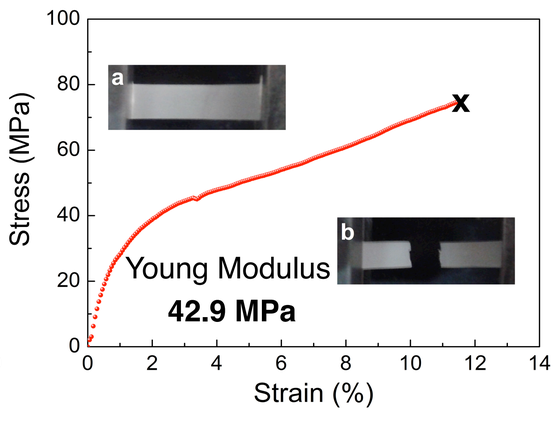
- **Easier**
- **Faster**
- **Low-Cost**

Characterization

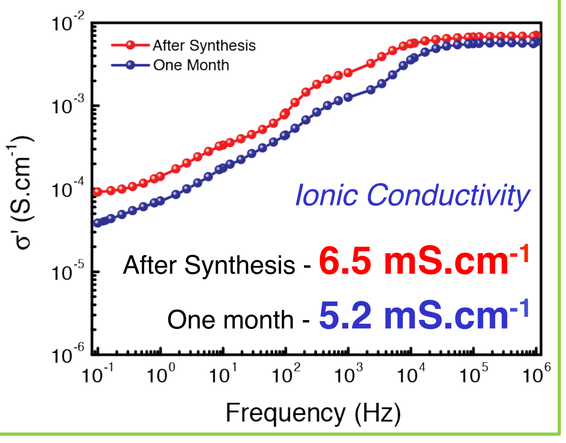
XRD



Stress/Strain



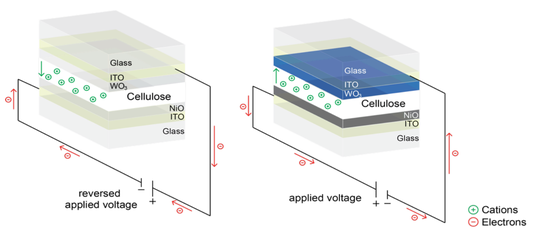
DRS



Electrochromic Device

Structure

Bleached State *Colored State*



Glass / ITO - *Commercial*

WO_3 - *Sputtering*

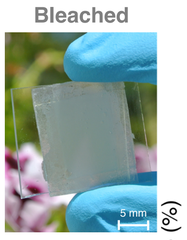
CELLULOSE SOLID ELECTROLYTE

NiO - *e-beam evaporation*

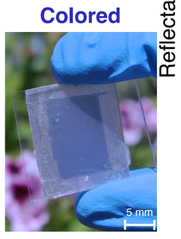
Glass / ITO - *Commercial*

Characterization

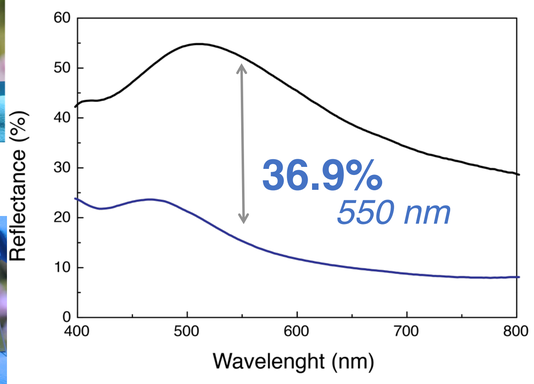
Bleached



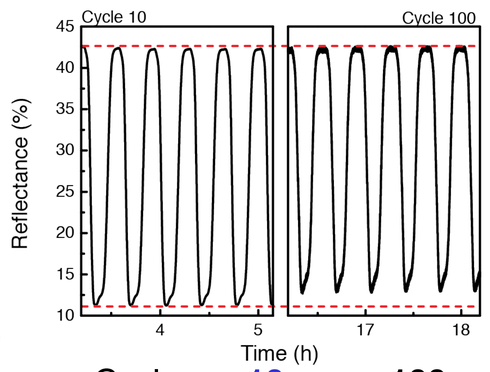
Colored



Reflectance



Excellent Stability



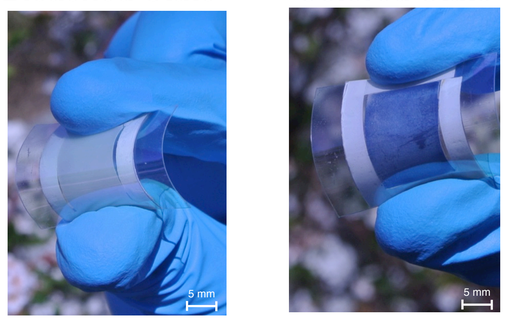
Cycles - **10** **100**

contrast ratio - **31.5%** **30.3%**

Flexible Device

Proof-of-Concept

Bleached State **Colored State**

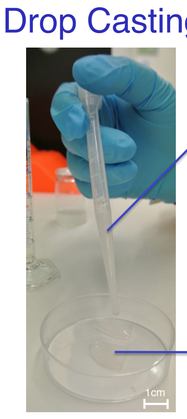


Electrochromic device build with commercial PET/ITO and WO_3 deposited by sputtering. CSE was sandwiched between the two electrodes

Electrochromic Cellulose

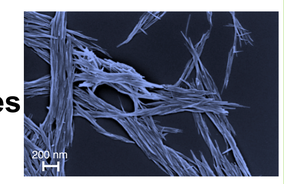
Synthesis

Drop Casting



WO_3 nanoparticles

Synthesized by Microwave Assisted Synthesis

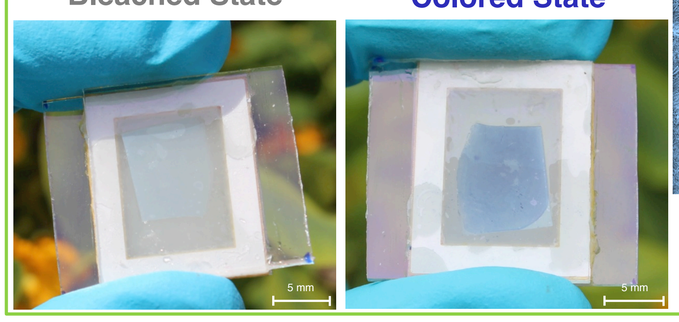


NCC Film

Preliminary Results

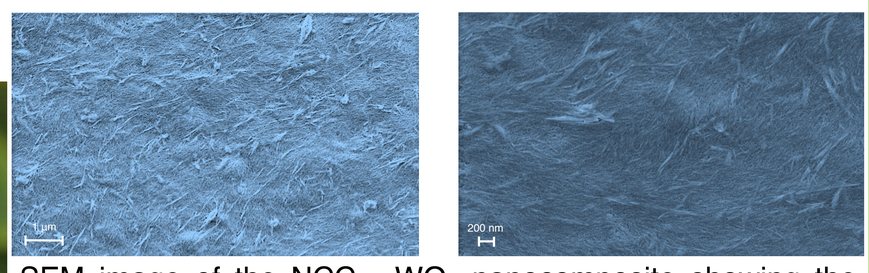
Electrochromic device build with commercial Glass/ITO and CSE was electrolyte.

Bleached State **Colored State**



SEM

NCC - WO_3 Nanocomposite



SEM image of the NCC - WO_3 nanocomposite showing the homogeneous dispersion of the WO_3 nanoparticles whitin the nacellulose nanofibers

Remarks

Cellulose Solid Electrolyte

- 100% Cellulose Matrix
- High Ionic Conductivity (**6.5 mScm^{-1}**)

Electrochromic Device

- Good Contrast Ratio - **36.9%**
- Stable over **100 Cycles**

Electrochromic Cellulose

- Good Contrast Ratio
- Reversible

Samples & Prototypes CSE NCC Device Flexible Device

Acknowledgements

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References

[1] E. Fortunato *et al.*, *IEEE Electron Device Letters 29,* 988-990 (2008)

[2] Gaspar, D. *et al.*, *Nanotechnology 25*, 094008 (2014)

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