Flexographic printed thermochromic stickers with visible color transition for smart sensing applications

M. Morais[1,*], J. Figueira[1], E. Carlos[1], M. C. Corvo[2], C. Marques[1], A. Gonçalves[1], R. Martins[1] and J. V. Pinto[1]

[1]MEON-CENIMAT/i3N, FCT-NOVA, Portugal, [2]SBMG-CENIMAT/i3N, FCT-NOVA, Portugal

*md.morais@campus.fct.unl.pt

Smart packaging

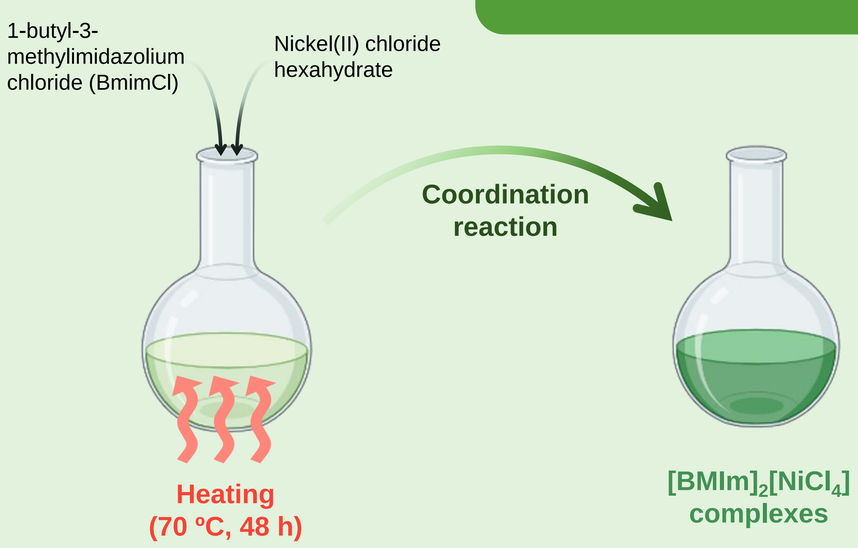
Temperature control

Temperature monitorization using materials with **fast response** and **high color contrast**

Thermochromic materials

Materials that can **change** their **optical properties**, either **reversibly** or **irreversibly**, depending on the reaction behind their thermochromism

Synthesis of thermochromic complexes



Synthesis based on a previously established procedure [1]

Preparation of thermochromic inks

$[BMIm]_2[NiCl_4]$ complexes

- 10 wt.%
- 20 wt.%

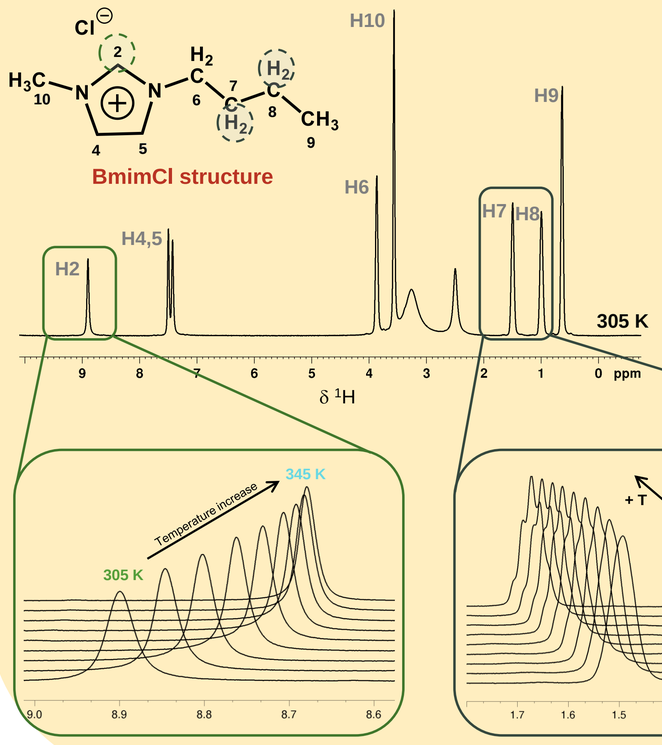
\+ Cellulose derivative solution

- Carboxymethyl cellulose (CMC)
  - 4 wt.%
- Hydropropyl cellulose (HPC)
  - 10 and 15 wt.%

Characterization of thermochromic complexes

Thermal stimulus → Dehydration → Structure transition from octahedral to tetrahedral → Change of optical properties

NMR spectrum of $[BMIm]_2[NiCl_4]$ complexes

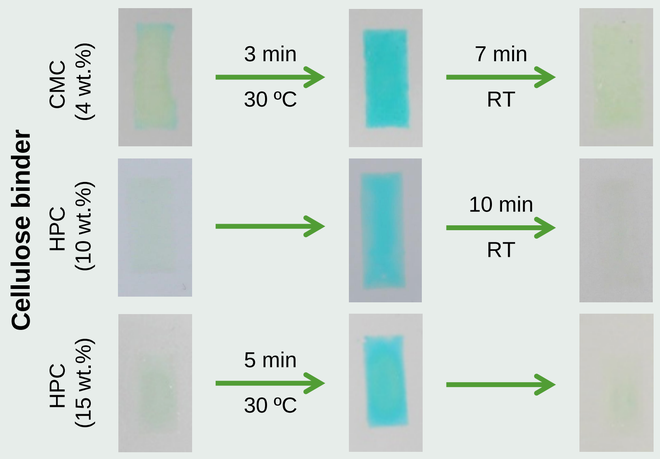


- Overall, all peaks present a chemical shift deviation at increasing temperature
- H(2), H(7) and H(8) present largest shifts (~0.20 ppm)

Reversible complexation reaction

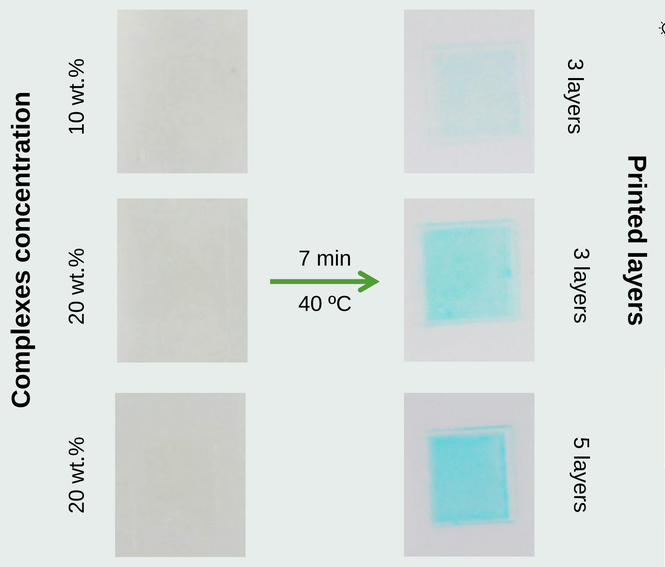
Evaluation of thermochromic behavior

- The first assays were performed with thermochromic layers printed through **doctor blade**, due to the simplicity of the technique.



- The stickers presented **fast response**
- The materials revealed **reversible thermochromism**

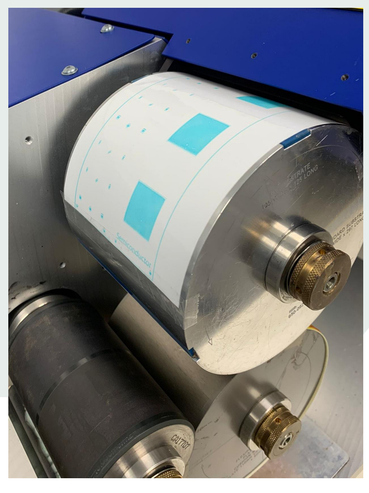
- Stickers were produced by **flexographic printing** using inks made of HPC (15 wt.%) and $[BMIm]_2[NiCl_4]$ complexes (10 and 20 wt.%). The color response of stickers made of 3 and 5 printed layers was evaluated.



- **Flexo-printed films** presented **lower color contrast**, when compared to the doctor blade films

Lower thickness of the flexo-printed films

- **Incrementing** the number of printed **layers increased** the color **contrast**



Conclusions and future prospects

- **$[BMIm]_2[NiCl_4]$ complexes** were, for the **first time**, **incorporated** into printable **inks** based on **cellulose derivatives**. **Flexographic printing** was the technique chosen to produce stickers with such inks.
- The ink with **15 wt.% HPC and 20 wt.% complexes** presented **higher stability** and **color contrast**. **Color change** from **light green** to **blue** was observed within **10 min** when the flexo-printed stickers were heated at **40 ºC**.
- **Encapsulation materials** to **protect** the printed **films** and ensure **repeatability** are being studied.
- **Standardization** methods for **color quantification** will be explored.

References

[1] Z. Wang, X. Hou, N. Duan, Y. Ren, and F. Yan, "Shape- and Color-Switchable Polyurethane Thermochromic Actuators Based on Metal-Containing Ionic Liquids," ACS Appl. Mater. Interfaces, vol. 13, no. 24, pp. 28878–28888, Jun. 2021, doi: 10.1021/acsami.1c06422.

This work is funded by National Funds through the FCT - Fundação para a Ciência e a Tecnologia, I.P., under the scope of the projects UID/50025/2020-2023 and LA/0037/2020 and through ThermalTrace- AAC17-SI-2019- 047094 - PT2020