

Title: NMR investigation of ink impregnation in paper.**Advisors:**

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The internship is funded by the Institute of Pulp, Paper and Fiber Technology - Graz University of Technology, Austria. The intern will be based at the University of Lorraine, [LEMTA laboratory](#), France.

Keywords: NMR, ink impregnation, inkjet printing, paper, liquid transport and diffusion

1. Context

Liquid penetration into a paper substrate is a current scientific topic in the paper and printing industry. A paper sheet can be viewed as a thin (100 μm) porous medium composed of partially oriented fibers. The pore size is a few micrometers and the porosity is about 20 to 30 %. Ink impregnation into paper is complex and governed by capillary forces. It depends, on one hand, on the paper surface properties (hydrophobicity, roughness) and its porous structure. On the other hand the ink composition (dye, pigment, type of solvent) and properties (surface tension, viscosity) is relevant.

The Institute of Pulp, Paper and Fiber Technology at Graz University of Technology is involved in studies focused on such transport phenomena, in relation with the paper industry [1].

The LEMTA laboratory at the University of Lorraine develops experimental methods using NMR and MRI to study transport phenomena in complex systems (thin materials in particular [2,3]).

Both institutes are joining forces to make progress in understanding these phenomena. We started to work on an experimental setup to perform NMR measurements on the ink/paper system. The setup is now operational and the method has been demonstrated.

2. Scientific questions

This research project concerns the experimental characterization of paper impregnation by a model fluid system. The system will be a water/glycerin mixture, representative of ink physicochemical properties. We are interested in observing the water/glycerin demixing phenomenon. Does it happen when the mixture is transported through the interface of the paper sheet? How fast? How far do the water and the glycerin go? What is the liquid distribution of the fluids in the depth of the paper?

Research program

To address these questions, the intern will progress through different steps:

- NMR characterization of the water/glycerin system.
- Improvement of the 1D imaging protocol in order to selectively measure the water or glycerin signal with good spatial and temporal resolutions.
- Characterization of water, glycerin and water/glycerin mixture impregnation into papers sheets. The influence of paper surface treatment will also be addressed.
- Communicate the intermediate results at a project meeting in Graz, Austria

This internship is planned for a 5 month-long period between February and July 2019. A previous experience on NMR will be appreciated but not mandatory.

To apply, please email a CV to jean-christophe.perrin@univ-lorraine.fr.

3. References

- [1] Krainer, S and Hirn, U, Short timescale wetting and penetration on porous sheets measured with ultrasound, direct absorption and contact angle. *RSC Adv.* **2018**, 8, 12861-12869.
- [2] Klein, M.; Perrin, J. C.; Leclerc, S.; Guendouz, L.; Dillet, J.; Lottin, O., Spatially and Temporally Resolved Measurement of Water Distribution in Nafion Using NMR Imaging. *ECS Transactions* **2013**, 58 (1), 283-289.
- [3] Robert, M.; El Kaddouri, A.; Perrin, J. C.; Leclerc, S.; Lottin, O., Towards a NMR-Based Method for Characterizing the Degradation of Nafion XL Membranes for PEMFC. *Journal of the Electrochemical Society* **2018**, 165 (6), F3209-F3216.