Electrochemical Morphogenesis of Conducting Polymers for Evolvable Electronics

Antoine Baron, Sébastien Pecqueur*

Univ. Lille, CNRS, Centrale Lille, Univ. Polytechnique Hauts-de-France, UMR 8520 - IEMN, F-59000 Lille, France
**sebastien.pecqueur@iemn.fr*

In electronics, circuits are predefined for a lifetime. Fabricating always the same with highly stable components is a real advantage for mass production. However when technologies are no longer up to date, electronic devices can only be discarded, poorly recycled, because they cannot adapt (Fig.1a). Living organisms, on the other hand, are constantly evolving (Fig.1b). They learn and interact with their environment, and when doing so, brain-neurons or tree-roots grow with appearent disorder but a surprising way to learn to exploit local ressources. The way they branch out can be described as morphogenesis and is the symbol of a natural intelligence, too complex to modelize. While conventional electronics seeks to eliminate disorder and variability, we hypothesize that it is possible to make use of it in a novel electronics that uses electrochemistry to mimic biological processes for adaptation.

In this study, we will discuss on morphogenesis of a conducting polymer (PEDOT:PSS) through the AC electropolymerization of EDOT in water. The dendritic objects exhibit various morphologies, differing in their thicknesses and number of branches.[1] Their growth mechanism involves diffusion and electromigration of charged species within the solution. We also present the first results characterizing a connection of those objects in the frequency domain, where various dynamics can be observed due to specific mechanisms at the different interfaces (Fig.1c,d)[2].

The electropolymerization of EDOT offers an inexpensive way to grow directed connections with a specific impedance to connect components in a system by voltage activation. It could be used to address the limits of the current electronics in terms of cost and flexibility while taking a form that is closer to what can be found in nature.

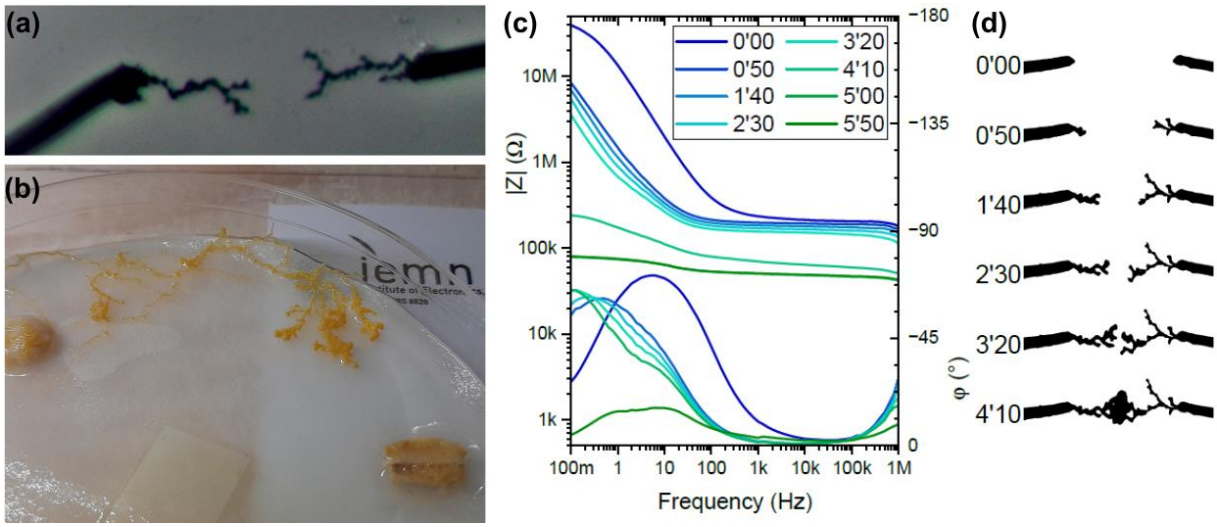

Figure 1: a) Microscope image of conducting polymer dendrites growing in water. b) Analogy with the biological morphogenesis of physarum polycephalum (blob) growing specifically towards food in a wet environment. c) Bode diagrams at different steps of the growth of a PEDOT:PSS dendritic interconnection. d) The corresponding morphologies at each step.

Acknowledgements
Funded by the French National Research Agency (ANR), grant number ANR-22-CE24-0001-01.

References
[1] K. Janzakova, A. Kumar, M. Ghazal, A. Susloparova, Y. Coffinier, F. Alibart, S. Pecqueur, *Nat. Commun.*, 2021, **12**, 6898.
[2] A. Baron, S. Pecqueur, DOI: 10.6084/m9.figshare.25213334