PhD POSITION

Contact

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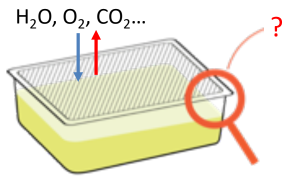

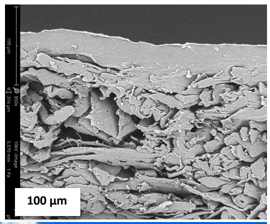



New multilayered materials based on cellulose and biopolymers for food packaging - Formalization of structure/mass transfer properties relationships.

Context. The way plastics are currently produced, used and discarded raises serious environmental and public health issues, with long-term effects that are not under control. Plastic packaging materials, unlike other materials such as paper, glass or metal, pose a serious problem as waste because of their fragmentation into persistent fine particles, capable of diffusing in all compartments including air. This induces a massive contamination of our environment by these micro- and nano-particles of plastics. The waste management solutions currently proposed for these plastics are not satisfactory and do not address the problem, including recycling, which is particularly highlighted by the EU and the various governments, which only delays the pollution (the recycling of plastics makes it possible at best to reuse the material once for applications most of the time other than those of the food packaging, the final phase of which will be a non-reusable plastic waste).

Issues are particularly high in the field of packaging, which accounts for 40% of total plastic consumption and generates 75% of the plastics accumulated in the environment. The main functions of packaging are to protect and stabilize food until its consumption. Roughly one-third of the edible parts of food produced for human consumption is lost and/or wasted throughout the food supply chain, from initial agricultural production down to final household consumption. One should keep in mind that when a food product is lost or wasted, a packaging product is also discarded in the same time creating some additional waste management issues. But to think that we can do without packaging is illusory.

Thus, the challenge relies nowadays on the improvement of the global environmental balance of the food/packaging system which is expected to become much more positive than it is now. This implies (i) to minimize the negative environmental impact of the packaging material, for instance via the use of materials biodegradable in natural conditions and/or recyclable in a closed loop (*vs.* materials resulting in accumulation, diffusion and harmful persistence in the environment) and the use of renewable resources without competition with food usages (*vs.* use of fossil resources), and (ii) to improve its usage beefit that strongly impact our environment, while remaining economically competitive and safe for the consumer.

The "tailor-made" design of food packaging increases the need for research dedicated to the mathematical modeling of mass transfers, which are the key properties governing food preservation. It is therefore necessary to be able to formalize the relationships between the structure and the mass transfer properties in packaging materials, which is still a bottleneck to be lifted in complex structures.

Despite extremely dynamic researches and developments on bio-based and biodegradable materials (more than 1 400 scientific publications/year on the last 10 years), commercially available bio-packaging does not yet properly meet the huge market and society demands. Currently marketed bio-polymers are either stemming from food resources (e.g. PLA, PBS, starch-based blends or PHB), or not biodegradable in natural conditions (e.g. PLA), or too expensive (e.g. PHAs), or not water resistant (e.g. starch-based blends, paper and cardboard).

Encouraged by favorable European regulations, recent innovative research has focused on developing PHAs (PolyHydroxyAlkanoates) from organic waste streams (e.g. crop residues, agro-food by-products or sewage sludge (e.g. FP7 EcobioCap, FP7 ANIMPOL, BIP BlueEcoPHA, H2020 NoAW and H2020 Resurbis projects). PHAs constitute a family of copolymers with tunable composition and properties, thus offering promising solutions, especially in terms of barrier properties towards gas and water vapour. Among them, P(3HB-co-3HV) with a high HV content (≥ 25%) and middle chain length-PHAs display interesting mechanical properties, but are not yet available on the market. The properties of PHAs can also be modulated by the purification step, the formulation (addition of nucleating agents to overcome the slow crystallization kinetic) and the compounding step. Finally, one other strategy to modulate the properties of PHAs while maintaining the biodegradability of the materials and reducing the final cost of materials is to mix it with low cost lignocellulosic fibres. The drawbacks that currently hamper their growth on the food packaging market are mainly their poor mechanical performance, their high cost and their stability in usage conditions.

Our planet also generates between 100 and 200 billion tons of vegetal biomass per year, with a quantity that can be mobilized around 0.5 to 1 billion tons per year. This biomass, made up of 40% cellulose, is an extraordinary renewable raw material. Paper and cardboard, produced from cellulose, are bio-sourced, biodegradable and recyclable materials that represent 32% of the packaging materials. However, its use is restricted due to its very low barrier properties and high hydrophilic nature. Another downside is their intrinsic reactivity and thus lower inertia than most conventional petrochemical-based plastics. To overcome those problems, cellulose was combined with petro-based polymers. However, the obtained packaging materials are not biodegradable and hardly recyclable and thus do not constitute a sustainable solution.

Objectives. In this context, **the objective of the present PhD project is to bring new knowledge and to formalize the relationships between the structure and the mass transfer properties in new multilayered materials combining a cellulosic support and a functional layer of biopolymer such as PHA.**

The two main scientific questions of the PhD are :

- Which is the impact of the formulation of the polymeric layer on the functional properties of developed multilayered materials ?
- Which is the impact of the 2D/3D structure of the multilayered materials on their mass transfer properties, with a focus on the phenomena at the interphases and by considering all the scale levels, including micro- and nano-scales ?

For that purpose, three technical bottlenecks will be addressed in the PhD, i.e. (i) the preparation of multilayered materials with controlled barrier properties, (ii) the quantitative and representative characterization of the 2D/3D structure of materials, including the characterization of the structure at the cellulose/biopolymer interface, and (iii) the *in situ* characterization of the functional properties of each layer, including interphases.

Research team. The ePOP is internationally recognized for its activities on sustainable food packaging materials. The PhD student will be associated to current European projects coordinated by the team.

Requirements

- Good/excellent level of Master Degree or Engineer in Process Engineering, Materials, Polymer Science, or other relevant disciplines.

- Demonstrated skills to effectively communicate in English and interact with other public and industrial partners

- Good ability to work within a team and be able of self-initiative

- Good knowledge and interest on physical-chemical characterization of polymers and/or composites, cellulose and/or paper

Duration : 3 years with a starting date expected on 1st oct. 2020.

Location : UMR IATE, Montpellier, south of France

Salary : about 1400 €/month (net salary)

Conditions : competition of the GAIA doctoral school (in June)

Appplication deadline : candidates must send their application (letter of motivation, CV with list of publications if any, and last academic marks report) before April, the 25th