Proposal research subject:

Titre : *Flexible and high barrier Multi-micro/nanolayered bio-based polymer films: Structure-properties relationships*

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The main objective of this project is to develop new bio-polymer films, obtained from renewable feed stock. They will have tailored properties and enhanced performances, compared to conventional films, such as highly transparent and improved transport/barrier properties. By using innovative multi-functional materials composed of multi-nanolayers made by the Forced assembled multilayer coextrusion process, it is the targeted to increase the gas barrier efficiency and/or the optical gradient of at least one or two orders of magnitude.

- The first part of this work concerns in particular the optimization of the choice of materials based on PLA, PHA and/or their copolymers constituting the layers depending on the applications. Some biobased fillers could be also introduced depending of the applications? We will specifically explore the consequences of the degree of compatibility of the polymers and their compatibization on the interfacial morphology. One part of the study will be to understand the influence of functionalization, molar mass, and polydispersity of multilayered materials based on PLA or it's derivate. Through model, rheological and melt dielectric properties experiments, we will attempt to understand and tune the properties of the interfaces. In particular instabilities and adhesion. These experiments will be supported by rheological modeling of the diffusion and/or reaction. A rheological study of multilayer systems in both shear and elongation will be carried out in order to elucidate the influence of different parameters (temperature, contact time, shear, etc).

- The second part is to carry out fundamental research to create the conditions for a better regulation of the coextrusion process and the production of biomaterials with controlled properties. These objectives cannot be achieved without a close relation between structure-processing and properties relationships. . The focus of this part will be more generic and will highlight the importance of the effects connected with the material on the mechanisms related to the appearance and development of instabilities defects. Well controlled properties are expected to result from the improvement of interlayer continuity and crystallization thanks of a better understanding of layers' shear and elongational flow properties. The project will present new attempts to reach homogeneous nanolayer distributions of dissimilar polymers used in layer multiplexing systems. The new developed design of the versatile technology will overcome the current drawbacks (stable flow with a high viscoelastic mismatch). The originality/focus of the project is to gain a true understanding from macro to nanoscale of the interfacial phenomena generated by this new technology, which is rarely present in the literature. As for the interphase created, it will be characterized in detail by XPS, AFM and EDX spectroscopies. The effect of confinement on the crystalline amount and morphology of the obtained layers will be investigated by SAXS/WAS and other techniques. Its effect on both oxygen and water barrier properties with controlled transparency will be studied depending of the obtained architectures. Hence, the outcome of the present thesis should foster development of new materials with a high added value. Numerous packaging applications could take benefit from these unique properties, especially in cosmetic, pharmaceutical, food, optics or energy, etc.

Authors' quoted references in the field:

[1] **H. Zhang, K. Lamnawar, A. Maazouz 2018.** Understanding of Transient Rheology in Step Shear and Its Implication To Explore Nonlinear Relaxation Dynamics of Interphase in Compatible Polymer Multi-microlayered Systems. **Ind. Eng. Chem. Res.,** 2018, *57* (23), pp 8093–8104

[2] **B. Lu, K. Lamnawar, A. Maazouz 2017.** Rheological and dynamic insights into an in situ reactive interphase with graft copolymers in multilayered polymer systems. **Soft Matter,** 2017, 13, 2523-2535.

[3] **Walha F., Lamnawar K., Maazouz A., and Jaziri M. 2017.** Preparation and characterization of Bio-sourced Blends based on Poly (lactic acid) and Polyamide 11: Structure-properties relationships and Enhancement of film blowing processability. **Advances in Polymer Technology**, 12 JUL 2017, DOI: 10.1002/adv.21864

[4] **Khemakhem M., Lamnawar K., Maazouz A., and Jaziri M.2017** Effect of core–shell acrylate rubber particles on the thermomechanical and physical properties of biocomposites from polylactic acid and olive solid waste "**Polymer engineering & science** 9 JUN 2017, DOI: 10.1002/pen.24642

[5] **Al-Itry R, Lamnawar K., Maazouz A, Billon N., and Combeaud C. 2015.** Effect of the simultaneous biaxial stretching on the structural and mechanical properties of PLA, PBAT and their blends at rubbery state. **European Polymer Journal, 68:288. doi:10.1016/j.eurpolymj.2015.05.001**

[6] **Al-Itry R, Lamnawar K., Maazouz A. 2015.** Biopolymer Blends Based on Poly (lactic acid): Shear and Elongation Rheology/Structure/Blowing Process Relationships**. Polymers, 7(939-962) 2015. Doi: 10.3390/polym7050939**

[7] **Al-Itry R, Lamnawar K. Maazouz 2014.** Rheological, morphological, and interfacial properties of compatibilized PLA/PBAT blends **Rheologica acta** 53, 7, 501-517 DOI: 10.1007/s00397-014-0774-2.

Short CV of the principal supervisor:

Prof._A. Maazouz was born in 1957. He is a Professor of polymer engineering and science in the Laboratory of Polymer Materials Engineering (IMP) at National Institute of Applied Science at Lyon (INSA de Lyon), France. Currently, he is co-Chairman of "Polymer Structure and Rheology" center in the lab of IMP-UMR CNRS 5223. He organized the world congress of the Polymer Processing Society (PPS 2016 in Lyon, France). He is also international representative in PPS. Prof. Maazouz's research interests cover wide domains, including i) Structure/processing/property relationships of polymers; ii) Rheology and process engineering of polymer materials, biopolymers and their composites; iii) Interfacial phenomena in the polymer and composites processing; iv) Monitoring and optimization of polymer processes (extrusion, co-extrusion, roto-molding, resin transfer molding, etc.). Contributions on these domains lead him to have more than 120 peer-reviewed scientific articles, 5 patents, 2 book chapters and more than 90 oral and poster communications where he has on numerous occasions been an invited speaker and a chair-man of conferences. He was recently honored by French government by the "Palm academic medal": Palmes académiques. Prof. Maazouz in resident member of the academy of science and technology of Morocco. He is also Reviewer of several scientific journals: *Polymer*, *International Material Forming*, *Rheologica Acta*, *Polymer Engineering & Science*.

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