

Proposal research subject:***Interfacial Rheology and dynamic on confined Nanolayered polymers:
Fundamental studies towards a better control of interfaces/interphases.***

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Prof. A. MAAZOUZ/ Professor at IMP@INSA

The present thesis deals with the Multi-scale Studies of Confined polymers in Nanolayered Structures based on model polymers with tailored interface/interphases properties. The main objectives are to understand the fundamentals of the interfacial phenomena (interfacial reaction, interdiffusion, interfacial slippage as well crystallization) over different length scales. Some innovative interfacial rheological investigation will be developed. The results will offer some new enlightenment for fundamental understanding of layer confinement and the interphases development. Dual experiments and simulations will be performed. Overall, based on these finding, the outcome of the thesis should foster development of new rheological models based on some new insights on the tube models adapted for confined polymer's chains.

The first part will focus on the better chose and characterizations of polymer pairs and their copolymers. The confinements will be obtained thanks to some high glass transition polymers with various molar masses. Other dielectric model polymers will be also chosen. Through rheological study in both shear and elongation, melt dielectric properties experiments and modelling we will attempt to understand and tune the chains dynamic across the interfaces. The properties of the triggered interface/interphase will be linked to the local entanglements that could be gradually established from diffusion and/or reaction. Therefore, it will be exciting task to investigate nanoscale phenomena in term of segmental and chains motions, spanning to interfacial tension and morphology evolutions to macroscopic scale of mechanical/rheological modifications.

Secondly, effects of Nanolayer polymer confinement on the crystalline properties will be studied. Effects of the contact time (ie. given for diffusion or reaction), temperature and viscoelastic mismatch will be investigated. Layer homogeneity and morphological properties will be studied by AFM and TEM. The developed crystalline properties in Nano layered structures will be in turn evaluated by WAXS and SAXS. Hence, the changes in solid dielectric properties resulting from layer multiplication will be modelled depending of the developed interphases and crystalline morphology.

International collaboration: Pr. Joao Maia from the group of Pr. Eric Baer Case Western Reserve University-(CWRU) (CLIPS- CWRU-USA). Also with Dr. Bo Lu, a previous Phd Student of our group.

Supervisor:

Khalid LAMNAWAR (Associate Professor, IMP @INSA de Lyon), Tel. 04 74 81 93 09 ou 06 33 68 00 53.

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Material science and engineering with a good background in chemistry, physics, with good background on Mathematics and mechanics. Candidate with knowledge of rheology, Polymer science are also appreciated.

Authors' quoted references in the field:

- [1] Lu B., Lamnawar K.*, Maazouz A., Sudre G. 2018 Critical role of interfacial diffusion and diffuse interphases formed in multi micro-/nanolayered polymer films based on poly(vinylidene fluoride) and poly(methyl methacrylate). **ACS Applied Materials and Interfaces**. Aug 29;10(34):29019-29037
- [2] B. Lu, K. Lamnawar, A. Maazouz 2017, *Rheological and dynamic insights into the in situ reactive interphase with graft copolymer in bilayered system*. **Soft Matter** 2017, 13, 2523 – 2535
- [3] H-G Zhang, K. Lamnawar, A. Maazouz and J. M. Maia. 2016 *A nonlinear shear and elongation rheological study of interfacial failure in compatible bilayer systems*. **Journal of Rheology** 60, 1-23

- [4] H-G.Zhang, K. Lamnawar, A. Maazouz, 2013. *Rheological Modeling of the Mutual Diffusion and the Interphase Development for an Asymmetrical Bilayer Based on PMMA and PVDF Model Compatible Polymers*. Macromolecules Volume: 46 Issue: 1 Pages: 276-299. <http://dx.doi.org/10.1021/ma301620a>.

Short CV of the principal supervisor:

Dr. Khalid Lamnawar's research is focused on polymer science, rheology and processing with a dual research dedicated to experimentation and modelling. The main objective is developing some multi-scale studies to link the rheology of polymers, processing technology and properties of micro/nanostructured materials together. He is the author of more than 125 references, including 50 articles in peer-reviewed journals (48 already published and referenced in Scopus or WOS), 2 Book chapters, 1 Editorial Book of Abstracts & proceedings,....., 2 patents, 70 proceedings, and more than 60 international conferences with oral presentations, many keynote and invited speaker in national or international conference, university and Industry, 24 national Conferences. He is also a reviewer for internationally reputed scientific journals...He has co-supervised and been the advisor for more then 30 Master's theses, 11 PhD of which 7 have already been defended. One of his PhD students (2010-2013) working on "Interfacial rheology of compatible multilayer structures" was awarded "The Best Doctoral Dissertation" by the French Rheology Group (GFR). He is author of some of invited & keynote lectures in the industry, universities and international conferences as well at word or regional PPS. Recently, he was the Scientific and Technical Program Coordinator, Secretary and webmaster of the 32nd international Conference of the Polymer Processing Society- France- July 25-2, 2016, 750 attendees. <https://pps-32.sciencesconf.org/> (Chair: Professor A. Maazouz). His great contribution took more than 3 years for preparation and it was one of the key for the event success. He also provided some expertise for French Government and European Projects: ANR" National Research Agency', Biomedicine Agency, Ministry of Industry... Thanks to his outstanding contributions, he has been recognized with numbers of awards, including...(Excellence grant for research, 1st rank" from French government, Palmes Académiques, ...). He is member of the editorial Board of Journal of Composites and Biodegradable Polymers. Since 2017, he is head of Mechanical Engineering Plastics Processing through apprenticeship engineers department. He is author of some features paper in high impact factor journals. He also provided some expertise for French Government and European Projects: ANR" National Research Agency', Biomedicine Agency, Ministry of Industry, European Research Foundation, ACS, Some recent contributions are available at: https://www.researchgate.net/profile/Khalid_Lamnawar. The defence of his 'HDR' is scheduled by 24 May 2019. .