DocMASE Project Proposal 2015-02

Project Title	**Biobased nanocomposites films and coating materials for packaging materials**
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Second University and Advisor	Universitat Politècnica de Catalunya – Centre Català del Plàstic (Spain) Prof. Maria Lluïsa Maspoch
Project Description (with **image**, if applicable)	In this project novel and advanced nanocomposites will be developed using extrusion and by combining cellulose nanocrystals and nanofibres derived from biomass with biopolymers such as poly lactic acid (PLA) as a matrix. PLA is an interesting biopolymer but it has low melt strength and also it is very brittle making it difficult to be used in film applications. Our previous research project has shown that only a small amount of cellulose nanofibers (1%) can improve the melt properties of the PLA as well as affect its fracture mechanism making it possible to use in blow molding process and film extrusion.(1, 2) Also transparent materials can be obtained because the size of the nanocrystals is less than the wavelength of visible light and at the same time nanosized crystals can improve the barrier properties by hindering and manipulating the diffusion and permeation of gas and water molecules through the material (3). PLA film could be used in food packaging films or products where cellulose nanofibers will reduce the water susceptibility of the packed product and at the same time control the loss of aroma or flavor in the product. The used methodologies will be polymer and composite processing methods such as compounding extrusion and film extrusion and blow molding. The nanocomposites will be prepared by compounding extrusion where liquid feeding is used to feed nanomaterials into the extruder (4). The compound is pelletized using strand pelletizer and then extruded to films. The structural characterization of developed materials will be done using high resolution microscopy technics, (AFM, HR-SEM, TEM) to study the dispersion and polarized optical microscopy for crystallization studies, mechanical testing (tensile, toughness), thermal properties (TGA, DMA, DSC), moisture stability, water vapor and gas permeability, UV- spectroscopy, X-ray analysis for crystallinity, oxygen barrier and moisture barrier, porosity and density measurements etc. In collaboration with the research group of "Polymer and Composite Technology" (POLYCOM) of the Universitat Politècnica de Catalunya (UPC), the characterization of developed composites will be extended to melt rheology and fracture behaviour (through fracture mechanics theories) analysis. These activities will be realized in the installations of the R&D Centre Català del Plàstic (CCP) (www.upc.edu/ccp). **Tasks** 1) Compounding of different nanocomposite materials PLA or other biopolymer matrix, different nanocelluloses as well as additives will be tested 2) Film extrusion of nanocomposites and blow molding of nanocomposites 3) Alignment of the nanocellulose in the films 4) Materials characterization and testing 5) Presenting the results in international conferences and wring 4-5 scientific publications.

Previous Publications	[1] Herrera N, Mathew AP, Oksman K, Plasticized polylactic acid/cellulose nanocomposites prepared using melt-extrusion and liquid feeding: Mechanical, thermal and optical properties accepted to Comp. Sci. Tech. 2014. [2] Jonoobi M, Aitomäki Y, Mathew AP, Oksman K, Thermoplastic polymer impregnation of cellulose nanofibre networks: Morphology, mechanical and optical properties, Composites part A, 58 (2014), 30-35. [3] Herrera M, Mathew AP, Oksman K. Gas permeability and selectivity of cellulose nanocrystals films(layers) deposited by spin coating. Carbohydrate Polymers, 112(2014)494-501. [4] Hooshmand S, Aitomäki Y, Skrifvars M, Oksman K. All-cellulose nanocomposite fibers produced by melt spinning cellulose acetate butyrate and cellulose nanocrystals, Cellulose, 21, 4 (2014) 2665-2678. [5] Aitomäki Y and Oksman K. Reinforcing efficiency of nanocellulose in polymers, Reactive and Functional Polymers (2014) 10.1016/j.reactfunctpolym.2014.08.010. [6] F. Carrasco, L.A. Pérez-Maqueda, O.O. Santana, M.Ll. Maspoch. *Enhanced general analytical equation for the kinetics of the thermal degradation of poly(lactic Acid) / montmorillonite nanocomposites driven by random scission.* Polymer Degradation and Stability, 101, 52-59 (2014). (DOI: 10.1016/j.polymdegradstab.2014.01.014). [7] C. Rodriguez, D. Arencon, J. Belzunce, M. Ll. Maspoch. *Small punch test on the analysis of fracture behaviour of PLA-nanocomposite films.* Polymer Testing, 33, 21-29 (2014). DOI: 10.1016/j.polymertesting.2013.10.013 [8] J. Cailloux, O. O. Santana, E. Franco-Urquiza, J. J. Bou, F. Carrasco, M. L. Maspoch . *Sheets of branched poly(lactic acid) obtained by one-step reactive extrusion–calendering process: physical aging and fracture behavior.* Journal of Materials Science, 49, 4093-4107 (2014). DOI: 10.1007/s10853-014-8101-y [9] E. Franco-Urquiza, J. Velázquez-Infante, J. Cailloux, O.O. Santana, M.LL. Maspoch. *Influence of morphology on the mechanical properties and fractura behaviour of PLA/oMMT composites films.* Advances in Polymer Technology. (2014). (DOI: DOI: 10.1002/adv.21470) [10] F. Carrasco, L.A. Pérez-Maqueda, P.E. Sánchez-Jiménez, A. Perejón, O.O. Santana, M.Ll. Maspoch. *Enhanced general analytical equation for the kinetics of the termal degradation of poly(lactic acid) driven by random scission.* Polymer Testing , 32, 937-945 (2013). (DOI: 10.1016/j.polymertesting.2013.04.013).
References	(1) Herrera N, Mathew AP, Oksman K, submitted to Comp. Sci. Tech. 2014. (2) Herrera Natalia, Licentiate thesis, LTU, Dec. 2014. (3) Petersson L, Oksman K, Comp Sci Technol 66 (2006) 2187 (4) Oksman K, Mathew AP, Bondeson D, Kvien I. Manufacturing Process of Polylactic Acid (PLA) – Cellulose Whiskers Nanocomposites, Compos Sci Technol 66 (2006) 2776
Requirements of the candidates / Requirements during the doctoral programme (courses, seminars, etc.)	Swedish requirements (which are more rigorous) with respect to the credit points for courses will be followed. The student will pass courses in the amount of 60 ECTS corresponding to one additional year of studies (3 y reasech+1y courses evenly distributed). The fourth year will be financed by Lulea University of Technology. 15 ECTS of the 60 will be obtained in common courses, workshops and summer schools organized by DocMASE.