Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes the PhD subject and supervisor proposed by the French Polytech network of 14 university engineering schools. Please contact the PhD supervisor by email or Skype for further information regarding your application.

Supervisor information	
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Polytech name	Polytech Clermont-Ferrand
University name	Université Clermont Auvergne (UCA)
Country	France

PhD information	
Title	Enzymatic and biochemical cross-linking of chitosan applied to the formation of hydrogels and bio-based materials
Main topics regards to CSC list (3 topics at maximum)	Materials, green chemistry, intelligent construction
Required skills in science and	Biological engineering, chemistry Engineering,

engineering	material engineering.

Subject description (two pages maximum)

The development of natural and renewable biomolecules exhibiting competitive bonding properties constitute an real industrial challenge. In this context, the biochemical structure of chitosan associated with its mechanical properties, its biocompatibility and its biodegradability open the way to a lot of original applications in the adhesive and binder areas. Chitosan is a polysaccharide derived from the alkaline deacetylation of chitin, a polysaccharide of animal or fungal origin very abundant in the natural environment. This copolymer of β-(1,4)-linked glucosamine and N-acetylglucosamine residues is the only cationic polysaccharide of natural origin. Soluble in acid solutions, this biocompatible and antimicrobial macromolecule has been the subject of numerous publications over the past 10 years, particularly for its rheological, flocculant, film-forming and biological active properties. It finds applications in the field of water treatment, oenology, nutraceutical and biomaterials. Recent work (**see references list**) carried out within the Institut Pascal UMR 6602 UCA/CNRS/SIGMA Clermont within the framework of several national programs has shown that crustacean chitosans are able to interact due to high adhesive properties with a number of materials such as wood, aluminum and glass. The biocomposites obtained are resistant to mechanical stresses that can exceed 20 MPa, which makes it possible to classify the adhesives based on chitosan in the category of structural adhesives, in the same way as the epoxy resins. Note to mention that from 2015, the structural adhesive market represents around 25 billion of euros/year for a total volume of 10 million of tons/year and currently the development of bioadhesive is booming. In order to make the supply of raw material more reliable, it would be useful to develop the fungal chitosan sector as natural bioadhesive (biocompatible and biodegradable). The proposed thesis topic has two objectives: (i) the first will be to characterize the adhesive properties of fungal chitosans from filamentous fungi (Aspergillus niger,…) in order to partly compare them with those of chitosan derived from crustaceans and to understand their role in the walls and (ii) in a second step, the covalent cross-linking of these polysaccharides (used alone or in combination with other polymers such as beta-glucans) by enzymatic (oxidase/peroxidase) and biochemical (genipin, glycerol epoxy, etc.) pathways will be considered in order to generate hydrogels mimicking the fungal walls. The latter will be characterized for their texturing, adhesive and mechanical properties in order to correlate the structures obtained (complex interpenetrating networks with intra- and intermolecular bypasses) with biological functionalities. the research will have to take into account the industrial constraints of implementation of the adhesive.

References list from Institut Pascal UMR 6602 UCA/CNRS/SIGMA Clermont *in chitosan field*:

1- Mathias J.D., Grédiac M., de Baynast H., Michaud P., Patel A. (**2011**). Adhesive composition including deacetyled chitosan, WO2011FR51687, FR20100055820.
2- Mati-Baouche N., Elchinger P.-H., De Baynast H., Pierre G., Delattre C., Michaud P. (**2014**). Chitosan as an adhesive. *European Polymer Journal*, 60: 198-213.
3- Elchinger P.-H., Delattre C., Faure S., Roy O., Badel S., Bernardi T., Taillefumier C., Michaud P. (**2015**). Immobilization of proteases on chitosan for the development of films with anti-biofilm properties. *International Journal of Biological Macromolecules*, 72: 1063-1068.

4- Elchinger P.-H., Delattre C., Faure S., Roy O., Badel S., Bernardi T., Michaud P., Taillefumier C. (**2017**). Antioxidant activities of peptoid-grafted chitosan films. *Applied Biochemistry and Biotechnology*, 181(1): 283-293.
5- Laroche C., Delattre C., Mati-Baouche N., Salahd R., Violeta Ursu A., Moulti-Mati F., Michaud P., Pierre G. (**2017**). Bioactivity of Chitosan and Its Derivatives. *Current Organic Chemistry*, 22(7): 641-667.
6- Delattre C. (**2017**). Current Opinion on Chitosan and its Derivatives: Biological Impact in Antimicrobial Applications. Advances in Biotechnology & Microbiology. 6(2): 555684.
7- Delattre C. (**2017**). Opinion about Advances of Chitosan in Pharmaceutical Field: From Past to Now. Modern Applications in Pharmacy & Pharmacology. 1(1): 000504.