

Université de Technologie de Compiègne – Thesis proposal

Part 1: Scientific sheet	
Thesis proposal title	Modeling the rupture of microcapsules in flow Simulation de la rupture de capsules sous écoulement
PhD grant	MultiphysMicroCaps , financed by ERC
Research laboratory	<i>Laboratory:</i> Biomechanics & Bioengineering Laboratory (UMR CNRS-UTC 7338), UTC Compiègne <i>research team:</i> Biological Fluid Structure Interactions <i>web site:</i> http://www.utc.fr/~salsacan/
Thesis supervisor(s)	Dr Anne-Virginie Salsac, DR CNRS (HDR), BMBI, UTC Dr Delphine Brancherie, Prof (HDR), Roberval Laboratory, UTC
Scientific domain(s)	Science and technology Biomedical and health science engineering <i>EURAXESS fields:</i> Biomedical Engineering, Mechanical Engineering, Simulation Engineering, 3D Modelling, Modelling Tools, Computational Mathematics
Research work	<p>Micro-capsules, which are fluid droplets enclosed in a thin elastic membrane, are current in nature (red blood cells, phospholipidic vesicles) and in various industrial applications (biotechnology, pharmacology, cosmetics, food industry). They are used to protect and transport active principles, by isolating them from the external suspending fluid. One application with high potential is the use of microcapsules for active substance targeting, but scientific challenges remain to be met, such as finding the optimal compromise between payload and membrane thickness, characterizing the membrane resistance and controlling the moment of rupture. Once injected in an external flow, the particles are indeed subjected to dynamical loading conditions, which result from the complex 3D capsule-flow interactions. One of the limitations of the numerical approaches currently used to predict the behavior of capsules subjected to an external flow comes from the fact that they do not consider capsule damage nor rupture.</p> <p>The objective of the thesis project is to build a numerical model of the motion of a microcapsule suspended in flow and of its rupture. The microcapsule will be modeled as a liquid droplet enclosed in a thin membrane with hyperelastic properties. The challenges will be to account for the multiphysics phenomena governing the problem, which require solving for the inner and outer fluid flows, the deformation of the membrane, and crack initiation/propagation. It will allow to study the different phases of the capsule breakup (crack initiation, crack propagation, release of the inner content).</p>
Key words	Microcapsules, membrane rupture, fluid-structure interaction, drug targeting
Requirements	<p><i>Skills:</i></p> <ul style="list-style-type: none"> - Strong scientific background in solid and/or fluid mechanics and in scientific computing - Notions of biomechanics and bioengineering will be a plus - Proficiency in English – ability to communicate in French (at least basic with the desire to learn) - Excellent interpersonal and communication (written and verbal) skills <p><i>Personal Qualities:</i></p> <ul style="list-style-type: none"> - Ability to work collaboratively as part of a team in an interdisciplinary context - Flexibility, motivation, pro-activity, commitment to high quality - Commitment to continuous educational and professional development - Commitment to UTC's and CNRS' policy of Equal Opportunity, ability to work harmoniously with colleagues and students of all cultures and backgrounds <p><i>Qualification:</i> MS degree or equivalent qualification.</p>
Starting time	Fall 2020
Location	BMBI Laboratory, UTC

Funding/Cofunding or/and partnerships:

- ☐ Région Hauts de France (cf dossier)
☐ Labex
☐ Ecole doctorale
☐ Partenariat industriel
☒ Autre (préciser) European Research Council (Consolidator grant 772191)

Part 2: Job description	
Duration	36 months
Additional missions available	
Research laboratory	<p>The project will take place within the 'Biological Fluid-Structure Interactions' Group, directed by A.V. Salsac, which is one of the 3 research teams of the UTC Biomechanics & Bioengineering Laboratory (http://www.utc.fr/bmbi/). The group is specialized in the fields of biofluids and hemodynamics at both the microscopic and macroscopic scales. It focuses on the study of the fluid-structure interactions that occur between fluid flows and various flexible structures (vessel wall, capsule and cell membrane, biomedical devices, etc.). The strength of the group is the long expertise in numerical modeling of artificial capsules with the boundary integral method. The group has the unique characteristic of combining numerical and experimental expertise, which enables to translate theoretical results into practical applications. They have developed microfluidic techniques to produce and characterize microcapsules, as well as study their deformation when they flow in microtubes and networks.</p> <p>http://www.utc.fr/~salsacan/</p> <p>The project will be conducted in collaboration with Roberval Laboratory from UTC. Delphine Brancherie, who will co-supervise the PhD, is an expert in numerical modeling in Solid Mechanics and engineering, with special focus on modeling of rupture. She is specialized in the development of numerical tools to model complex multiphysics problem in mechanical engineering, correlate experiments and numerical simulation and optimize large-scale problems with a multi-scale approach.</p>
Material resources	<p>All of the tools and equipment needed for the project are available in the 'Biological Fluid Structure Interactions' team of BMBI and Roberval Laboratories:</p> <p>For the numerical simulations:</p> <ul style="list-style-type: none"> - Fluid-structure simulation codes based on the coupling between the Boundary Integral Method to solve for the fluid flow and the Finite Element Method for the capsule wall deformation - Structural code based on an embedded discontinuity approach to represent the failure mechanisms and simulate the crack propagation - Workstations, High Performance Computing facilities
Human resources	<p>The BMBI laboratory is composed of about:</p> <ul style="list-style-type: none"> - 40 permanent staff members (27 academic staff, 13 technical and administrative staff) - 31 PhD students - 8 Postdocs - 7 associated researchers - 15 Master students
Financial resources	<p>MultiphysMicroCaps, financed by ERC, which is a large project that explores the use of deformable liquid-core capsules of micrometric size to efficiently transport active material, with a primary focus on health-related applications. It is focused on the design of innovative sophisticated numerical models and high-tech experiments, needed to determine the potential of such vectors for the protection of active substances, predict membrane breakup to control the delivery, and optimize their properties for specific industrial and biomedical applications.</p>

Working conditions	What is expected from the candidate is to have a sense of autonomy and to be capable to work in group. His/her mission will be to conduct the research project, present his/her results during the research meetings (meetings with the advisors, lab meetings, etc) and to the rest of the scientific community via publications in international journals and conferences.
Research project	MultiphysMicroCaps, financed by ERC
National collaborations	<ul style="list-style-type: none"> - Solid Mechanics Laboratory, Ecole Polytechnique - INRIA Paris Institute
International collaborations	<ul style="list-style-type: none"> - School of Engineering and Materials Science, Queen Mary University of London (UK)
International cosupervision (cotutelle)	
Contact	<p>To apply please send a complete CV, a letter of motivation, 2 letters of recommendation or the contact details of 2 referring persons, as well as the result transcripts for all the courses followed at university to:</p> <p>Dr Anne-Virginie Salsac (+33 (0)3 44 23 73 38, a.salsac@utc.fr) BMBI Laboratory (UMR CNRS-UTC 7338) UTC CS 60319 60203 COMPIEGNE cedex, France</p> <p>Prof Delphine Brancherie (+33 (0)3 44 23 52 71, delphine.brancherie@utc.fr) Roberval Laboratory UTC CS 60319 60203 COMPIEGNE cedex, France</p> <p>Please note that only candidates who have been shortlisted will be contacted</p>

Please contact first the thesis supervisor before applying online
on <https://webapplis.utc.fr/admissions/doctorants/accueil.jsf>