PH.D. POSITION AT THE STLO (RENNES) AND UMET/PIHM (LILLE)

Understanding the mechanisms of thermal fouling in falling film evaporators by microfluidics and microscopy approach

Keywords: **soft matter, dairy fluids, protein denaturation, fouling dynamics, microfluidics**

URGENT APPLICATION BEFORE JUNE 20TH

Research description

Thermal fouling is an unsolved question for the dairy industry and consists in the accumulation of the solid fraction of a processed liquid stream on a stainless-steel surface due to the combined action of flow and thermal and concentration gradients. This continuous deposit has very costly consequences on the production effectiveness, strongly affecting the pressure drop, the thermal transfer, the flow rate in the equipment and favoring the formation of biofilms. Therefore, understanding and preventing the phenomena related to thermal fouling is crucial to optimize the operation unit efficiency and to improve the quality of the products. Until now, most of the studies available in the literature focused on the fouling dynamics in heat exchangers and led to contradictory results based on the off-line analysis of the solid deposits. Conversely, the fouling mechanisms have been rarely explored in the evaporators despite their increasingly essential and sensitive use in dairy industry (*e.g.*, infant formula production).

The hypothesis that will be explored in this Ph.D. thesis is that the initiation of the fouling process is not due exclusively to protein thermal denaturation in the liquid stream once a critical temperature is achieved (T>65°C), but also to the impact of the high shear rate near the equipment walls (100 s^{-1}). Indeed, the shear-induced could possibly promote the unfolding of whey proteins and their successive adsorption. The main challenge of the project will be to provide a direct observation of the fouling dynamics in mixes of dairy proteins and minerals by microscopy and microfluidics. We aim to characterize the different steps of the accumulation reproducing the environmental and flow characteristics typical of the evaporators in microchannels with variable geometry.

The research questions addressed in this Ph.D. project will follow a deductive logic, from the observation of the phenomenon to its physical interpretation:

- Which are the components preferentially involved in the fouling in the evaporators?
- Which process parameters have the greatest influence on the development of solid deposits?
- Is it possible, based on these elements, to identify control modes limiting the drawbacks linked to the fouling?

Context

The Ph.D. work will benefit from the fruitful collaboration between the STLO (Rennes; https://www6.rennes.inrae.fr/stlo_eng) and the UMET (Lille; https://umet.univ-lille.fr/index.php) research teams. This scientific synergy has been largely set off in the course of the last years and especially in the framework of the scientific network of the LIA FOODPRINT and the ANR project ECONOMICS, which significantly focus on the investigation of the fouling phenomena and the development of anti-fouling materials for heat exchangers used during heat treatments in dairy industry.

Candidate profile

The project is at the interface between several disciplines (physics, process engineering, dairy physico-chemistry). A profile with a master's degree in physics, with research experience in biological systems if possible, or in chemical or process engineering, will be preferable.

The potential candidate should have an interest for the investigation of the physics of the soft matter and in particular of colloidal systems. An attitude to work in a multidisciplinary team, combining fundamental research and potential functional applications in the industrial domain.

Duration, contact and application

Duration: 3 years
Based in Rennes (STLO)

Starting date: September-December 2022

Gross month salary: 1975€

Supervisor: Pr. Romain Jeantet (Institut Agro-STLO)
Co-supervisor: Pr. Maude Jimenez (UMET-Lille) - Dr. Luca Lanotte (INRAe-STLO)

Applications, including a motivation letter, CV and the contact information of 2-3 references, as well as informal questions and enquiries can be addressed to Dr. Luca Lanotte (luca.lanotte@inrae.fr) or to Pr. Romain Jeantet (romain.jeantet@agrocampus-ouest.fr).