The French-German Research Institute of Saint-Louis (ISL) situated in the border triangle of Germany, France and Switzerland is an internationally renowned research institute belonging to a global industrial and economic network. The spectrum of our core activities comprises a variety of topics: aerodynamics, energetic and advanced materials, lasers and electromagnetic technologies, protection, security and situational awareness. Our activities are related to both basic and applied research.

ISL is offering a PhD Position

Research field: New energetic materials

Spray flash evaporation: understanding crystallization mechanisms

The NS3E laboratory is structured around four topics, having a strong synergy: nanothermite, energetic and inert nanomaterials, detection of energetic materials and synthesis by detonation. To obtain nanomaterials, Spitzer and Risse developed the Spray Flash Evaporation process, SFE which is now protected by four patents and rewarded by the "Grand Prix Lazare Carnot" in November 2015. The process has proven to be efficient to obtain organic (mainly energetic materials), eocrystals (caffeine/oxalic acid) or inorganic nanoparticles (zinc oxide). However, little attention was paid to investigate the mechanisms involved in this crystallization process. In order to control the particle synthesis, the spray flash evaporation process must be deeply investigated to identify how the different parameters impact the nanoparticle properties. Knowing the mechanisms will potentially largely extend the applicative scope of the process.

A project is currently ongoing to bring some lights and knowledge on the mechanisms governing crystallization in this process in order to rule over the properties of the nanoparticles. The goal is to understand the particle formation for simple product to go to complex and multicomponent product to tune particle size and morphology.

The PhD will be recruited in the framework of this project. The principle of the SFE process are described below: the pressurized and superheated solution(s) containing dissolved precursors is/are initially sprayed through a nozzle. The droplets are then created in the atomization chamber under vacuum. Flash evaporation and subsequent crystallization occurred. Both phenomena are interdependent. The solvent evaporation is ruled by thermodynamics and will affect nucleation. In a first part, the flash evaporation and droplet generation will be studied. A Phase Doppler Particle Analyzer will be used to measure droplet size and velocity at different position of the spray. This method has already proved its efficiency and first study on the solvent spray provide some results regarding the turbulence and the droplet expansion phenomena occurring inside the chamber. This work will be continued in the framework of the current PhD by studying the effect of the main operation conditions (superheat degree, pressure drop, vacuum flowrate, etc.) on the droplet size and velocities. This part will enable us to identify the evaporation rate.

At the same time, it is important to acquire solubility data for our compound in order to correlate evaporation to supersaturation.

In a first step inert materials will be studied to identify solubility in our conditions. A pilot will be designed and implemented for that purpose. By correlating solubility and evaporation, a modelling of the evolution of the supersaturation will be done.

The goal is to identify the suitable operating conditions to tune particle size. This measurement will probably lead to result useful to modify the current design of the SFE and optimize its performance.

In a first step, inert material will be used to understand mechanisms (caffein, pharmaceutical compound) and could be extended to current energetic materials used at the lab such as RDX or HMX.