

Bachelor's level internships 2026

Magnetic nanoparticles functionalization for magnetothermal healing of polymer composites (*laboratory: IMP, Campus la Doua*)

Vitrimer materials are thermosetting polymers that exhibit self-healing properties when activated by certain stimuli, owing to the incorporation of dynamic bonds. Among these various stimuli, thermal activation remains the most widely used, enabling material repair through an increase in temperature. Magnetothermal heating is a magnetic induction heating technique. Magnetic particles are exposed to a high-frequency alternating magnetic field, which generates heat within the particles and the material in which they are dispersed. This localized and controlled heating allows for precise temperature control, greater efficiency than conventional convective heating, faster heating rates, and contactless operation.

The objective of our project is to achieve the most efficient magnetothermal heating possible while minimizing the amount of nanoparticles introduced into the material. To accomplish this, it is necessary to control the dispersion of the nanoparticles in order to prevent aggregation and thus obtain a highly homogeneous composite material.

The aim of the internship is to functionalize magnetic nanoparticles using simple chemical approaches, disperse them within epoxy-based vitrimer materials, and investigate their dispersion state using various characterization techniques, particularly electron microscopy. The project will be carried out in close connection with an ongoing PhD research project in the laboratory.

Monte Carlo-Based Compartmental Modeling for Polymerization in Stirred Tank Reactors (*laboratory: CP2M, Campus la Doua*)

A chemical reactor used to study emulsion polymerization, specifically particle aggregation, is the focus of this project. A single-phase CFD simulation of the reactor has been developed and validated against Stereo PIV measurements. This simulation provides access to key turbulence parameters: turbulent kinetic energy at the Taylor microscale and energy dissipation at the Kolmogorov microscale.

The 3D CFD results serve as input data for a dynamic compartmental modeling approach (CMA), implemented in C++ and Python. This framework discretizes the reactor into compartments, enabling the localization of turbulent parameters throughout the reactor volume. Intercompartment exchange, scalar mixing, and particle mixing are evaluated using Monte Carlo methods, and the model has been validated for both scalar and particle mixing, with strong agreement.

Building on this, a Monte Carlo approach has also been developed to model particle aggregation within each compartment prior to particle exchange. This sub-model performs well for binary aggregation cases and has been validated against exact analytical solutions for three standard aggregation kernels. The goal of this internship is to finalize and extend this Monte Carlo aggregation model to handle realistic conditions in the reactor. The developed framework will enable simulation of polymerization in stirred tanks and allow tracking of localized phenomena, such as particle size distribution, at specific positions within the reactor during the polymerization process. The intern will require background in stochastic methods and computational modeling.