The out-of-equilibrium phenomena of soft matter on a nanometer-length scale remains largely uncharted territory. On the other hand, fundamental understanding within that field is essential for innovative solutions and overcoming industrial challenges while dealing with time and processing-dependent properties at the nanoscale. The proposed research aims to unravel and exploit glassy behavior, a hallmark of many out-of-equilibrium materials, under one- and two-dimensional geometrical nanoconfinement.

We will take advantage of the fact that nonequilibrium phenomena are intrinsically ingrained in the dynamics of glasses. In turn, restricting the length scale to nanometric adds more hitch that drives the system away from equilibrium, thus unlocking a new set of opportunities not attainable at the macroscale.

This project postulates that *by capturing molecular mobility intimately coupled to the equilibration process, we can control and predict its rate*. Therefore, one of the central targets of this research proposal is to provide a new outlook on the mechanism and equilibration kinetics in confined space. We will do it through a series of non-trivial experiments with complex thermal histories, including the following ingredients: isotherm testing, asymmetry of approaching equilibrium, memory effects, and rejuvenation. *Our original approach assumes using a 'material time' concept and verifying if equilibration kinetics followed in one confinement geometry can be used to predict the response of the same system in other confinement geometries*. We also aim to tune out-of-equilibrium phenomena at the nanoscale level. This will be achieved using an external high electric field and vapor deposition technique; the latter gives access to ultra-stable "ideal" *glasses*. These are highly ambitious and challenging aspects of the proposed research. Since in the spotlight of this proposal is to unravel nonequilibrium phenomena related to the glassy dynamics at a nanometer-length scale, it shows great potential to add a new twist to a fundamental understanding of the behavior of molecular systems in confined space.

If we succeed, our results may reveal a promising road map to design, develop, and optimize processing conditions to obtain nanometric-size organic materials of desired (controlled) properties.

WHAT DO WE WANT TO DO? Understand better the behavior of soft matter in confined geometry by studying nonequilibrium phenomena at different confinement levels.
WHY? Nonequilibrium effects have a critical impact on the structure and dynamics of soft matter confined at the nanoscale level.
HOW? By employing multiple experimental approaches allowing to measure dynamics at different timescales, modifying contributions of entropy, thermal energy, and density changes (molecular packing).