Lab project M1 PPN & QuanTEEM

12/05/2025 – 20/06/2025

Title of the project: Molecular Data Storage and Decoding using Solid-State Nanopores

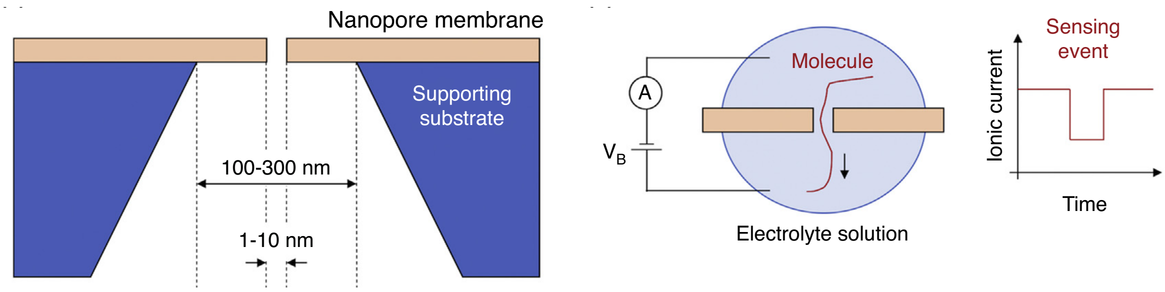
Supervisor(s): Adrien NICOLAÏ / Patrick SENET

Laboratory / Department / Team : ICB / NANO / PHysics applied to Proteins

Collaborations:

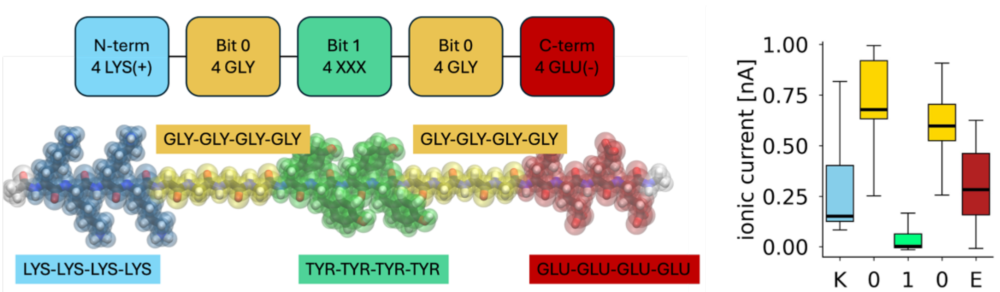
Summary: Biological peptides have emerged as promising candidates for data storage applications due to their versatility and programmability. Recent advances in peptide synthesis and sequencing technologies have enabled the development of peptide-based data storage systems for realizing novel information storage technologies with enhanced capacity, durability, and data access speeds.

In particular, solid-state Nanopores are powerful platforms for single biological molecule sensing without any labeling and with high sensitivity. The detection principle using Nanopores relies on measuring the relatively small variations of ionic current as charged peptide immersed in an electrolyte traverse the nanopore, in response to an external voltage applied across the membrane.



The passage of the molecule through the pore yields information about its structure and chemical properties. Atomically thin two-dimensional materials with nanometer-sized pores, such as single-layer MoS_2, represent the ideal sensor because of their ultimate thinness. Despite the benefits they offer, their application for peptide sequencing remains challenging since the fast translocation speed provides short observation time per single molecule.

In this study, we will performed the sequencing of biological peptides through single-layer MoS_2 Nanopores using Molecular Dynamics. Peptide sequences will be comprised of amino acids representing bit 0 and bit 1 information (see below), with the nature of amino acids in the sequence being changed to generate the best possible configurations. From MD, the goal will be to evaluate the efficiency of these peptide sequences to represent binary information based on ionic current traces monitored during their passage through the nanopore.



Type of project (theory/experiment): Theoretical / Computational project

Required skills: Atomistic Modeling / Molecular Dynamics / Programming (Python or Matlab)