Polyelectrolyte behavior in charged nanoporous medium: adsorption/desorption kinetic, structure and dynamics

Starting time: 3-year grant starting in October 2020 (after validation by the Ecole Doctorale)

Location: **Laboratoire PHENIX**, Sorbonne-Université, Campus Pierre et Marie Curie, 4 Place Jussieu, 75252 Paris, France (http://www.phenix.cnrs.fr)

PhD Supervision: **Emmanuelle Dubois** (emmanuelle.dubois@sorbonne-universite.fr, personal webpage: http://www.phenix.cnrs.fr/spip.php?article773) and **Nicolas Jouault** (nicolas.jouault@sorbonne-universite.fr, personal webpage: http://www.phenix.cnrs.fr/spip.php?rubrique238)

Keywords: polyelectrolytes, nanoporous systems, adsorption, zeta-potential

Ecole doctorale : ED388 – Chimie physique et chimie analytique de Paris Centre

Monthly salary: gross 1700 euros (around 1400 euros net)

Project summary: The proposed PhD subject aims to study the interaction between charged polymers, i.e. polyelectrolytes (PEs), with charged concave surfaces typically encountered in nanoporous materials, systems used for many industrial purposes (filtration devices, batteries…). Diffusion phenomena of PEs in charged nanochannels as well as the PE adsorption/desorption and exchange behavior have been barely studied for now although this issue has a significant importance in many applications such as designing pores for biosensors, filtration or chemical separation, catalysis or detection of single molecules.

Here we propose to investigate different aspects (kinetic, structure and dynamics) of the diffusion, adsorption/desorption and exchanges of PEs in charged nanochannels by using a model system composed of well-known PEs (such as polystyrene sulfonate or polyacrylic acids) confined in charged nanoporous anodic aluminum oxide (AAO). AAO, synthesized in our lab and recently deeply studied [A,B,C], is composed of non-connected cylindrical channels with perfectly tunable length and pore diameter through the experimental synthesis conditions (see Fig. 1, left). The PhD student will study these different aspects by combining several experimental techniques such as i) streaming potential measurements [D, Fig.1 right] to determine the AAO surface charges and monitor the PE penetration and adsorption/desorption, and ii) flow measurements, infrared spectroscopy and NMR imaging and relaxometry to investigate the PE structure and dynamics. This multidisciplinary project will provide the successful candidate a strong experimental experience useful for further academic or industrial positions.

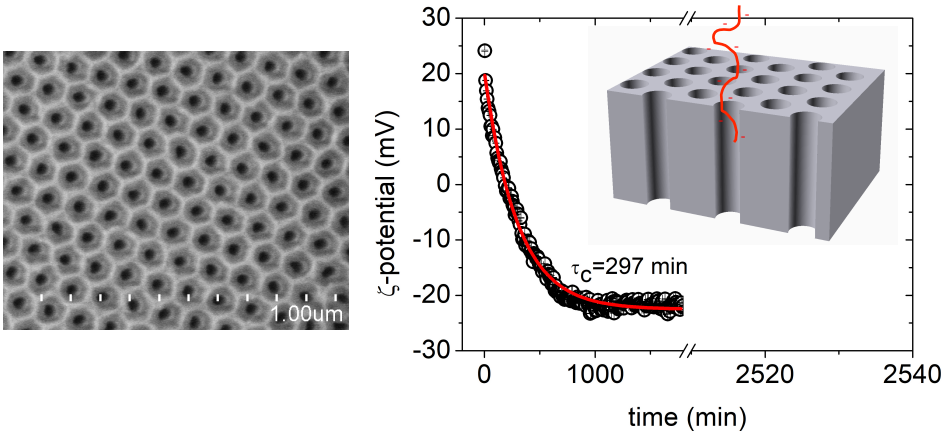

Fig. 1: left: Top view Scanning Electron Microscopy (SEM) image of AAO, right: zeta-potential measurements monitoring the PE penetration in AAO.

The MEM team: The PhD student will work in the « Multiscale Experiments and Modeling (MEM) » team (http://www.phenix.cnrs.fr/spip.php?rubrique8) in the multidisciplinary PHENIX laboratory located in the campus Pierre et Marie Curie of Sorbonne Université, in the center of Paris. The MEM team gathers 18 permanent researchers and 14 non-permanents researchers (postdocs and PhD students) from different nationalities. The team focuses on the understanding and prediction of the behavior of charged systems (polymers, nanoparticles, electrolytes…) under many conditions such as confinement using experimental techniques or simulations. The involved complementary skills coupled with regular team meetings provide a stimulating scientific environment for young PhD students.

Candidate profile: A master degree in Soft Matter, Chemical physics, Physics, Materials science or related fields is required. The candidate should have a strong background in physical chemistry with an interest for experiments in lab. Knowledge in polymer physics and some experience in electrokinetic phenomena will be appreciated. The candidate should be highly motivated and have the ability to work with different scientists, internal or external to the PHENIX laboratory.

Contact: Please send a CV (with at least 2 references contact) and a motivation letter to Emmanuelle Dubois (emmanuelle.dubois@sorbonne-universite.fr) and Nicolas Jouault (nicolas.jouault@sorbonne-universite.fr) before the **2020, 25th May**.

References:

[A] A. Christoulaki et al., *Duplex nanoporous alumina and polyelectrolyte adsorption: more insights from a combined neutron reflectivity and electron microscopy study*, ***Nanoscale***, 2019, 11, 2148-2152

[B] A. Christoulaki et al., *A novel methodology to study nanoporous alumina by small-angle neutron scattering*, ***J. Appl. Cryst.***, 2019, 52, 745-754

[C] A. Christoulaki, Experimental approaches in studying polyelectrolytes inside a porous matrix : the case of nanoporous alumina membranes. ***PhD thesis***, Sorbonne Université, 2018. (English version : https://hal.sorbonne-universite.fr/tel-02352376)

[D] A. Christoulaki et al., *Probing polyelectrolyte adsorption in charged nanochannels by streaming potential measurements*, ***Submitted to ACS Macro Letters***, 2020