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Laboratory of Advanced Separations

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Master's project in chemistry/chemical engineering

Characterization and benchmarking of transport properties two-dimensional membranes for dissolved gas extraction in aquatic environments

<u>Project advisers</u>:
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<u>Context</u>:
Measuring dissolved greenhouse gases in aquatic environment constitutes an important contribution to better understand their biogeochemistry and to evaluate their fluxes at the interface between sediments and water or between water and the atmosphere. A classical technique for quantifying dissolved gases consists in sampling water at different depths using dedicated bottles (called Niskin), followed by off-line measurements in the laboratory. But the results are strongly limited by the lack of detailed spatial and temporal resolution of the sampling technique.

Over the last decade, important technological efforts were conducted to develop in-situ instruments, able to characterize the dissolved concentration of greenhouse gases in real time and at high resolution in water. One of the project advisers, Jérôme Chappellaz, developed such an instrument with his team in France. It relies on optical-feedback cavity-enhanced absorption spectroscopy coupled to membrane extraction of the gases from water. The new technology was used over the last years to notably document with high spatial and temporal resolution the amount of dissolved methane in environments such as (1) the Mediterranean Sea as test-bed for the technology, (2) the Arctic ocean where methane degassing from the seabed is of major concern, (2) Lake Kivu in Rwanda where large amounts of dissolved methane exist in bottom waters, (3) the Black Sea and (4) an alpine lake in France.

So far, this technology uses commercial membranes made of polydimethylsiloxane polymer or PDMS, for extracting dissolved gases from water and for feeding the embedded laser spectrometer in the probe. At EPFL, the team of Prof. Agrawal has developed atomic-thick graphene membranes with high but selective gas flux which is interesting for characterizing transport for selective permeation of gases (e.g., CH_4, N_2O, and NH_3) with respect to other dissolved gases (N_2, O_2, CO_2, Ar).

The mid-term aim of the two project advisers is to develop custom membranes allowing to enrich or deplete specific permeated gases, depending on the application. But as a first step, they propose here to characterize the physical properties and permeance of existing PDMS membranes as a benchmark and compare this to the performance from porous graphene membranes.

<u>Proposed work</u>:
Membrane coupons from new and used membranes from two different commercial providers will be physically characterized by *pressure rise permeation test*. Permeation coefficient of N_2, O_2, Ar, CO_2, CH_4, N_2O, and NH_3 will be measured and compared with existing literature. One of the aspects to address will be the possible physical ageing of PDMS membranes following their use at important water depths and/or in aquatic environments including aggressive chemicals such as H_2S. This will be combined with characterization of graphene membranes prepared by coating PDMS on top of the graphene to understand the synergistic improvement in gas sieving from graphene nanopores.