Ionic conductivity in weak electrolytes via irradiated glass capillaries

With the emergence of solid state batteries, the ionic conductivity in polymers and glasses becomes once again a hot topic. In this work, we propose to study the ionic conductivity of weak electrolytes (low conducting glasses) which were preliminarily charged by an ion beam. This differs from the more usual case where the dielectric (glass) is sandwiched between two conducting plates and globally neutral. Here the dielectric carries a non-zero charge which may influence the conductivity of weak electrolytes. As an original analysis tool, we use glass capillaries and ions beams and study the charge relaxation using the guiding power of glass capillaries.

Guiding power of glass capillaries: Under ion impact, low conducting glasses accumulate electrical charge. The latter generates an electric field that, if sufficiently strong, prevents the following particles to hit the insulating surface. This is the origin of the guiding power of glass capillaries. The guidance of the ions is provided by the formation of a self-organized charged patches that deflected (by elastic collisions) ions through the capillaries. The ion beam plays a double role, (i) it charges the glass and (ii) it probes the temporal evolution of the electric field generated by the accumulated charges, as well as its subsequent relaxation. Following the deflection of the beam on a detector in time, means following the relaxation of the charge with high precision, much higher than what traditional methods offer. Covering for example the outer capillary surface with a metal conductor (typically lithium), which plays the role of the anode in solid state batteries, our capillary-ion beam system allows eventually to study the effect of the anode on the relaxation of the accumulated charge.

This work, which may lead to a PhD thesis, will include both a theoretical and experimental study. Indeed, our group has developed a numerical code for the theoretical study of ion transport through capillaries and has a novel experimental setup for experimental study. The student will have to model the charge transport in glasses with excess charge carriers and test the model with our experimental setup. We also have a priority access to the PELIICEAN platform, for the implantation of ions below the surface of the glasses (doping of glasses), which opens up the way to the study of the conductivity of doped glasses.

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