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Muon-spin Relaxation Studies of Diffusion Processes in Battery Materials

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Solid state diffusion is a very complex mechanism and, up until recently, studies of such properties have mainly been conducted by macroscopic methods that do not yield true material properties. This has been a major problem for materials development regarding e.g. Li-ion batteries where the basic operational principle is based on diffusion of Li-ions. Although the microscopic diffusion coefficient of Li+ (DLi) in solids has been frequently evaluated by Li-NMR, difficulties arise for materials that contain magnetic ions. As a result, it is very difficult to correctly estimate DLi by Li-NMR for most battery materials, particularly for positive electrode materials. Since DLi is one of the primary parameters that govern the charge and discharge rate of a Li-ion batteries, such situation is very unsatisfactory. In order to rectify the shortcomings of NMR and electrochemical measurements, we have developed a novel method that utilizes the muon-spin relaxation (muSR) technique to probe the microscopic ion self-diffusion constant (Dion) in a straightforward manner. In this poster, we will give an introduction to the method itself [1-2] but also summary our muSR work on Li-diffusion in battery cathode materials [3-6]. Furthermore, we will show that the method is not limited to studying only Li-ion diffusion but can also be extended to other groups of compounds [7] and applications e.g. vacancy order formation in transition metal oxides. Finally, we will compare our method to other available microscopic techniques that are able to study ion diffusion in solids, e.g. quasi-elastic neutron scattering (QENS), as well as make an outlook towards future developments.

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