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Towards a microscopic understanding of charge carrier mobility in dielectrics with muon spectroscopy

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This paper reports the development of a novel technique using spin polarised positive muons to probe local charge redistributions within polymeric dielectrics under externally applied E-fields (EEF's). These materials are used in many high voltage applications, and knowledge of charge dynamics is crucial to their successful use, as it dictates their ultimate ability to function as a dielectric. Conventional bulk characterisation methods are useful tools in this regard, but only give information at a micron level, whereas muons give a molecular view and can therefore bring new insight into how charge transport at this level develops prior to breakdown. Here we report the first investigation of this type, studying muons implanted in a polymer epoxy (DGEBA) subjected to an EEF.

DGEBA consists of long chain molecules, including phenyl groups, where muonium can add to form radical states. We have measured ALC lines in this system and found a broad resonance peak with a coupling consistent to addition to the ring. When exposed to a comparatively large externally applied electric field (EEF), but still well below its intrinsic breakdown voltage (Vbr), a change in the muon asymmetry across the entire resonance peak was observed. The largest change in amplitude was observed at the magnetic field corresponding to the centre of the ALC resonance. Working at this fixed magnetic field, changes in amplitude of the resonance curve were explored as a function of applied EEF. Both negative and positive EEF's were applied along the beam direction.

Measurements show an almost perfect linear dependence of the asymmetry of the ALC line to the applied EEF. However,there is a curious departure in this behaviour when small negative EEF's are applied that merits further investigation. Our contribution discusses early results and considers what they tell us about charge mobility in DGEBA on the microscopic level.

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