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Development of a stable measurement system for Radio-Frequency studies of muonium reactivity with metal nanoparticles and surface-adsorbed molecules in mesoporous hosts

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We have recently begun an investigation of paramagnetic (free-radical) final states formed on metal nanoparticles by muonium reactivity with surface-adsorbed molecules. The nanoparticles are incorporated into mesoporous silica, facilitating specific reaction steps in the silica host that involve H-atom transfer reactions important to studies in heterogeneous catalysis. Radio-frequency (RF) methods are an essential tool for characterising final state species in these systems, and a non-metallic sample cell is essential for running these measurements to ensure the RF field penetrates the sample. Initial measurements were carried out using an existing cell with a body made from PEEK polymer, using a 1/16"capillary to enable vapour to be introduced into the cell in-situ. Unfortunately, several significant problems were encountered during initial experiments, the most serious being a temporal instability in the signals measured for both pure silica and for systems loaded with small pressures of benzene. This paper reports in detail on the problems encountered using the PEEK cell, and then discusses the development of a more reliable experimental setup giving better reproducibility for these measurements. The new sample cell has been fabricated from Shapal, a ceramic material with good thermal properties. Previous experience of using Shapal components in gas RF cells has suggested this is a 'clean'material that gives none of the outgassing issues previously associated with PEEK. While rebuilding the cell, the opportunity was also taken to improve the conductance of the vapour transfer tube. The success of the new cell is demonstrated both through off-line tests and by muon measurements, including a series of TF 2G muonium spin precession measurements designed to verify the temporal stability of the experimental setup. Finally, an RF cavity was fashioned, and RF measurements made for muons stopped in bare silica, with signals from both diamagnetic and paramagnetic muon states clearly seen.

Primary author: COTTRELL, Stephen (STFC)

Co-author: Prof. FLEMING, Donald (TRIUMF and Department of Chemistry, University of British Columbia, Vancouver, BC, Canada)

Presenter: COTTRELL, Stephen (STFC)

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