

Muonium Chemistry Experiments in the Gas Phase with Pulsed Surface Muons at ISIS

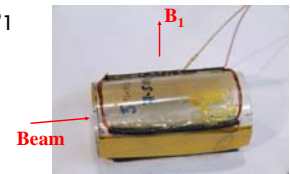
Target cells developed for gas phase muonium chemistry designed for radio frequency (RF) and level crossing measurements up to 50 bar

Ideal Cell Design

- Body chemically inert, muon inert and non-magnetic
- Thin window to allow passage of ~4 MeV positive muons
- Sufficient length to stop muons over range of pressures
- Body and window electrical insulators, external RF coil
- Adjustment of RF coil to match muon stopping distribution

Design of RF coil

- Static field and beam collinear, perpendicular RF field, B_1
- Saddle coil used: length 6cm, diameter 3cm
- Coil volume (42cm^3) limits B_1 (8-10G)
- Tuned coil, working frequency 7-10MHz
- Birdcage or Litz coils may be preferred in future



PEEK Cells appear to satisfy many design criteria, BUT...

- **Polymers lack strength for the higher pressures**



0.6mm window,
14 bar
Up to length 30cm,
diameter 3cm

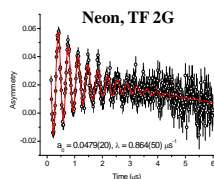


0.7mm laminate Mylar window, 50 bar
Window: $100\text{mg}\cdot\text{cm}^{-2}$
About 50% muons stop in window!
Small window diameter
 $\Rightarrow <20\%$ muons in gas sample!

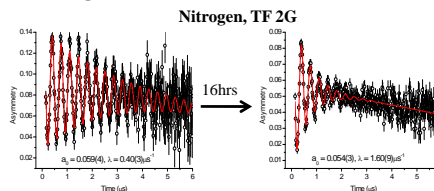
- **Outgassing of impurities from PEEK affects the μSR experiment**

High purity Neon:
Unexpected Mu signal!

Impurity 'X' likely cause:
 $\text{NeMu}^+ + \text{X} \rightarrow \text{Mu} + \text{NeX}^+$



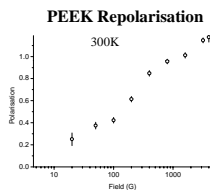
Nitrogen:
Mu relaxation increases with time gas in cell



- **Paramagnetic species formed in PEEK complicate signals from gas**

Diamagnetic polarisation, P_D , ~ 0.1

Full polarisation is recovered in LF, suggesting 90% muons form a radical state with a hyperfine coupling of $\sim 250\text{G}$



ALC- μSR shows a broad feature between 1.4 and 2.3T, consistent with multiple overlapping Δ_1 and methylene proton Δ_0 resonances of cyclohexadienyl radicals with restricted rotational motion

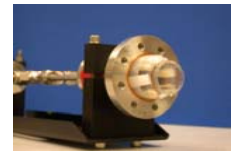


Therefore Metal Cells are the only option...

- Body non-magnetic stainless steel
- Single layer and laminate window investigated:
0.125mm (single): 25 bar, (5 layer * 0.025mm): 35 bar
50 bar achieved with 0.175mm 7 layer laminate

However ...

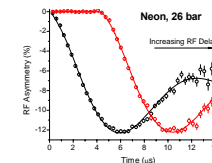
- Internal RF coil:
fixed position, narrow pressure range, requires RF feed-through



but this system is clean!

Experiments in the Gas Phase ...

Diamagnetic and muonium fractions in inert gases were studied (see J. Phys. B: At. Mol. Opt. Phys. 38 (2005) 119)



Delayed RF measurements confirm the formation of the diamagnetic species is due to prompt processes