Canadian Association of Physicists

Association canadienne des physiciens et physiciennes

Contribution ID: **90** Type: **Poster not-in-competition (Undergraduate Student) / Affiche non-compétitive (Étudiant(e) du 1er cycle)**

The Peculiar Behaviour of Dissolved 129Xe in Low and High Concentrations of Ethanol-Water Mixtures

Monday 8 June 2020 13:45 (15 minutes)

Inhaled hyperpolarized (HP) 129Xe MRI is a non-invasive and radiation-risk-free lung imaging method. Simultaneous ventilation/perfusion lung measurements of functional gas exchange within the lungs are possible due to the natural solubility of xenon in lung tissue compared to other imaging gases. Therefore, 129Xe is a unique probe for exploring xenon within and beyond the lung, such as lung parenchyma, red-blood-cells (RBC), and even other organs such as the brain, heart & kidney. This measurement is possible due to the distinct and large range of chemical-shifts ((CS)=200ppm) of 129Xe when residing within parenchyma & RBC compared to the gas phase.

We've conducted CS measurements of HP 129Xe dissolved in ethanol-water mixtures in interval of 0-100% ethanol concentration in order to make a 129Xe MRI phantom mimicking CS (˜19ppm) specific for 129Xe residing in parenchyma & RBC. For each concentration, a 20ml of mixture was shaken with 20ml of 129Xe gas then scanned using 3T GE MRI750 scanner. A FID acquisition (flip angle=33o, TE/TR=0.4ms/1.5s, BW=17kHz, 1024 points) was used to resolve the gas & dissolved-phase peaks. The 129Xe frequency obtained for xenon dissolved in a deionized water (0% mixture) was our reference frequency, i.e., zero-CS (0ppm or 0Hz). We've observed a linear increase of the CS values in Hz on the concentration interval of 0-30% (0 to +116Hz). However, at 40% ethanol concentration, the relative CS became negative (-50Hz, i.e., zero-crossing occurred at ˜38%) and it continued to decrease on the interval of 40-100% (up to -1031Hz). A significant decrease of the 129Xe gas peak signal was observed for high ethanol concentrations (>60%).

To our knowledge, a zero-crossing effect observed near 40% concentration was not previously reported in a literature. We expected to see a gradual increase in CS with the ethanol concentration increase; However, this was true only for the low concentrations (<30%). We hypothesize that the electron density surrounding 129Xe became similar to that in the pure water case (0Hz at ˜38%) and after this, becomes even weaker. The structure of ethanol-water mixtures is a longstanding scientific issue but, the use of HP 129Xe MRI may help to understand these structures better.

We found that the relative frequency shifts obtained at 30% (+116Hz) and 80% (-531Hz) mimic well CS of 129Xe when residing within parenchyma & RBC.

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Session Classification: DPMB Best Student Oral Presentations

Track Classification: Physics in Medicine and Biology / Physique en médecine et en biologie (DPMB-DPMB)