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Towards a Gas Filtration Setup for Ultra-Sensitive SF_6 Gas Based Dark Matter Searches

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The gas SF_6 has become of interest as a negative ion drift gas for use in directional dark matter searches. However, as for other gas targets in such searches, it is important that contamination can be removed as problems with signal detection can arise. Radon gas contamination can decay and produce unwanted background events, able to mimic genuine signals. Outgassing and gas leakage from the detector cylinder can introduce contaminants such as water, oxygen and nitrogen, which can capture interaction-produced electrons, thus suppressing signals. Many gas based rare-event physics experiments manage contamination by continuous flow and disposal of the target gas. However, SF_6 is the most potent greenhouse gas, making this method problematic. Therefore, an alternative method must be implemented for future SF_6 based experiments, where the gas is reused and recycled.

The demonstration of radon removal from SF_6 gas with molecular sieves (MS) was a significant advance towards an SF_6 filtration system. It was also found that other MS types were able to capture water, oxygen and nitrogen from SF_6. This makes it possible to remove both radon and air contaminants by using an MS filter mixture. Unfortunately, since commercial MS are primarily used in the petroleum industry, where having low radioactive content is not essential, commercial MS intrinsically emanate radon at levels unsuitable for ultra-sensitive rare-event physics experiments.

A method to produce low radioactive MS has been developed in Nihon University (NU). A comparison with a commercially available Sigma-Aldrich MS was made by calculating a parameter indicating the amount of radon intrinsically emanated by the MS per unit radon captured from SF_6. It was found that the NU developed MS (V2) emanated radon at least 98.9% less per radon captured, making it a better candidate for use in an SF_6 filtration system. To the author's knowledge, these are the lowest intrinsically emanating radon-absorbing material per unit mass (activated charcoal or molecular sieves).

In this talk, we will discuss the design, construction and test results of a new MS SF_6 filtration setup using a custom gas handling and circulation system. The gas system utilises a Vacuum Swing Adsorption (VSA) technique, making on-site regeneration of the MS possible. The regeneration functionality enables the MS filter to be reused, allowing continuous long-term operation of the filtration setup. The gas system's capabilities were tested with a small-scale low-pressure 100L SF_6 TPC detector. A long-term comparison of the detector's performance with and without the gas system operating preliminary results are presented.

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