Characterization of Wet Aerosol Transportation for Online Chemistry Experiments
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Introduction
Transactinides are elements with atomic number Z > 103, and the chemical properties of these elements continue to influence our understanding of the periodic table due to the influence of relativistic effects [1]. These elements do not occur naturally and are made artificially by means of target bombardment with projectiles using particle accelerators, as shown in this figure:

Once a heavy element is formed, it must be separated from unreacted beam using a process known as physical pre-separation [2] and thermalized (stopped) in a recoil transfer chamber (RTC) before it can be used in a chemical experiment. This process is illustrated in the following figure:

An RTC has been fabricated at Texas A&M University, and its stopping capabilities have been characterized in a series of experiments [3]. The RTC is shown below.

After thermalization in the RTC, the ions will be attached to KCl aerosols in the "aerosol chamber" (AC) for transport to a chemistry chamber (RTC) before it can be used in a chemical experiment. This process is illustrated in the following figure:

Experimental Procedure
The efficiency of aerosol transportation depends on a number of factors, including:
- Chemical properties of the radionuclide.
- Gas flow rate inside the chamber.
- Size of the aerosol particles.
- Half-life of the radionuclide.

We chose to use a 229Th source to provide activity for these experiments. This source produces a number of radionuclides with varying chemical properties and half-lives. (See the figure below). Using a 229Th source will make a simple, affordable, and easy-to-manipulate system, and eliminates the need to use accelerator time for these experiments.

If any water from the wet aerosols were to enter the RTC aerosol chamber, then this could potentially damage the electronics used in this area. Therefore, we created an AC chamber simulation system in order to avoid complications. The following system was developed to perform experimental runs that would allow us to characterize the KCl aerosol transport and measure the efficiency.

Experimental Setup:

Wet KCl aerosol particles are created at a constant rate and are guided to the simulated AC chamber to make them interact with the 229Th source. Aerosol particles carrying radionuclides then go through a filter holder with a sorbent and two filter papers. All particles are intended to be collected by sorbent. Small sorbent particles or smaller aerosol particles that pass through the holder (if any) can then be collected by a second filter with different pore size inside a collection chamber. Collection of aerosol particles was measured by monitoring mass changes on the whole filter holder with sorbent inside by weighting it before and after each run. The atomizer reservoir bottle and aerosol dryer (squared items) were made artificially by means of target bombardment with projectiles using particle accelerators, as shown in this figure:

A system for testing "wet" KCl aerosols with the RTC has been developed.

The KCl aerosol generator has been checked with a "simulated AC chamber.

Four different sorbent materials have been studied for aerosol particle collection.

229Th is not suitable as a source for the efficiency tests.

Additional work is needed to optimize the use of wet aerosols before they can be used in online experiments.

Future work
- Use a radioactive source with greater activity and more suitable decay properties for future characterizations.
- Incorporate an aerosol dryer to allow the aerosols to be used with the actual RTC.
- Add a generator reservoir bottle in order to maintain constant concentration of the KCl solution.
- Add an aerosol particle neutralizer to prevent aerosols from being influenced by stray electric fields in the RTC.

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References

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Results and Analysis
Initial experiments were performed without radioactive material to prevent contamination. Four different sorbent materials were tested, and the mass of aerosols collected were measured in 2 min intervals. The data in the following figure suggest that the sorbents were becoming saturated and/or the rate of production of aerosols by the generator is not constant.

The HPGe spectra suggest that no significant activity was collected on the sorbent. The experiments were repeated using an NaI detector (which has significantly higher efficiency), and the data are shown below.

These data suggest that the strength of interaction between the radionuclides and the aerosols is weak, or that the activity from the source was too low to measure effectively.