IDENTIFICATION AND SEPARATION OF GASES SUCH AS OXYGEN, HELIUM (3) OR HELIUM (4)

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Introduction

Detection and harvest of Helium 3 gas has been investigated by a number of researchers, due to its economic value. Helium 3 is an isotope of Helium 4, is stable, and can be used in a variety of applications to include medical instrument cooling, aerospace applications, and energy applications.

Objection

The objective of this proposal shall demonstrate the efficient extraction and separation of helium, hydrogen and oxygen can be accomplished using a simple gravity-driven piston acting on a sample of lunar simulant with trapped gas.(gas extraction) and subsequent separation (O_2, He 4, He 3, and H_2) using a solar powered miniature centrifuge (Figure 1).

Previous Research

A number of researchers, government agencies, and commercial industries are interested in developing a market for Helium 3. Companies such as SpaceX, Boeing, and various start-up companies are interested in acquiring the technology, but not necessarily developing the technology. Research and development of the harvesting and diagnostic techniques has largely fallen upon various research labs, both government, educational and commercial facilities.

Existing He recovery schemes have been investigated using closed-cycle designs, which currently have drawbacks when applied to extreme environments. The major issue is power. A second is space, and a third, need for sophisticated equation. On the one hand, while mature products exist, such as the gas bag recovery systems occupy substantial lab space. In addition, the gas bag or balloon for storing the He boil-off and lubricated compressor introduces contamination issues.

Currently, separation of gases or liquids has been successfully accomplished using methods such as centrifugation, and electro precipitation. Other techniques using alternative pressures and temperatures along with various radical scavengers to combine with helium.

However, the only method that can truly separate Helium 3 from Helium 4 is centrifugation. Other hybrid methods include centrifugation of radical scavenger – Helium combinations but these do not address the separation and distinction between Helium 3 and Helium 4. The difference between the two isotopes is an extra neutron (Helium 4) and a spin of ½ (Helium 3) instead of 0 (Helium 4).

A closed-cycle helium recycler was developed for continuous uninterrupted operation for magnetometer-based whole-head magnetoencephalography (MEG) systems.   It generally The recycler consists of a two stage 4 K pulse-tube cryocooler and is mounted on the roof of a magnetically shielded room (MSR). A flexible liquid helium (LHe) return line on the recycler is inserted into the fill port of the MEG system in the MSR through a slotted opening in the ceiling. The helium vapor is captured through a line that returns the gas to the top of the recycler assembly.

A high purity helium gas cylinder connected to the recycler assembly supplies the gas. Existing He recovery schemes for the research laboratories, mainly gasbag-style systems and closed-cycle designs, suffer from various drawbacks and very rarely meet both the need and financial situation of individual laboratories that run vibration-sensitive cryogenic instruments. On the one hand, while mature products exist, the gas bag style recovery systems occupy substantial lab space that is not easily accessible to many research laboratories. Besides, the gas bag or balloon for temporarily storing the He boil-off together with the oil-lubricated compressor used to further compress He into the medium-pressure storage tanks introduces significant contamination and leakage.

Wang et. al., (2024) successfully used low vibration sound to release helium from entrapped substrates. However, higher frequency waves were not fully addressed, nor were any mention of second harmonics which may ignite any remaining hydrogen. Lin et. al., also described an economical and efficient helium recovery system, but did not discuss how such a system could be used in microgravity, or in the presence of other gases.

Villaloga and Rabitz, (1986), as well as other more recent investigations (Perez and Jiang 2009), Nik, (2023) and Wang et. al., (2025), presented a theoretical model to describe the collision of gas molecules with solid substrates. In particular molecules of interest included platinum, nickel and tungsten.

Methodology

There are three different filters which are needed to separate the following gases, O2, He 3, He 4 and H2 .Materials such as aerogel, polypropylene, and carbon nano carbon particles, which could be acquired from Sigman Aldrich Chemical Company, or American Elements Inc.

These materials should be mixed into a homogeneous blend in order to facilitate steady gas flow. A General Electric Blender, or similar product can accomplish this effort. It must be mixed at 2000 to 3500 rpm for 30 seconds to achieve complete mixing. The mixture is then placed in a stainless-steel cold container of suitable size, such as 5 cm by 5 cm by 5 mm square. Once the material is placed into the mold, it is pressurized using a Carver Press Heating and Pressurization unit, or similar apparatus, and subjected to 2.2 – 2.7 atm pressure at the materials' respective glass transition temperature, for 120 seconds or more.

The second filter material is used to separate He3 from He4, is composed of carbon graphite nanoparticles. The covalent radius of He3 is about 63 picometers, whereas the He4 covalent of about 120 picometers.

Thus, a material whose interatomic radius is between 63 and 120 picometers is suitable for use as a He3/He4 filter. Furthermore, examples of such filter material could be carbon graphite. Tungsten Carbide nanoparticles. Tungsten Floride. Or Boron Floride. The preparation temperature of this part of the assembly should be circa 1200 C, and 3.2 atmospheres, according to first principles modeling techniques.

Results

Below is a schematic of the device used to collect Helium 3 and Helium 4.

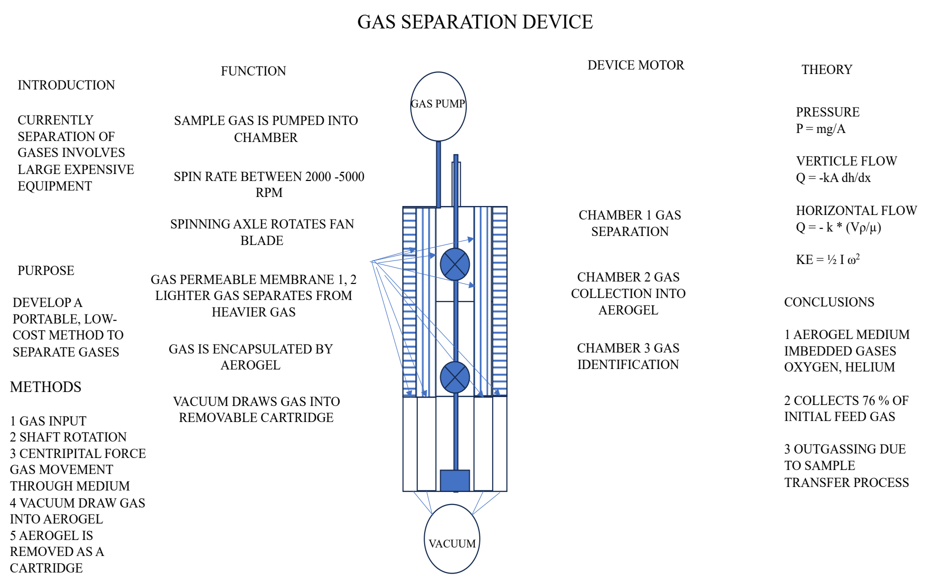

Figure 1 Schematic description of helium separation device.

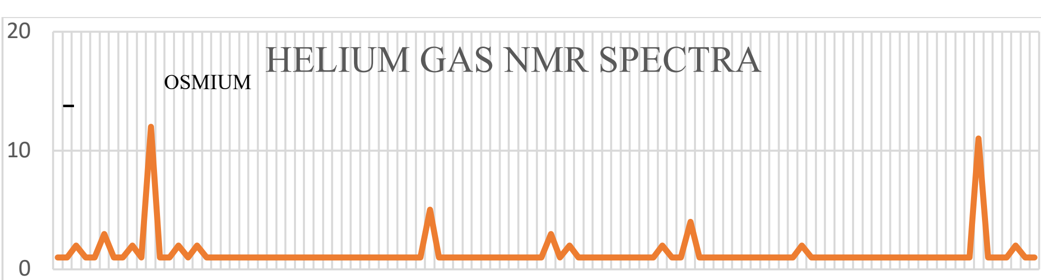

Figure 2 Comparison between NMR signals of helium 3 with respect to control osmium tetroxide.

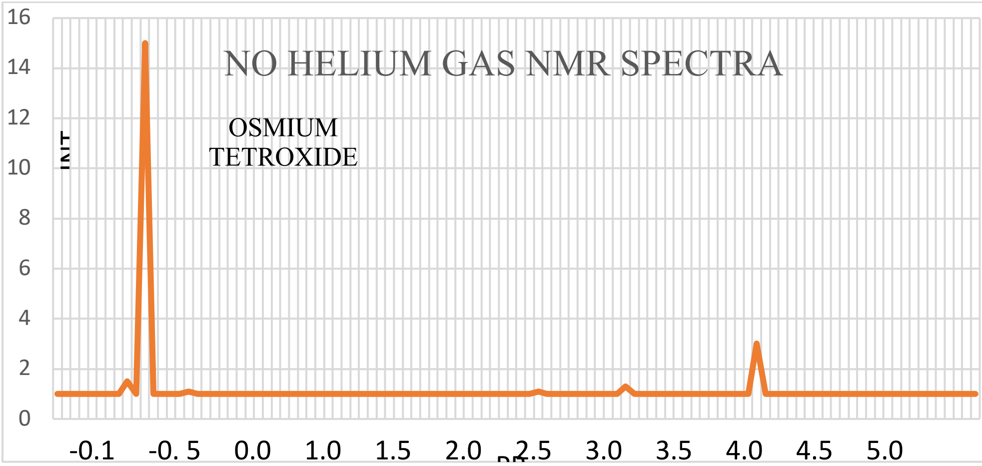

Figure 3 Sample spectral sample containing no added helium with respect to control osmium tetroxide.

T. Sternfeld, R. E. Hoffman, M. Saunders, R. J. Cross, M. S. Syamala, M. Rabinovitz, *J. Am. Chem. Soc.* **2002**, *124*, 8786-8787.

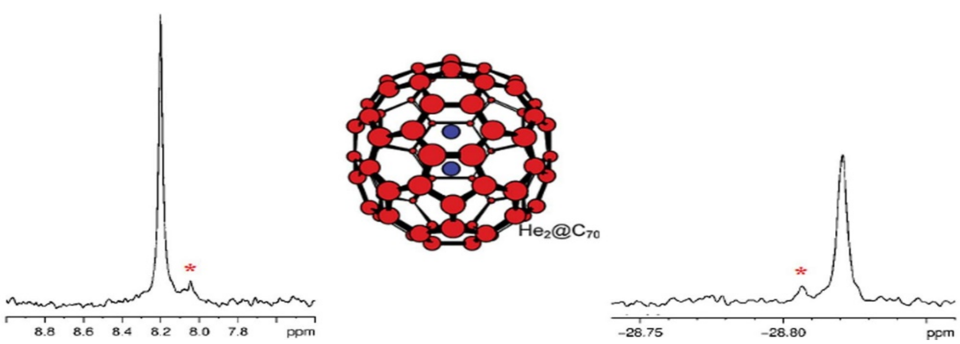

Figure 4 Illustration of previous investigations which discern signals of helium 3 and helium 4 using NMR.

Conclusions

Key commercial applications are in the fields of national security, quantum computing, medical imaging, energy, oil and gas exploration, and space sciences. There is currently a significant shortage in the supply of helium 3 for these applications.

Harvesting locations such as the Moon, asteroids, or even earth locations near volcanic activity are the most likely sources rich in helium 3.