**Chem4P Project Plan Intro**

Helium is the 2nd most abundant element in the universe, existing as a colourless, inert, monoatomic gas. It has many different important applications in the real world, not all of them being obvious. For example, liquid helium is used as a cryogenic coolant in MRI and NMR, providing temperatures low enough for the superconducting magnets to function. In 2016, 30% of helium was used in MRI alone.1 The gas also has key roles in many other fields. It is used in deep-sea diving air mixtures as it is non-toxic and has no narcotic effect like oxygen and nitrogen do. It is also used in welding as a shielding gas because of its inertness, and as a carrier gas in analytical techniques such as gas chromatography for the same reason.

However, despite helium’s abundance in the universe, global supplies are dwindling. There are two reasons for this: number one is that helium is a non-renewable gas, meaning that once all of the Earth’s natural reserves have been tapped the supply will run out. The second reason is that once helium has escaped containment (as it often does due to its small size and the high financial cost of buying a recycler for the vented gas – up to several millions of dollars)3 it leaves the Earth’s atmosphere, becoming lost in space. The severity of the issue was confirmed in 2017 when the European Union added helium to its list of critical raw materials.4 Because of helium’s many different applications, it is obvious that a shortage would cause many fields, including science and healthcare, to not be able to function normally. To add to this issue, the global demand for helium is expected to rise while the production capacity has reached its limit.

The only useful method for producing of helium is to extract it from specific natural gas fields, i.e., those with a concentration greater than 0.3%. Helium is present in the air at concentrations of 5 ppm,however this concentration is too low to extract a meaningful quantity.5 Conventional methods of helium extraction from natural gas fields involve cryogenic distillation. This process requires extremely low temperatures and high pressure in order to provide an environment suitable for the separation of residual gases like hydrogen and nitrogen. Therefore, it is expensive and requires the use of lots of energy.5 New methods could be designed to extract helium from natural gas which make the extraction process more efficient.

Metal organic frameworks (MOFs) are increasing in popularity as a topic of research. These are crystalline materials made from organic and inorganic building blocks, formed through a process of molecular self-assembly. They are remarkable for their large internal surface area and for the ease of tuning their properties e.g. pore size. They have gained considerable attention as a molecule capable of adsorbing different gases such as CO­2.6The use of MOFs could be a promising solution to the helium shortage issue.

1. U.S. Department of the Interior, U.S. Geological Survey, Minerals Yearbook (2016). [*"Helium"*](http://minerals.usgs.gov/minerals/pubs/commodity/helium/mcs-2015-heliu.pdf) <https://d9-wret.s3-us-west-2.amazonaws.com/assets/palladium/production/atoms/files/myb1-2016-heliu.pdf>
2. Kidnay, A.J. and Parrish, W. (2006) Fundamentals of Natural Gas Processing, CRC Press, Boca Raton, FL
3. “Helium should be recycled” Nature **547**, 6 (2017) https://doi.org/10.1038/547006a
4. King, A. Helium and rubber added to EU critical raw materials list. <https://www.chemistryworld.com/news/helium-and-rubber-added-to-eu-critical-raw-materials-list/3008055.article> (accessed Oct 04, 2022)
5. Kidnay, A.J. and Parrish, W. (2006) Fundamentals of Natural Gas Processing, CRC Press, Boca Raton, FL.
6. Tao Jia, Yifan Gu, Fengting Li, Progress and potential of metal-organic frameworks (MOFs) for gas storage and separation: A review, Journal of Environmental Chemical Engineering, Volume 10, 2022,