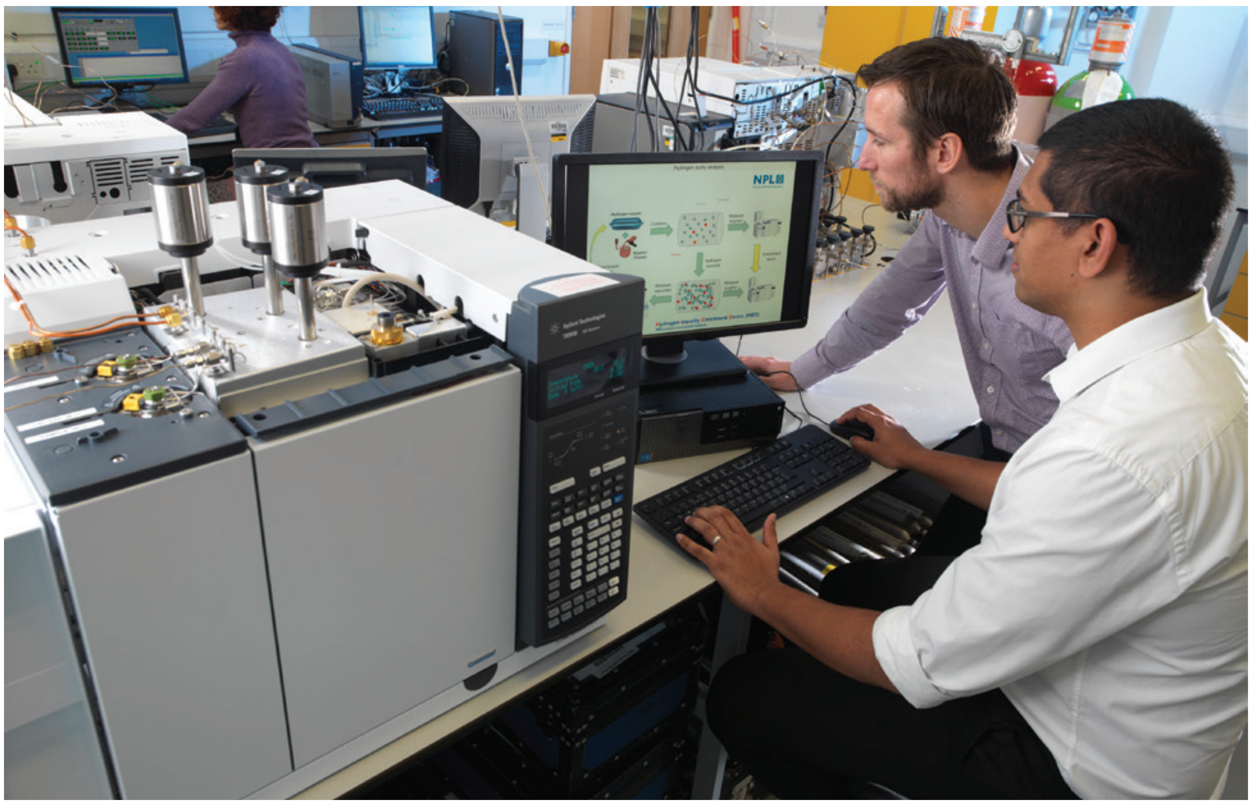
GAS PURITY ANALYSIS IS ESSENTIAL FOR SUSTAINABLE CARBON CAPTURE AND STORAGE

The concept of Carbon Capture and Storage (CCS) is to recover carbon dioxide (CO_2) from industrial process gas emissions and inject the CO_2 deep into the ground for long term storage. Atmospheric emissions of CO_2 from existing combustion processes, such as cement production or electrical power generation can thereby be reduced to slow down climate change.

Several new projects have also been proposed to construct steam methane reformers (SMR), or auto thermal reformers (ATR) to produce large quantities of hydrogen for heating and mobility applications. CCS is an integral part of these schemes to ensure that they produce blue hydrogen and play a role in sustainable decarbonisation.

SMRs and ATRs are most commonly fed with natural gas which is rich in methane. When the natural gas rises from the underground gas reservoir, it is generally accompanied by large quantities of CO_2 which has existed with the methane in the underground gas field for thousands of years. Many CCS schemes plan to use depleted natural gas reservoirs for the long-term storage of CO_2, thereby refilling them with a gas that they previously contained. So, the CCS process can be thought of as returning CO_2 to its underground home. For example, the Fergus gas terminal at Peterhead in Scotland would be integral to the Acorn project. In this case, the flow direction of the existing natural gas pipeline would be reversed to pump carbon dioxide from onshore sources, back out to the gas fields under the North Sea.

Before we store CO_2 deep underground, we must ensure that important gas purity criteria have been met. When we use CO_2 to freeze food or carbonate beverages the need for using a high purity gas is abundantly clear and there are equally compelling, but different reasons that CO_2 purity is also a critical issue in CCS applications. However, at present there is no common standard to define the quality of CO_2 that should be used in CCS projects. Many of the brightest minds in gas purity assay are working hard to address this gap.



NPL Gas Reference Materials Accrediation Quality Management team

Gas purity standards in Hydrogen and Healthcare can lead the way

The purity of Hydrogen for use in fuel cell electric vehicles is subject to an international standard, namely the 'ISO14678:2019 Hydrogen fuel quality – product specification'. Impurities such as carbon monoxide and hydrogen sulphide are capped at levels that will guarantee the hydrogen is compatible with standard modern fuel cells and does not poison the sensitive catalysts. The maximum combined argon and nitrogen concentration is also specified to avoid the long-term accumulation of these inert air gases in the fuel cell which would result in a potentially dangerous loss of vehicle power.

In patient healthcare, as has been highlighted by the many thousands of respiratory treatment cases caused by Covid-19 worldwide, oxygen is also used extensively as a medical therapy. It is directly inhaled by vulnerable people and its purity must be tightly controlled. In this medical application, there are also rigorous standards set by the main international Pharmacopeia which govern the production, identification and assay of medical

NPL Gas mixture standard preparation © copyright NPL

oxygen to ensure that it will help to cure, not harm patients.

International standards also govern the use of nitrogen in pharmaceutical drug manufacturing applications. In some cases, nitrogen is used as an active pharmaceutical ingredient and in other applications, such as packaging, it is used as processing aid. The European, Japanese and US Pharmacopeia all recognise the importance of nitrogen in pharmaceutical applications and have specified stringent quality standards to ensure that the purity is appropriate.

The examples above focus on three different gases: hydrogen, oxygen and nitrogen. What they share are a minimum purity for the gas and maximum concentrations of impurities which could be harmful to the application. Some also specify the analytical method to conduct the purity assay or the analysis of trace impurities. So, in the consideration of a future standardised purity specification for CO_2 in CCS applications, there are some parallels to learn from.

The importance of carbon dioxide purity in CCS applications

In the realm of international metrology, many issues are being considered as the debate about the requirement for a CCS CO_2 standard is taking place. Dr Arul Murugan, Senior Research Scientist for Energy Gases at NPL in the UK says that "in some CCS schemes, the idea is to liquify the carbon dioxide either for immediate storage or to enable its transportation by ship to an offshore platform where it will be further processed. Incondensable gases such as nitrogen or methane could reduce the efficiency of this process by increasing the required energy input. Furthermore, these gases do not behave in the same way as CO_2 when injected underground and they take up valuable storage space".

Murugan adds that "in other CCS schemes, the proposal is to compress CO2 to a high pressure so that it can be cost effectively transported in long distance pipelines before being injected into suitable geological structures deep underground. These compressor stations and pipelines are highly valuable assets which must be protected." If there are combinations of gases in the CO_2, that can result in corrosion, such as ammonia and moisture or hydrogen sulphide and moisture they may cause irreversible damage to the pipeline or even the storage site itself. This corrosion of the CCS infrastructure would be costly to repair. Corrosion could also pose a safety risk if it went unnoticed and caused a pipeline rupture. In these cases, detection of these trace contaminants is essential to prevent problems escalating.

Process performance and gas distribution asset integrity are not the only reasons for careful analysis and control of CCS CO_2 purity.

Nitrogen for pharmaceutical packaging

Green Hydrogen concept

The safety of the personnel operating the CCS equipment and the general public are also of paramount importance. CO_2 intended for CCS may also contain trace levels of highly toxic chemicals such as mercury or hydrogen cyanide. Whilst operators cannot always prevent these molecules being present at tiny levels, they can monitor their concentrations to ensure that they exist in the gas only in minute traces which would ensure that any potential CO_2 leak from the CCS processing equipment or storage site does not pose a health risk. Murugan continues to say that "with all these operational, health and safety considerations in mind, my team at NPL are starting to develop the analytical methods and traceable reference materials required for performing these important purity analyses".

DRAX Power Station UK

Many nations in may also wish to participate in CCS schemes, but if their country does not have the appropriate geological profile, they must rely on exporting their CO_2. So, for the trade in CO_2 for CCS will inevitably become international. This is a key driver for the development of an international standard for CCS CO_2 purity to ensure a harmonised approach and consistent levels of safety. The standard will also lock in parameters that players in the CCS industry can design around to ensure optimal performance of their equipment.

Accurate gas analysis closes the loop

Internationally acclaimed metrological bodies, such as NPL, play a role beyond defining the composition of gas standards for new applications. They also produce high precision gas standard mixture cylinders that contain the required chemical species at the relevant concentrations. These certified gas mixtures can be used to calibrate gas analysers in the field which are in service to measure the CO_2 purity.

CCS asset owners need to be sure that their gas storage terminals, compression stations and distribution pipelines will not be attacked by corrosive impurities in the CO_2. Speaking as Head of Product Management for the continuous gas analyser product range within ABB's Measurement & Analytics business line, Steve Gibbons

ABB LGR-ICOS Online Natural Gas Analyser © copyright ABB

says that "our LGR-ICOS gas analyser is ideal to monitor trace levels of many gases, such as moisture, oxygen and hydrogen sulphide. Oxygen is a tracer that is used to provide early warning of pipeline leaks. Hydrogen sulphide is toxic and when combined with water, it causes corrosion problems. So, in one instrument we have the capability to address several concerns that these trace impurities raise". Laser techniques are highly responsive to small concentration changes, so they can rapidly enable mitigating process control interventions to deescalate potential issues before they become major problems.

Operators also want to be sure that the inert gases, which rob power from the gas compressor, are present only at minimal concentrations. Methane and nitrogen are the most common inert gases found in carbon dioxide. Gibbons says that "in some cases, we would recommend a TCD gas analyser, such as the Caldos27 to measure nitrogen or an NDIR analyser like the Uras26 to measure methane. Or, the LGR-ICOS can also be used to measure methane alongside the reactive gases". In closing, he adds that "our gas analysers have been used for many years to uphold rigorous gas purity standards. For example, the EU and US Pharmacopeia monographs specify that a paramagnetic oxygen analyser must be used for the identification and purity assay of medicinal oxygen. That's an application where our Magnos28 has been used for decades".

Author Contact Details

Stephen B. Harrison. sbh4 GmbH • Kranzlstraße 21, 82538 Geretsried, Germany • Tel: +49 (0)8171 24 64 954 • Email: sbh@sbh4.de • **Web: www.sbh4.de**