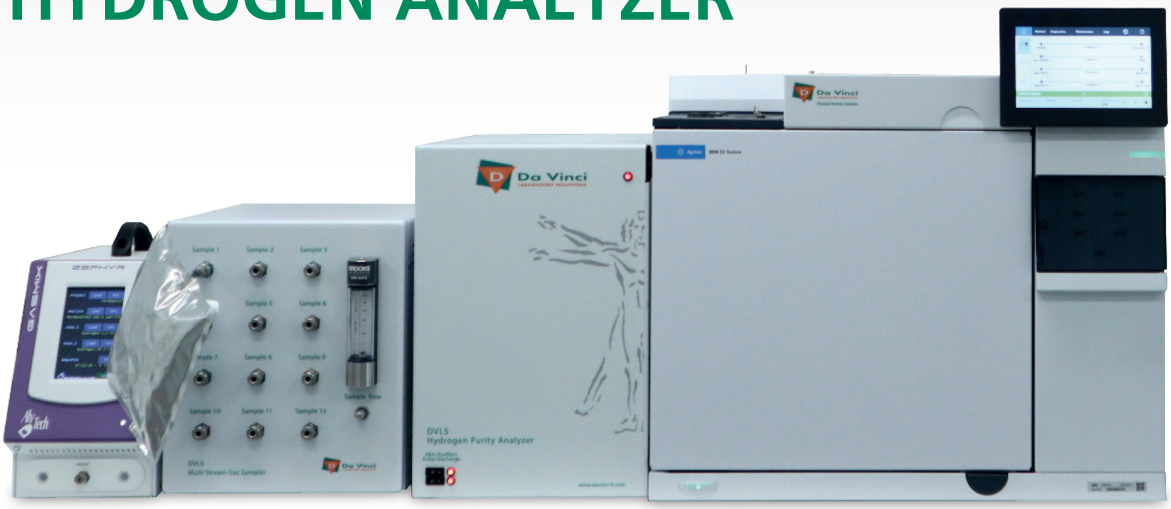
THE ANALYSIS OF IMPURITIES IN HYDROGEN FUEL USING THE DVLS HYDROGEN ANALYZER



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Hydrogen is becoming more prominent as a potential fuel as a sustainable replacement of (hydro) carbon-based fuels. When combusted, it emits only water vapor rather than carbon dioxide, making it a cleaner energy carrier. Hydrogen can be produced through a variety of methods, depending on the source material and energy input. Green hydrogen is produced by electrolyzing water using renewable energy sources such as wind or solar power. Blue hydrogen is obtained through steam methane reforming or autothermal reforming, combined with carbon capture and storage. Grey hydrogen is produced without carbon capture, often as a by-product of oil refining processes.

The hydrogen is often used for fuel cell applications. To prevent damage to the fuel cell, the hydrogen supplied must meet stringent purity requirements. ISO 14687 defines the maximum allowable levels of various impurities in hydrogen intended for fuel cell applications. Da Vinci Laboratory Solutions (DVLS) has developed a gas chromatographic analysis for the determination of permanent gases in hydrogen. This application note describes the performance of the DVLS Hydrogen Purity Analyzer.

EXPERIMENTAL

The system is comprised of three chromatographic channels. The first channel is used for the determination of argon, oxygen and nitrogen using a Pulsed Discharge Helium Ionization Detector (PDHID). The second channel is used for the determination of carbon monoxide, methane, carbon dioxide and heavy hydrocarbons using a methanizer and Flame Ionization Detector (FID). The third channel is used for the determination of helium using a Thermal Conductivity Detector (TCD). After the analysis of an hydrogen sample, the sampling path could be purged using high purity helium to eliminate carry-over from out-of-spec samples. The system was equipped with a DVLS Multi Stream Gas Sampler (MSGS) and a AlyTech Gas Mix for calibration.

Using the Gas Mix and a primary calibration standard, a multi-level calibration was performed. Using a low concentration, the detection limits were determined. Finally, a repeatability was obtained.

RESULTS

Using the Gas Mix, the calibration curves seen in Figure 1 were obtained. Each concentration level has been analyzed in triplicate.

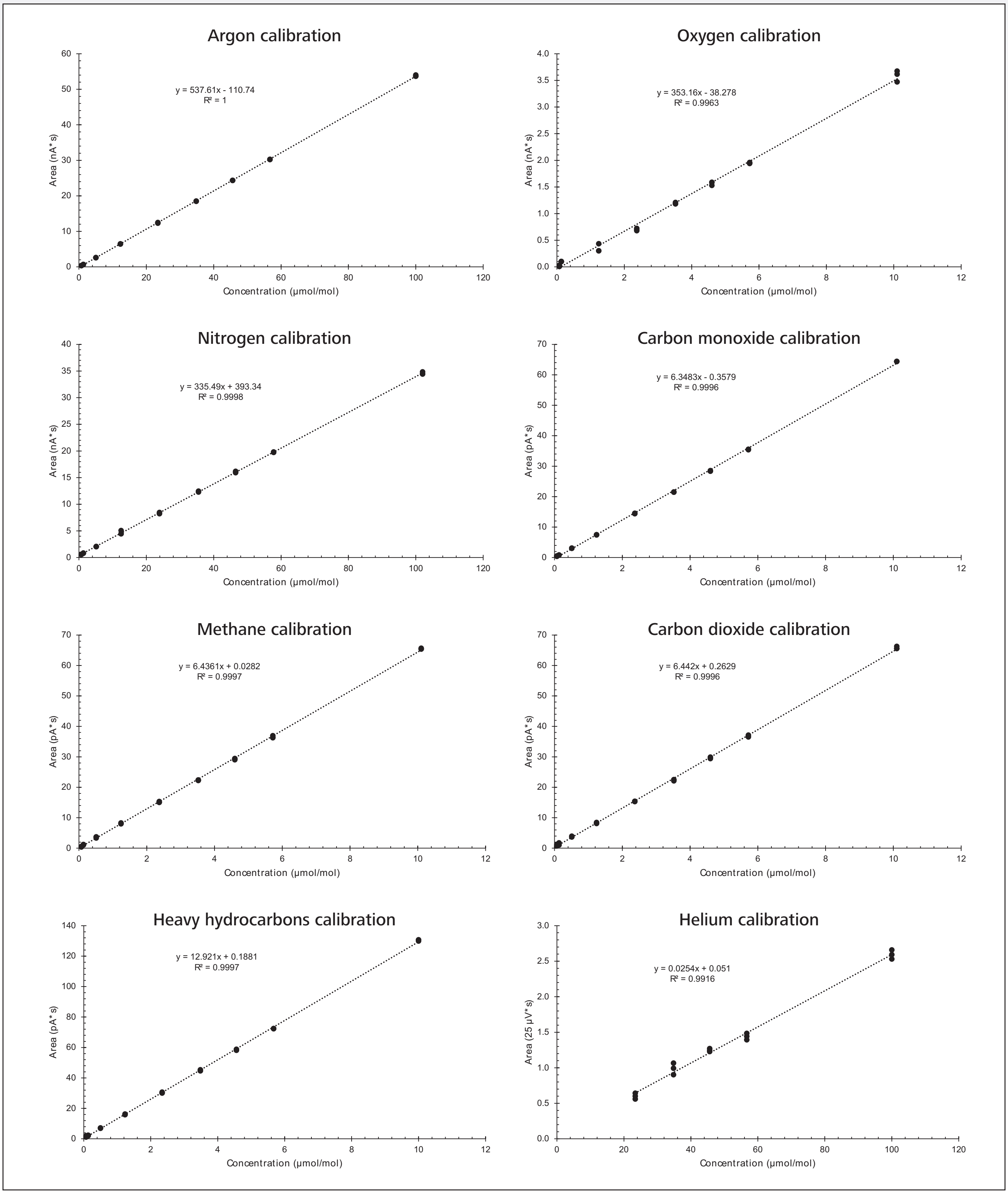

Figure 1: Calibration curves

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As seen in Figure 1, each calibration line shows linear response over the calibrated range. The individual data point for the helium calibration, show some deviation due to the low concentrations which are close to the detection limit. The obtained detection limits are compared to the ISO specifications in Table 1.

The detection limits shown Table 1 meet the requirements set by the ISO specifications. This is further supported by the chromatograms shown in Figure 2, Figure 3, and Figure 4. These chromatograms contain hydrogen standards with impurities below the limit set by ISO.

Table 1: Detection limit results compared to the ISO specification

Compound	ISO Specification (µmol/mol)	Detection limit (µmol/mol)
Argon	300	<0.1
Oxygen	5	<0.1
Nitrogen	300	<0.1
Carbon monoxide	0.2	0.1
Methane	100	<1
Carbon dioxide	2	<1
Heavy hydrocarbons	2	<1
Helium	300	<50

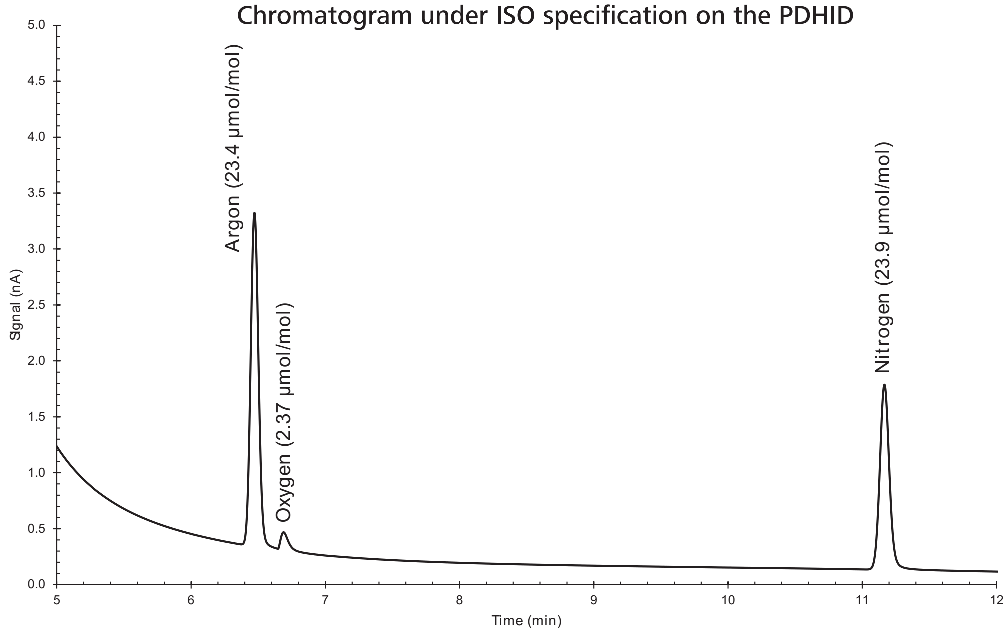

Figure 2: Hydrogen standard containing impurities complying with the ISO specification on the PDHID

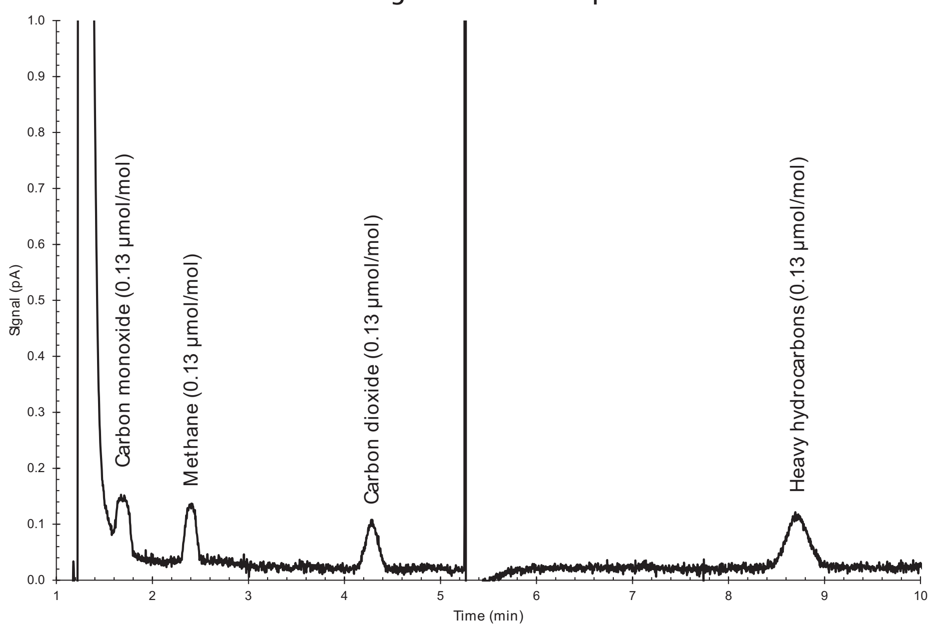

Figure 3: Hydrogen standard containing impurities complying with the ISO specification on the FID

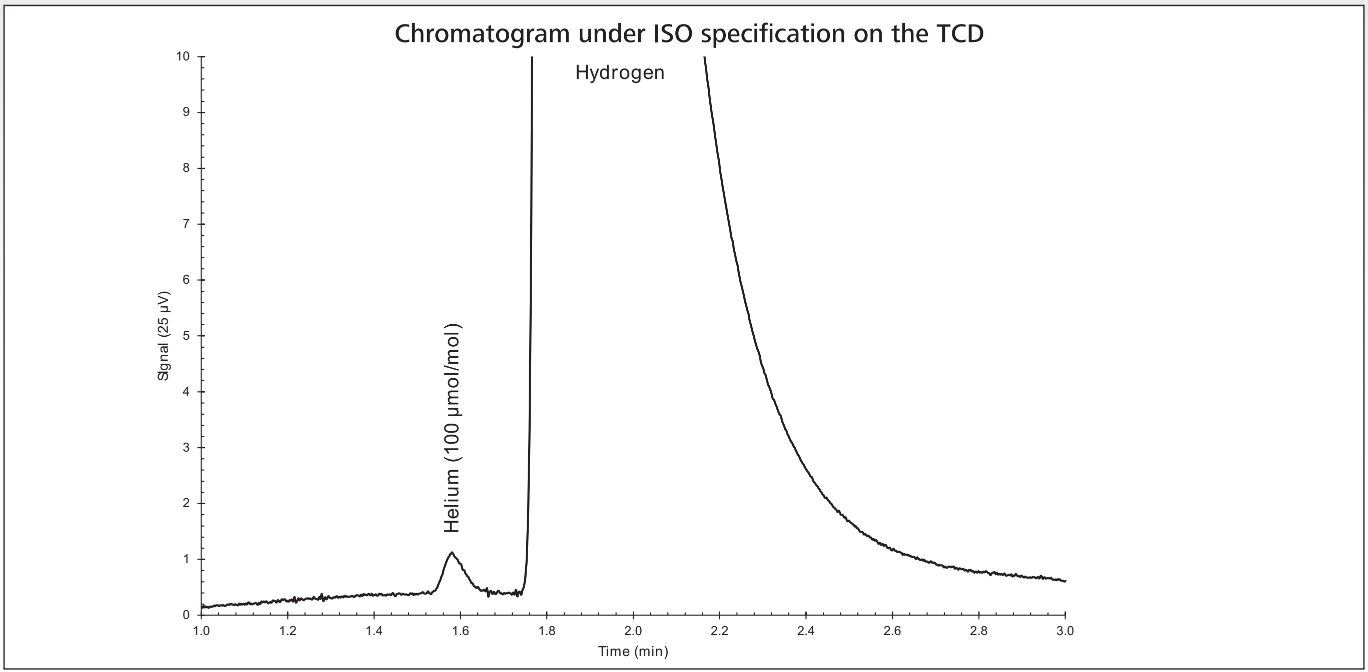

Figure 4: Hydrogen standard containing impurities complying with the ISO specification on the TCD

In Figure 2, a baseline separation between argon and oxygen with a resolution of 2.0 can be seen. Helium is separated from the hydrogen bulk with a resolution of 3.4 as seen in Figure 4. The obtained repeatability can be found in Table 2.

Table 2: Twelve repeatability runs

Run	Argon	Oxygen	Nitrogen	Carbon monoxide	Methane	Carbon dioxide	Heavy hydrocarbons	Helium
1	101	10.5	104	10.2	10.1	10.1	10.0	92.4
2	100	10.4	104	10.2	10.2	10.1	10.0	96.2
3	100	9.8	109	10.2	10.1	10.1	10.0	91.4
4	102	10.2	110	10.2	10.1	10.1	10.0	94.4
5	102	10.4	110	10.2	10.1	10.1	10.0	93.9
6	103	10.5	111	10.2	10.1	10.0	10.1	97.5
7	102	10.5	110	10.2	10.1	10.1	10.1	90.5
8	103	10.6	112	10.2	10.1	10.1	10.0	102.9
9	103	10.6	110	10.2	10.1	10.1	10.0	93.0
10	103	10.7	110	10.2	10.1	10.1	10.0	97.9
11	102	10.5	107	10.2	10.1	10.1	10.0	93.3
12	012	10.5	105	10.2	10.1	10.1	10.1	94.9
AVG	102	10.4	109	10.2	10.1	10.1	10.0	94.9
STDEV	0.95	0.24	2.69	0.01	0.03	0.03	0.02	3.39
RSD (%)	0.94	2.30	2.48	0.13	0.26	0.31	0.25	3.58

In Table 2, it can be seen that all compounds have an RSD below 5% and some compounds even have repeatability below 1% RSD.

CONCLUSION

The DVLS hydrogen fuel analyzer provides excellent repeatability and detection limits for the determination of impurities in hydrogen fuel. The total analysis time is approximately 20 minutes with RSD below 5% and detection limits that meet the ISO specifications.

More information:

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