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Optimizing the Efficiency and Productivity of GC/MS Workflows to Improve Laboratory Sustainability

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Introduction

Today, laboratories consume a staggering 10 times more energy and water than a typical office [1]. Labs with GC and GC/MS systems have unique sustainability challenges due to the resource-intensive nature of these instruments. They consume large amounts of gas and energy while also generating hazardous waste products. According to Agilent customer surveys, 85 percent of labs and organizations have sustainability goals in place, and 83 percent of lab leaders believe their current workflow requires optimization to meet their sustainability ambitions [2]. A more efficient laboratory is a more sustainable one. This poster outlines some simple approaches that laboratories can take, today, to optimize workflow efficiency and productivity, thus minimizing resource consumption.

Experimental

Laboratory workflows are the cornerstone of laboratory operations. In this poster we will illustrate the impact of column scaling for GC/MS workflows, the use of hydrogen as an alternative, renewable carrier gas for GC and GC/MS. Hydrogen offers unique safety and reactivity challenges that we will address with Agilent HydroInert source. Lastly, we will demonstrate simple and effective ways to conserve gases, focusing on existing helium carrier gas workflows. In the end, these simple, easy-to-implement practices will illustrate how sustainability can be accomplished in conjunction with improving workflow profitability and productivity.

Column Scaling

Column scaling, using the Agilent GC Method Translator software, is an easy-to-implement practice to reduce both analysis time and gas consumption. High-efficiency GC columns refers to mini-bore columns with 0.18 mm internal diameter (ID). When scaling methods, it is critical to maintain the column phase ratio to ensure identical chromatography. Scaling 203 pesticides from a 30 m x 0.25 mm x 0.25 um GC configuration to a 20 m x 0.18 mm x 0.18 um reduced the run time in half, saving 9 minutes per analysis, and also reduced gas consumption by 28%, as shown in Figure 1. It's important to note that while column scaling reduces run times and carrier gas consumption, sample capacity reduction also occurs. A 64% capacity reduction in capacity occurs when scaling from a conventional narrow-bore to a high-efficiency minibore column as shown in Table 1.

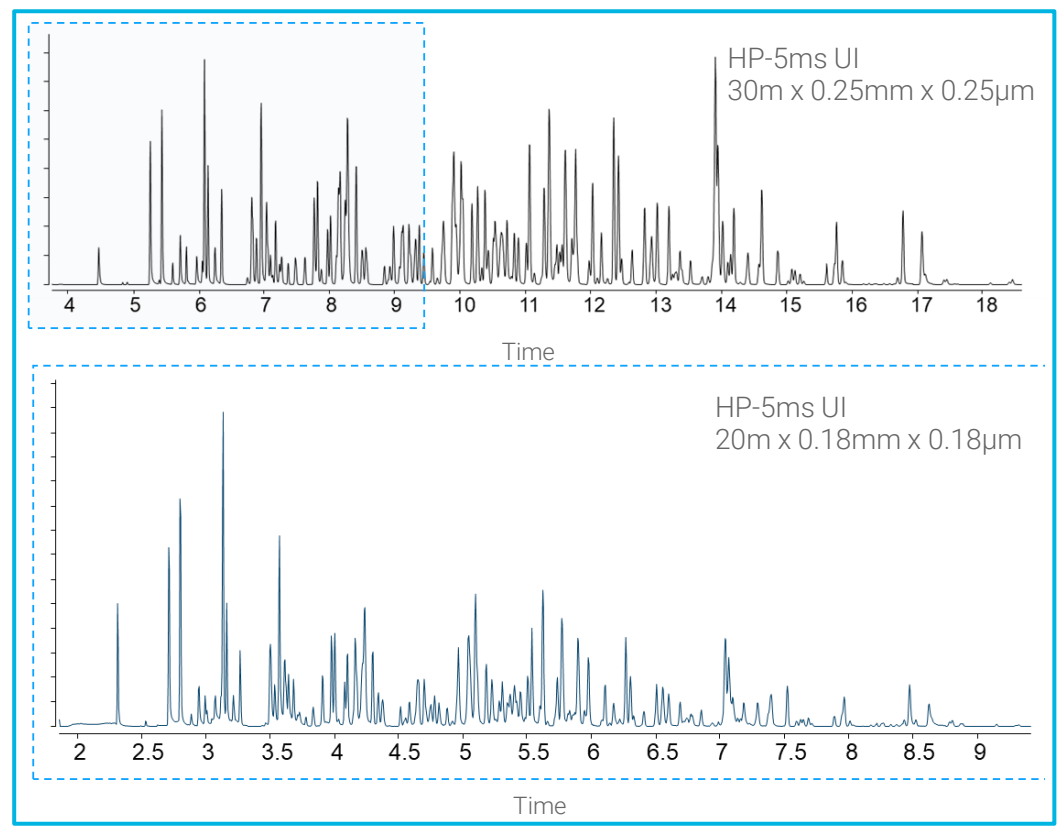

Figure 1. Chromatogram comparison for a 203-pesticide mixture using a conventional and high efficiency column configurations.

	Analysis Time (minutes)	Column ID (mm)	Common Name	Flow Reduction	Capacity Reduction
Conventional GC/MS	25	0.25 mm	Narrow-bore	0	0
High-Efficiency	10	0.18 mm	Mini-bore	28%	64%
Ultra Fast	4	0.10 mm	Micro-bore	85%	94%

Table 1. Column scaling impact on analysis time, flow reduction, and sample capacity reduction.

Alternative Carrier Gases

Carrier Gases

Helium shortages have impacted analytical laboratories since 2006 and repeatedly been in short supply[3]. While helium's availability has improved in recent years, there are still concerns surrounding supply stability and rising costs. Knowing the cyclic nature of the helium supply chain, exploring alternative carrier gas options like hydrogen and nitrogen are necessary for laboratory managers looking for sustainability, flexibility, and cost savings measures. Specifically, hydrogen carrier gas is a good option for GC/MS methods and when using the Agilent Method Translator tool, methods can easily be transferred. Figure 3 highlights parameter adjustments for translation like pressure, flow, velocity, and temperature program rates to ensure similar relative retention orders with the alternative gas. Hydrogen when compared to nitrogen as a carrier gas provides the best alternative for chromatographic resolution and speed. Figure 4 demonstrates a method transfer of helium to hydrogen carrier gas for ASTM D5769.

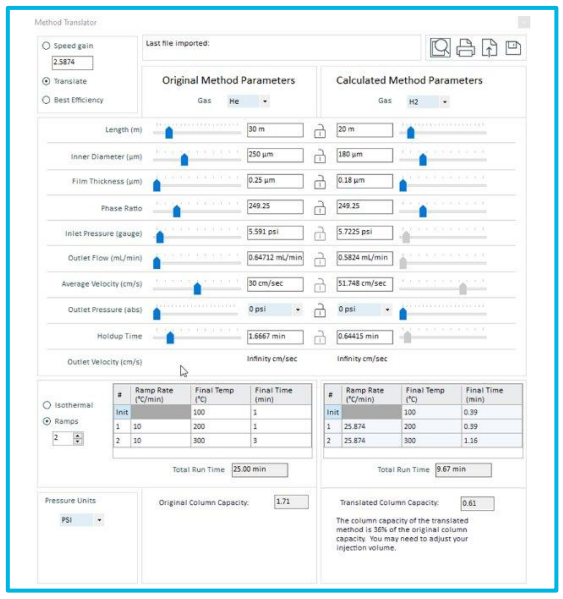

Figure 3. Example of transferring helium carrier gas method to hydrogen using the Agilent Method Translator tool.

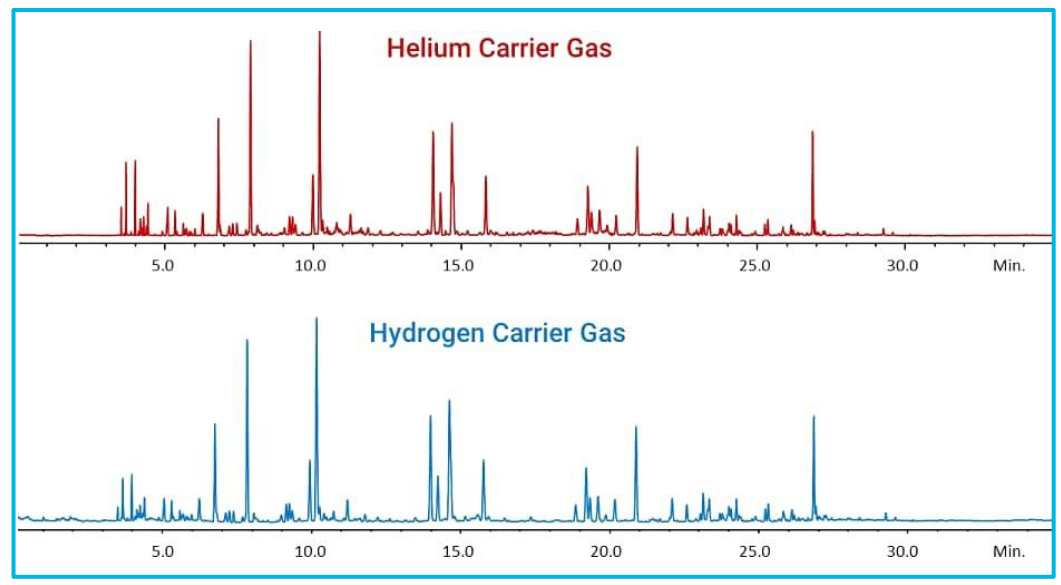

Figure 4. Method translation from helium to hydrogen carrier gas for ASTM D5769: GC/MS analysis of aromatics in gasoline.

Ionization Source Specifically Designed for use with Hydrogen Carrier Gas

Hydrogen is widely recognized for its benefits in gas chromatography (GC), including cost-effective generation in the lab, rapid chromatography, minimizing carrier gas consumption, and higher sample throughput. However, its reactivity can lead to hydrogenation and dechlorination reactions in the mass spectrometer electron ionization (EI) source, complicating its application in many scenarios. To address these issues, Agilent has developed a specially designed extractor source for the Inert Plus GC/MSD and triple quadrupole GC/MS systems, enhancing performance with hydrogen carrier gas. The Agilent HydroInert source maintains mass spectral fidelity and allows users to utilize existing helium-based mass spectral libraries. But because it is not inert, hydrogen does not work well with semivolatile organic compounds (SVOCs) like those described in methods, such as EPA 8270. Figure 4 shows the analysis of nitrobenzene with and without the use of the HydroInert source. Nitrobenzene is a compound venerable to reduction when using hydrogen carrier[4].

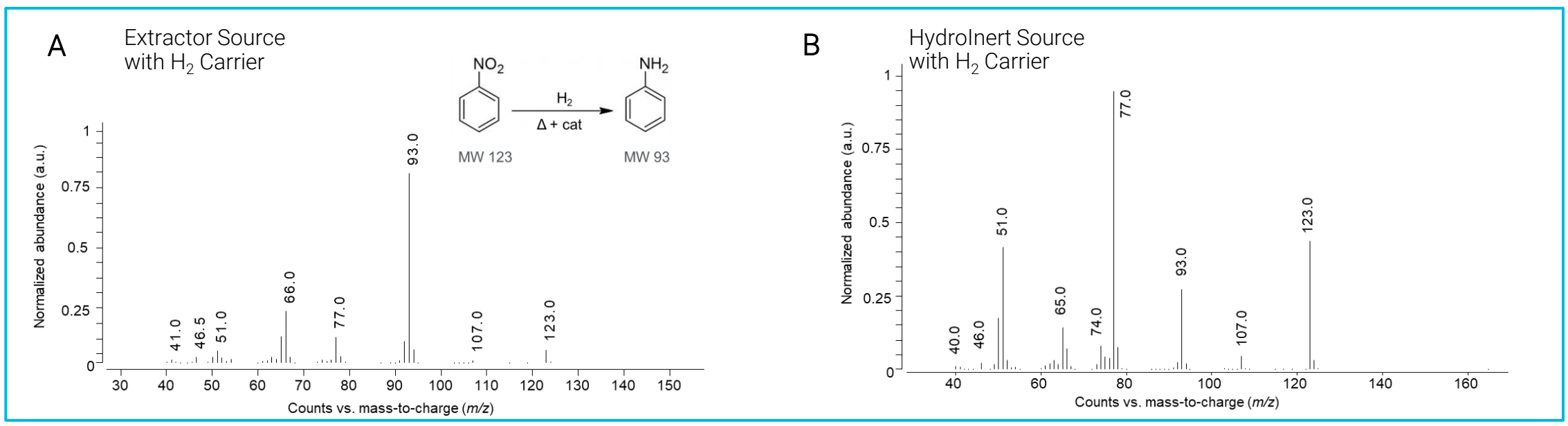

Figure 4. (A) Extractor source (3 mm extraction lens) showed nitrobenzene undergoing reduction to aniline with the abundant m/z 93 ion. (B) The HydroInert source showed an improved ratio of m/z 123.

Consumables Impact

Tailored GC Columns

Consumables in GC/MS workflows are often overlooked as contributing factors to sustainability and optimization. For example, minimizing column bleed and improving GC column thermal durability can have a major beneficial impacted for both data quality and instrument uptime. Agilent J&W 5Q GC columns provide the lowest bleed standard for GC/MS workflows. This provides less downtime from ion source cleaning, faster conditioning, and minimize reruns due to data quality issues. Figure 5 and 6 highlight thermal stability and sensitivity of the DB-5Q and HP-5Q columns.

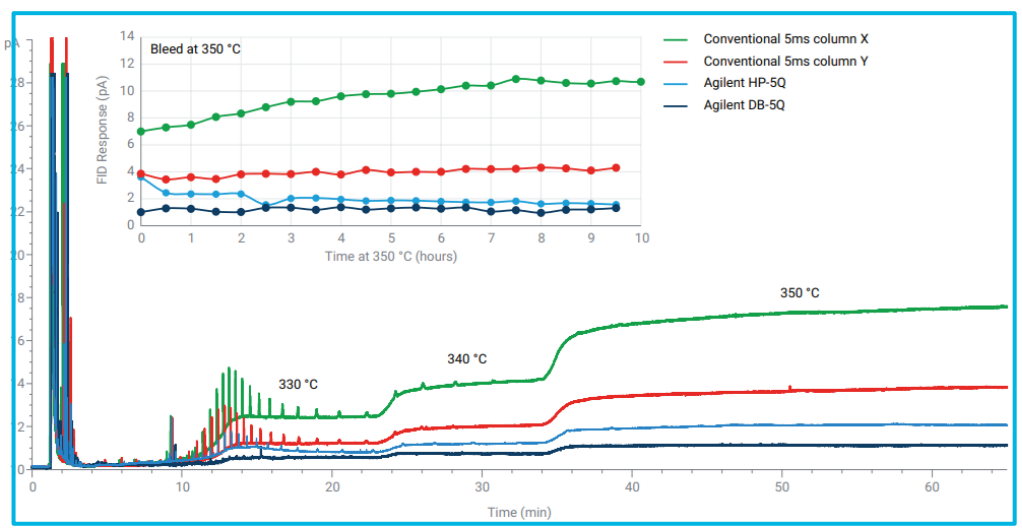

Figure 5. Comparison of bleed profiles of traditional 5ms type GC phases vs. the Agilent J&W DB-5Q and HP-5Q phases.

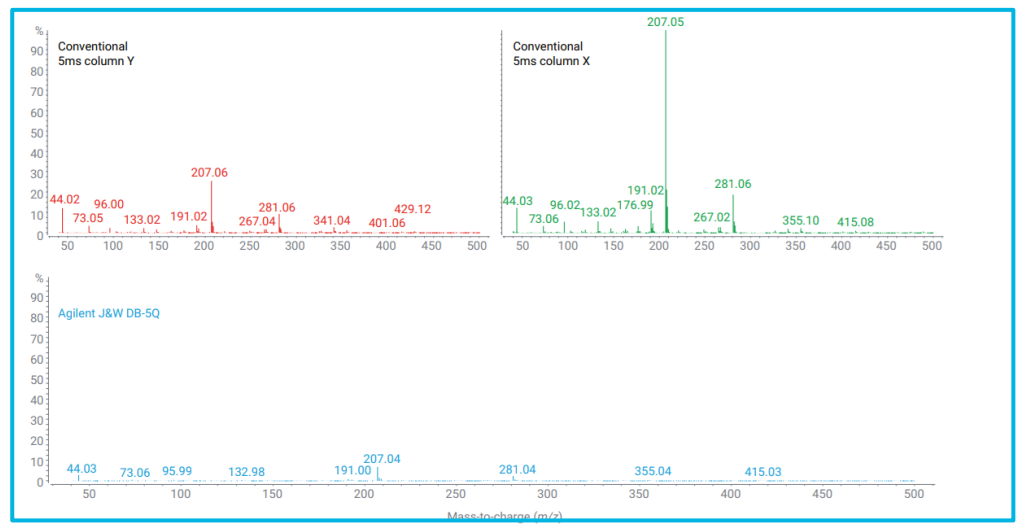

Figure 6. Comparison of bleed spectra of traditional 5ms type GC phases vs. the Agilent J&W DB-5Q and HP-5Q phases.

Software Features

Helium Conservation Module and Gas Saver

When converting existing methods to alternative carrier gases is not an option for GC/MS workflows, the Agilent Gas Saver can afford laboratories a way to conserve helium usage. The Helium Conservation module bridges two EPC channels to deliver a single carrier gas flow to the GC. This allows a GC method to switch to a different gas (typically nitrogen) when your GC is idle. When combined with Gas Saver, laboratories are provided both flexibility and maximum efficiency of consumption for alternative carrier gas usage. Figure 7 shows a 3.8X reduction in helium consumption using Gas Saver and a 7X reduction when combining Gas Saver and the Helium Conservation module.

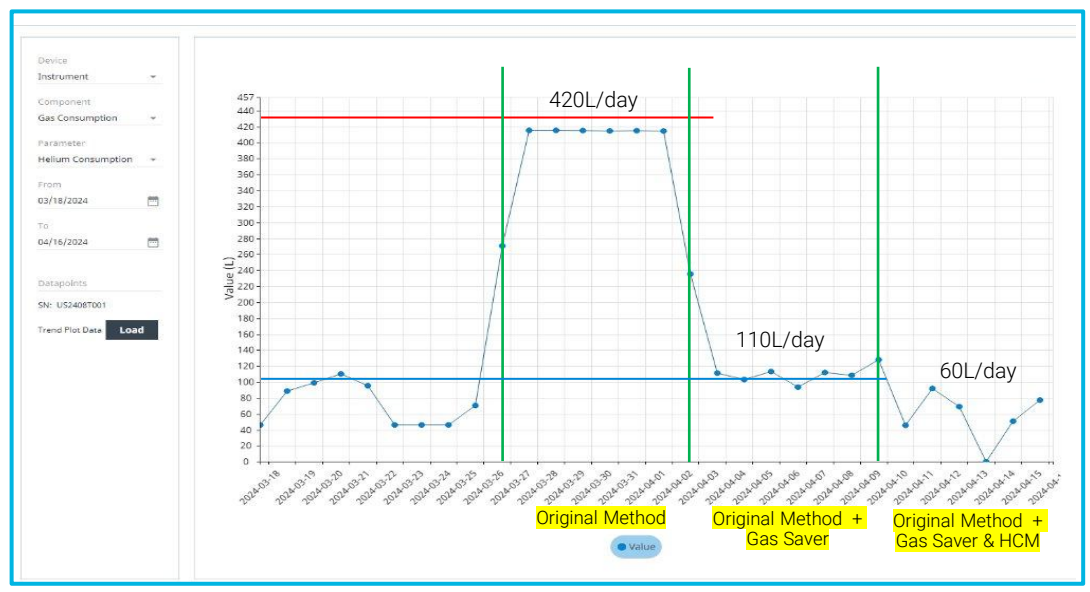

Figure 7. Scenarios of monthly helium consumption comparison with Gas Saver and HCM.

Conclusions

Optimizing the efficiency and productivity of GC/MS workflows are critical for analytical laboratories to stay competitive and profitable. This poster demonstrated a time savings of 50% with column scaling from a conventional GC/MS column to a high-efficiency column, successful alternative carrier gas method transfer, reducing potential source reactivity when using hydrogen carrier, and demonstrated 3.8 to 7X factor reduction of carrier gas consumption when using software features and the Helium Conservation module.

https://www.agilent.com/en/promotions/asms

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