Fast GC: Good Separations in Less Than 10 Seconds

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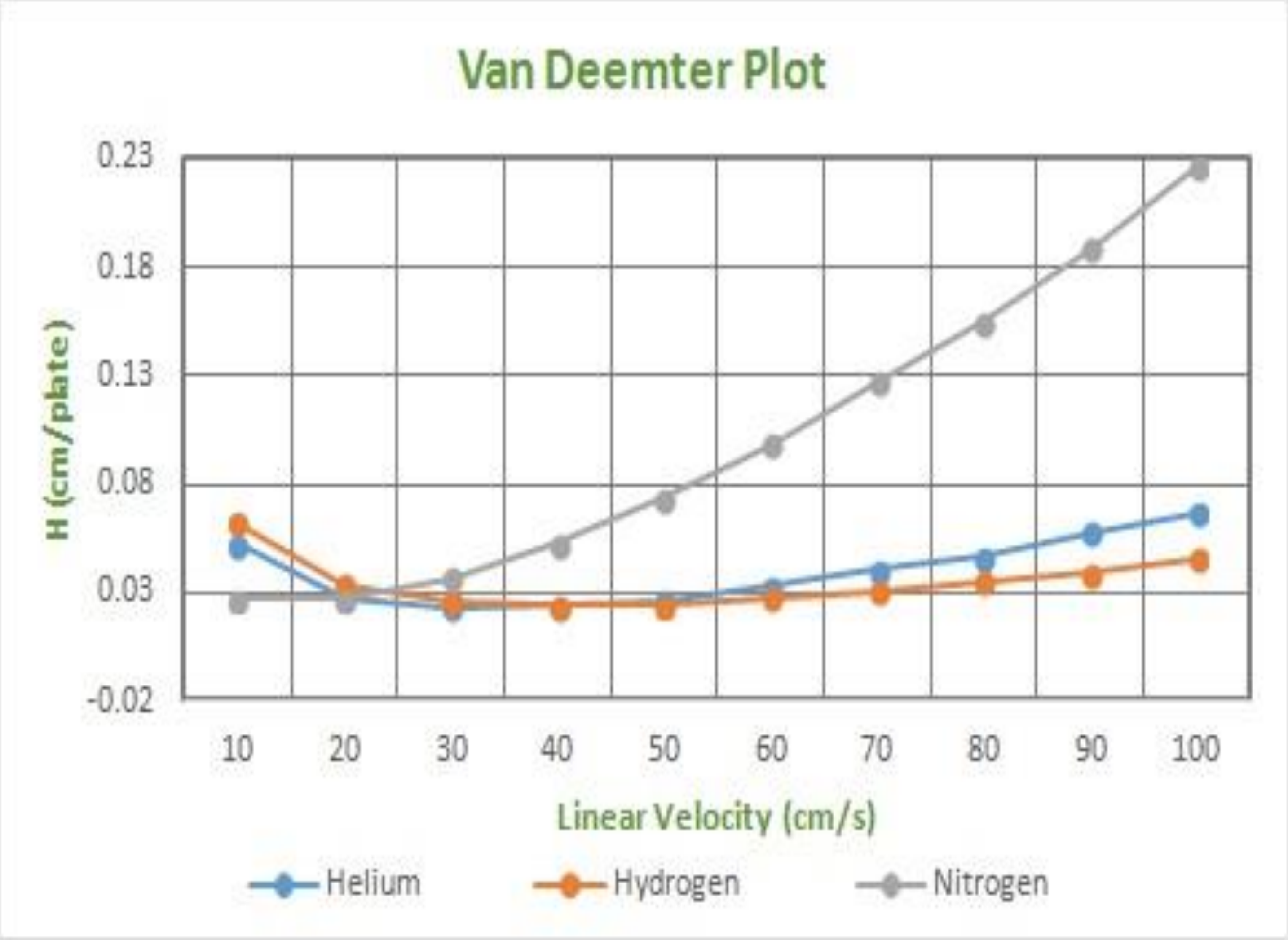
Introduction

Gas Chromatography is one of the most widely used analytical techniques in the world, yet most analysis times are measured in minutes rather than seconds. Small column diameters and thin films can be used in conjunction with hydrogen carrier gas to produce flatter Van Deemter curves (maintaining higher efficiencies over a wider range of flow rates). Using the Van Deemter equation as a guide, we investigate the best combinations of ultra-short (<1M), small diameter (50 µm), thin film columns with high flow rate hydrogen carrier gas and fast heating. The work was done on a modified Agilent 6850 GC with a high voltage (240V) power supply using hydrogen as a carrier gas. The results include a <30 second temperature programmed run of a 10-component hydrocarbon/alcohol mix and a <5 second analysis of 3 hydrocarbons in hexane.

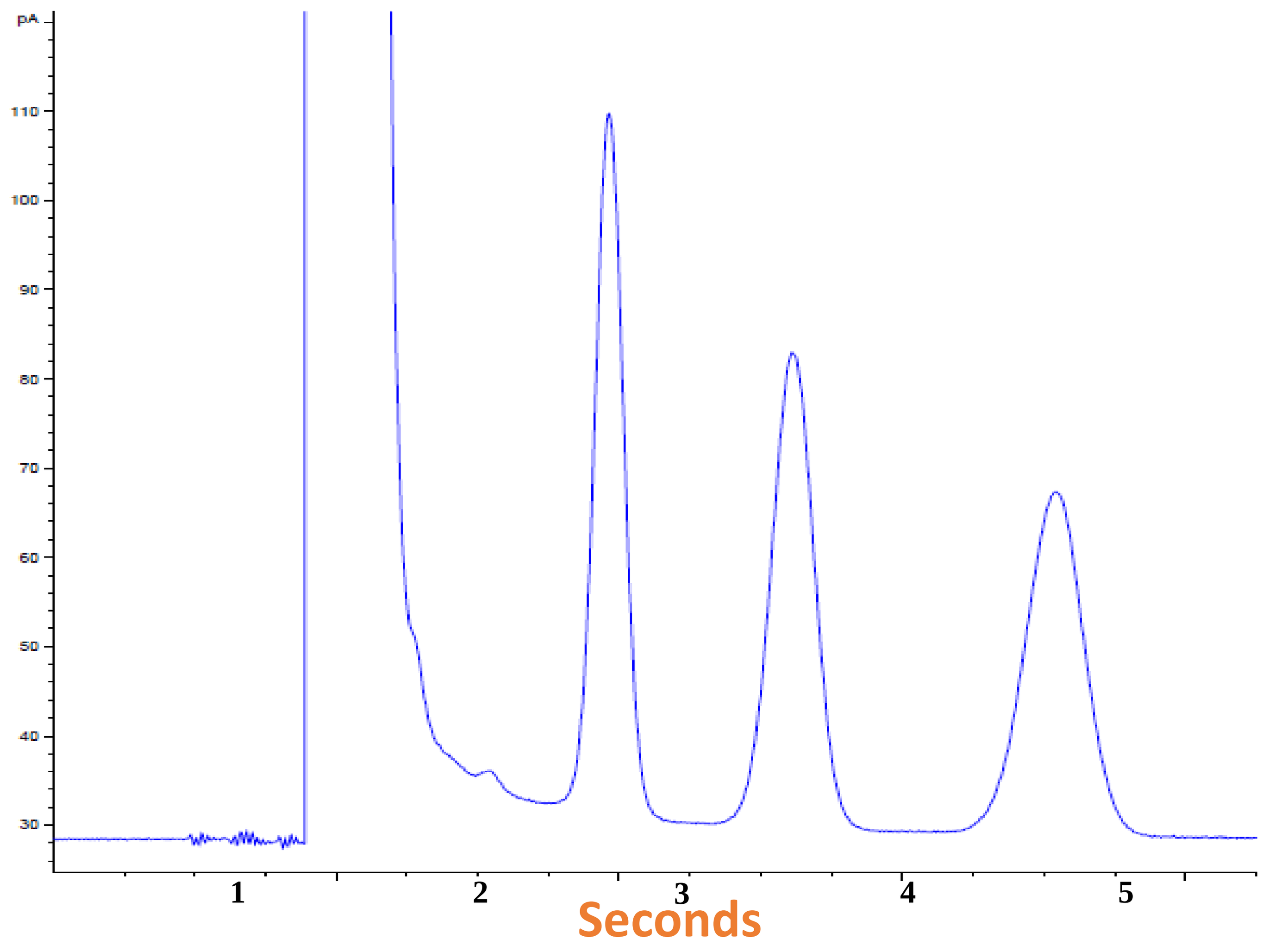
Experimental Conditions

GC	Agilent 6850 with 240 V power supply Agilent 7890
Column	4m x 0.18 mm x 0.18 µm DB-5 30m x 0.25 mm x 0.25 µm DB-5 0.5m x 0.05mm x 0.05 µm DB-5
Temperature Program	Isothermal or 80°C to 200°C at 125°C/min 80°C to 200°C at 120° and 240°C/min
Flow Mode	Constant Flow
Linear Velocity	30 cm/sec, 150 cm/sec, 450 cm/sec
Carrier Gas	Hydrogen
Septum Purge	3 mL/min
Injection Mode	Split
Split Ratio	Varied 50:1 to 400:1
Injection Volume	0.2 µL or 0.1 µL
Injection Temperature	250 °C
Detector Temperature	250 °C

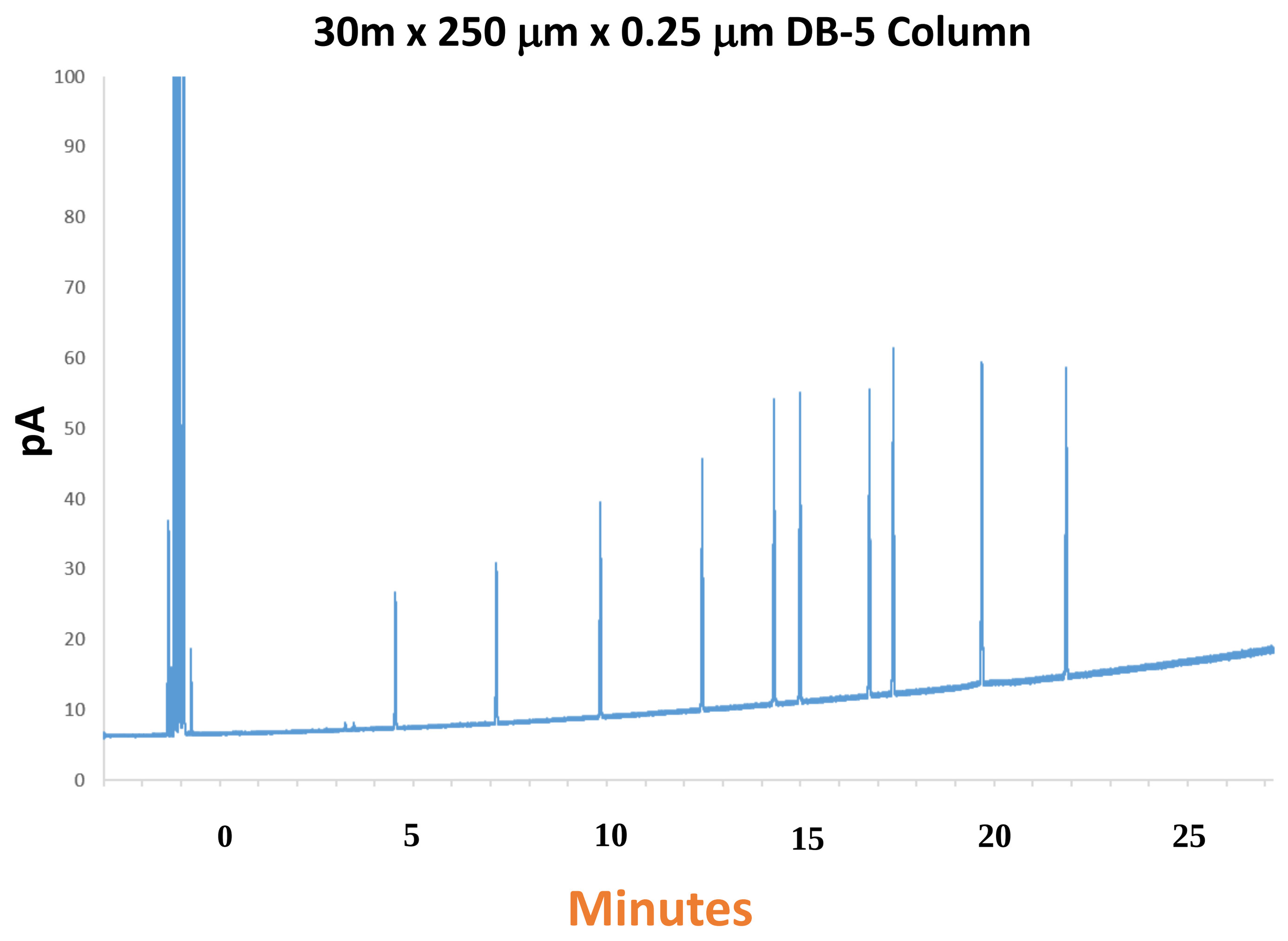
Linear Velocity Versus HETP



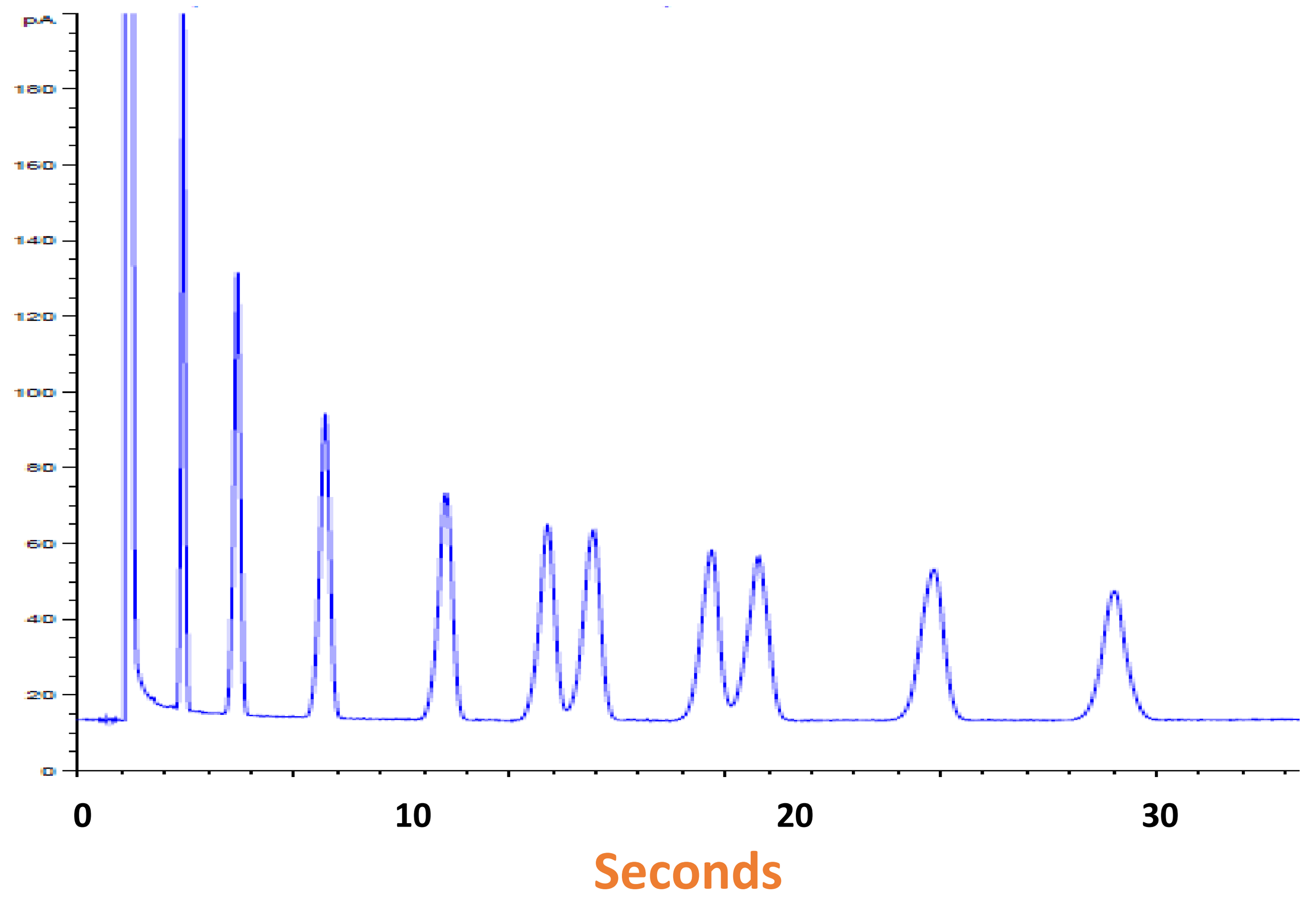
Fast Isothermal GC with H2 Carrier Gas



Typical Temperature Programmed GC Analysis



Fast Temperature Program with H2 Carrier Gas



Conclusion

Gas Chromatography is the world's most popular analytical tool, but it is rarely optimized for analysis time. In 1956, JJ Van Deemter published his paper on the theory of GC. While most analysts shrug this off as just theory, the applied scientist can take advantage of the important mathematical relationships pointed out in this landmark paper. Van Deemter, and subsequently Marcel Golay taught us that there is a complex, but highly predictable relationship of the linear velocity, column diameter, film thickness and molecular weight of the carrier gas. Essentially, smaller diameter columns, along with thinner films, combined with lower molecular weight carrier gasses all lead to a "flatter" Van Deemter curve (faster analyses without sacrificing as much efficiency). In this paper, the GC's were operated with a linear velocities up to 450 cm/sec (20x the optimum!), while still yielding acceptable separations (Resolution > 1.50). The practical implications of this are far reaching. Many analysts could cut their isothermal retention times in half, simply by switching to hydrogen carrier gas and doubling their linear velocities. So the same results in half the time! Temperature programmed analyses can be reduced by switching to hydrogen, and using shorter, smaller diameter columns, while increasing the programming rate and linear velocity.

Acknowledgements

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The hydrogen used in this study was generated on demand by a hydrogen generator capable of producing up to 1300 mL/min at 175 psi. (Parker Hannifin Model H2PEMPD-1300). The generator was able to generate enough ultra pure hydrogen (99.99999%) for both carrier gas and fuel gas for all of the GC/s used in this study.