Making sense of GC flow calculations - part 2

Important information

The inner diameter can vary from 0.245 to 0.255 mm for a typical 0.25 mm ID column. Therefore, when the inlet pressure and length are held constant, the flow rate can change by 16%. This stresses the importance of measuring and optimizing the linear carrier gas velocity after installing a new column.

Why measure or calculate the flow rate?

Flow rate is an important parameter in gas chromatography because it directly effects split ratio in a split injection. Split ratio is the ratio of the flow rate of gas through the split vent to the flow rate through the column. For example, if the flow rate of gas through the split vent is measured at 100 mL/min column and the flow rate is 1.0 mL/min, then the split ratio is 100:1. Correction can be made for measurement at different pressure and temperatures for precise calculations.

Why measure average linear velocity?

The average velocity is a function of the time it takes for a carrier molecule to get from one end of the column to the other. At the start of the column, molecules will move slowly (because of the high back pressure) but will speed up as they approach the end of the column (towards lower back pressure). The measured gas velocity is the average speed in the column. So why is this important to the chromatographer?

The reason is that there is an optimum value for the average carrier gas velocity to achieve maximum efficiency. By maximizing efficiency, resolution is also maximized. If the column dimensions change, gas velocity may stray from the optimum. The optimum value will depend on the nature of the carrier gas, column diameter, column length, film thickness and other variables. The linear carrier gas velocity can be easily measured (see equation below).

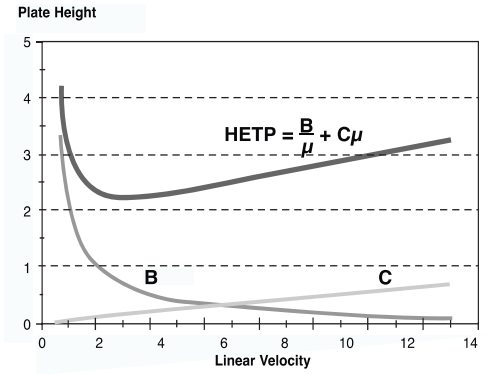

Figure 1. Van Deemter curve

Why is there an optimum value for the carrier gas velocity?

The molecules of your sample will enter and exit the stationary phase (partition) and will spend a different amount of time in the phase compared to different sample molecules. There is an ideal time for the sample molecules to spend inside the column and this is determined by the average gas velocity (μ). If the molecules spend too much time in the column, they will broaden (peak broadening) and diffuse into different sample molecules and might not be separated at the end. If the molecules don't spend enough time inside the column, they won't interact with the stationary phase long enough to achieve a separation.

These two factors are described by the B and C terms of the Van Deemter equation, respectively. The Van Deemter curve is shown in Figure 1. The lower the HETP (height equivalent of a theoretical plate), the better the column performance.

The average carrier gas velocity is the important parameter and should be set in the optimum range (see equation below) after column installation.

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Equation: Measure your carrier gas velocity

$$\text{Carrier gas velocity (m/sec)} = \frac{\text{Length of column (cm)}}{\text{Hold-up time in seconds of a non-retained solute } (t_m)}$$

Optimum ranges for carrier gas velocities:
Hydrogen = 30 – 50 cm/sec
Helium = 20 – 40 cm/sec
Nitrogen = 10 – 15 cm/sec

The hold-up time is measured from the retention time of an unretained component (such as methane) in the column.