Can you provide brief explanation of the terms Retention Time,Retention Factor (k), Retention Index (I), Separation Factor(α)?

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Retention Time of an Unretained Compound (tM)

Also known as the hold-up time, tM or tO is the time for an unretained compound to travel through the column. Unretained solutes molecules do not enter the stationary phase, and they travel down the column at the same rate as the carrier gas. This is equivalent to the time a compound spends in the mobile phase. It is the same for all compounds in a single chromatographic run. The unretained peak time is obtained by injecting an unretained compound and determining the time it takes from injection to elution into the detector.

Retention Factor (k)

The Retention Factor is another measure of retention. It is the ratio of the amount of time a solute spends in the stationary phase and mobile phase (carrier gas). It is calculated using Equation 1. The retention factor is also known as the partition ratio or capacity factor. Since all solutes spend the same amount of time in the mobile phase, the retention factor is a measure of retention by the stationary phase. For example, a solute with a k value of 6 is twice as retained by the stationary phase (but not the column) as a solute with a k value of 3. The retention factor does not provide absolute retention information; it provides relative retention information. An unretained compound has k = 0.

$$k = \frac{t_R - t_M}{t_M} = \frac{t'_R}{t_M}$$

Equation 1

Retention Index (I)

Retention Index is a measure of the retention of a solute relative to the retention of normal alkanes (straight chain hydrocarbons) at a given temperature. Equation 2a is used to calculate retention indices for isothermal temperature conditions. For temperature program conditions, Equation 2b can be used. The retention index for a normal alkane is its number of carbons multiplied by 100. For example, n-dodecane (n-C12H26) has I = 1200. If a solute has I = 1478 it elutes after n-C14 and before n-C15, and it is closer to n-C15. Retention indices normalize instrument variables so that retention data can be compared on different GC systems. Retention indices are also good for comparing retention characteristics for different columns.

$$I = 100_y + 100(z\text{-}y)\,\frac{\log t'_{R(x)} - \log t'_{R(y)}}{\log t'_{R(z)} - \log t'_{R(y)}}$$

Equation 2a

$$I_T = 100\left(\frac{t_{R(x)} - t_{R(y)}}{t_{R(z)} - t_{R(y)}}\right) + y$$

Equation 2b

t_R = retention time
x = solute of interest
y = normal alkane with y number of carbon atoms eluting before solute x
z = normal alkane with z number of carbon atoms eluting after solute x
z – y = difference in carbon number between the two normal alkanes

Separation Factor (α)

The Separation Factor is a measure of the time or distance between the maxima of two peaks. It is calculated using Equation 3. If α = 1, the two peaks have the same retention time and co-elute.

$$\alpha = \frac{k_2}{k_1}$$

k_1 = retention factor of first peak
k_2 = retention factor of second peak

Equation 3

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