INTERNATIONAL UNION OF
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ANALYTICAL CHEMISTRY DIVISION
COMMISSION ON ANALYTICAL NOMENCLATURE

RECOMMENDATIONS ON NOMENCLATURE FOR CHROMATOGRAPHY

RULES APPROVED 1973

LONDON
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Nearly ten years ago the Division of Analytical Chemistry approved a set of recommendations for the nomenclature of Gas Chromatography[1]. Since then the Commission on Nomenclature has been endeavouring to produce a unified nomenclature applicable to all forms of separation processes, and proposals have now been made for Liquid–Liquid Distribution[2] and for Ion Exchange[3]. In the present proposals prepared for the Commission by Dr D. Ambrose, Professor E. Bayer and Professor O. Samuelson, the work has been extended to all forms of chromatography. For the sake of uniformity, compromises have inevitably had to be made, as a result of which, for example, there are some changes from the recommendations in Ref. 1. Account was taken, in the drafting, of other relevant proposals[4–7].

It is recommended that quantities should be expressed in the units (or their multiples or submultiples) of the International System of Units, or in the units approved for use with the International System[8]; in particular, that physical dimensions, e.g. of columns, should be so expressed. It is to be noted that the symbol T relates to thermodynamic temperatures and should not be used to represent temperatures expressed on the Celsius scale[9].

1 CHROMATOGRAPHY

A method, used primarily for separation of the components of a sample, in which the components are distributed between two phases, one of which is stationary while the other moves. The stationary phase may be a solid, or a liquid supported on a solid, or a gel. The stationary phase may be packed in a *column*, spread as a *layer*, or distributed as a *film*, etc.; in these definitions *chromatographic bed* is used as a general term to denote any of the different forms in which the stationary phase may be used. The mobile phase may be gaseous or liquid.

2 PRINCIPAL METHODS

2.1 Frontal chromatography

A procedure for chromatographic separation in which the sample (liquid or gas) is fed continuously into the chromatographic bed.

2.2 Elution chromatography

A procedure for chromatographic separation in which an *eluent* (see Item 8.6) is passed through the chromatographic bed after the application of the sample.

2.3 Displacement chromatography

An elution procedure in which the *eluent* contains a compound more effectively retained than the components of the sample under examination.

3 CLASSIFICATION ACCORDING TO PHASES USED

In this classification, the first word specifies the mobile phase and the second the stationary phase. A liquid stationary phase is supported on a solid.

3.1 Gas chromatography (GC)

3.1.1 Gas–liquid chromatography (GLC)

3.1.2 Gas–solid chromatography (GSC)

3.2 Liquid chromatography (LC)

3.2.1 Liquid–liquid chromatography (LLC)

3.2.2 Liquid–solid chromatography (LSC)

3.2.3 Liquid–gel chromatography

In gas chromatography the distinction between gas–liquid and gas–solid may be obscure because liquids are used to modify solid stationary phases, and because the solid supports for liquid stationary phases affect the chromatographic process. For classification by the phases used, the term relating to the predominant effect should be chosen. Liquid–gel chromatography includes gel-permeation and ion-exchange chromatography.

4 CLASSIFICATION ACCORDING TO MECHANISMS

4.1 Adsorption chromatography

Separation based mainly on differences between the adsorption affinities of the components for the surface of an active solid.

4.2 Partition chromatography

Separation based mainly on differences between the solubilities of the components in the stationary phase (gas chromatography), or on differences between the solubilities of the components in the mobile and stationary phases (liquid chromatography).

4.3 Ion-exchange chromatography

Separation based mainly on differences in the ion-exchange affinities of the components.

4.4 Permeation chromatography

Separation based mainly upon exclusion effects, such as differences in molecular size and/or shape (e.g. molecular-sieve chromatography) or in charge (e.g. ion-exclusion chromatography). The term *gel-permeation*

chromatography is widely used for the process when the stationary phase is a swollen gel. The term *gel-filtration* is not recommended.

4.5 Other mechanisms

In addition to Items 4.1 to 4.4, there exist many techniques based upon other mechanisms. Examples are ligand-exchange, formation of charge-transfer complexes, and bio-specific sorption, e.g. formation of enzyme–substrate and antigen–antibody complexes. Classification according to mechanism should be avoided unless the predominant mechanism is known. In many instances more than one mechanism is involved.

5 CLASSIFICATION ACCORDING TO TECHNIQUES USED

All types of chromatography can be classified according to Section 3 by the phases used or according to Section 4 by mechanism, but the terms in this section specify techniques and may provide a more useful characterization of the process.

5.1 Column chromatography (CC)

5.2 Open-tube chromatography (see Item 8.4)

5.3 Paper chromatography (PC)

5.4 Thin-layer chromatography (TLC)

Chromatography carried out in a layer of adsorbent spread on a support, e.g. a glass plate.

5.5 Filament chromatography

6 TERMS FOR SPECIAL TECHNIQUES

6.1 Temperature-programmed chromatography

A procedure in which the temperature of the column is changed systematically during a part or the whole of the separation.

6.2 Flow-programmed chromatography

A procedure in which the rate of flow of the mobile phase is changed systematically during a part or the whole of the separation.

6.3 Salting-out chromatography

A procedure in which a non-sorbable electrolyte is added to the eluent to modify the distribution equilibria of the components to be separated.

6.4 Selective elution

An elution procedure in which a specific eluent is used, e.g. a complexing agent that forms stable non-sorbable complexes with one or a group of the compounds to be separated, but affects the other components only to a negligible extent.

6.5 Stepwise elution

An elution procedure in which two or more eluents of different composition are used in succession to elute the components in a single chromatographic run.

6.6 Gradient elution

An elution procedure in which the eluent composition is changed continuously.

6.7 Two-dimensional chromatography

A procedure applied in paper chromatography and thin-layer chromatography in which the components are caused first to migrate in one direction, and subsequently in a direction at right angles to the first one. The two elutions are usually carried out with different eluents.

6.8 Reversed-phase chromatography

A term of historical interest in liquid–liquid chromatography referring to an elution procedure in which the stationary phase is non-polar, e.g. paper treated with hydrocarbons or silicones.

7 TERMS RELATING TO THE METHOD IN GENERAL

7.1 Chromatogram

A graphical or other presentation of detector response, effluent concentration, or other quantity used as a measure of effluent concentration, versus effluent volume or time. The term is also applied to the layer or paper after separation has occurred.

7.2 Elution curve

A chromatogram, or part of a chromatogram, recorded when elution techniques are used.

7.3 Chromatograph (verb)

To separate by chromatography.

7.4 Chromatograph (noun)

The assembly of apparatus for carrying out chromatographic separation.

7.5 Elute

To chromatograph by elution chromatography. This term is preferred to the term *develop*, which has been used in paper chromatography and thin-layer chromatography. The process of elution may continue until the components have left the chromatographic bed.

7.6 Extract

To recover a compound from a chromatographic zone by treatment with a solvent.

7.7 Zone

A region in a chromatographic column or layer where one or more components of the sample are located.

7.8 Spot

A zone in paper and thin-layer chromatography of approximately circular appearance.

7.9 Starting point or line

The point or line on a chromatographic layer where the substance to be chromatographed is applied.

7.10 Baseline

The portion of a chromatogram recorded when only eluent or carrier gas emerges from the column.

7.11 Peak

The portion of a differential chromatogram (See Item 8.20) recording the detector response or eluate concentration (See Item 8.18) while a component emerges from the column (*Figure 1*). If separation is incomplete, two or more components may appear as one *unresolved peak.*

7.12 Elution band

Synonymous with peak.

7.13 Tailing

Asymmetry of a peak such that, relative to the baseline, the front is steeper than the rear. In paper chromatography and thin-layer chromatography, the distortion of a zone showing a diffuse region behind the zone in the direction of flow.

7.14 Fronting

Asymmetry of a peak such that, relative to the baseline, the front is less steep than the rear. In paper chromatography and thin-layer chromatography, the distortion of a zone showing a diffuse region in front of the zone in the direction of flow.

7.15 Step (on an integral chromatogram)

The portion of an integral chromatogram (See Item 8.21) recording the amount of a component, or the corresponding change in the signal from the detector as the component emerges from the column (*Figure 1*).

7.16 Step height (on an integral chromatogram)

The distance (KL, *Figure 1*), perpendicular to the time or volume axis, through which the baseline moves as the result of a step on an integral chromatogram (See Item 8.21).

7.17 Internal standard

A compound added to a sample in known concentration, for example, for

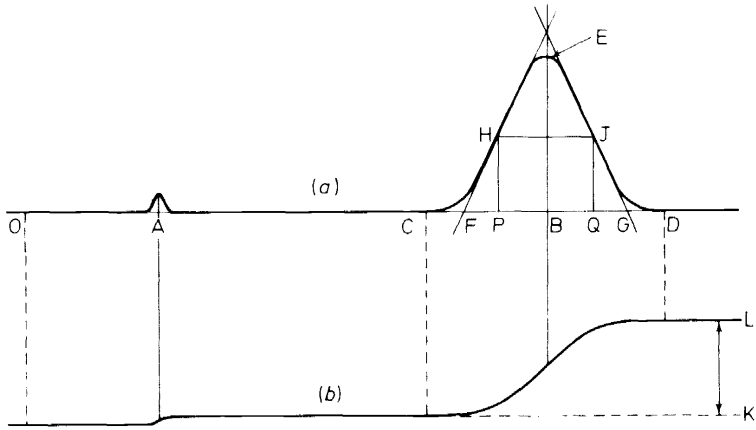

Figure 1. (a) Differential, and (b) integral chromatograms

the purpose of eliminating the need to measure the size of sample in quantitative analysis.

7.18 Marker

A reference substance chromatographed with the sample to assist in identifying the components.

8 TERMS RELATING TO THE SEPARATION PROCESS AND THE APPARATUS

8.1 Column

The tube that contains the stationary phase, and through which the mobile phase passes.

8.2 Packing

The active solid, stationary liquid plus solid support, or swollen gel put in the column. The term *packing* refers to the conditions existing before the chromatographic run is started (i.e. to the material introduced into the column) whereas the *stationary phase* (see Item 8.8) refers to the conditions during the run.

8.3 Packed column

A column filled with packing.

8.4 Open tubular column

A column, usually of capillary dimensions, in which the column wall, a liquid or an active solid supported on the column wall acts as the stationary phase.

8.5 Mobile phase
The phase that is moving in the chromatographic bed. It includes the fraction of the sample present in this phase.

8.6 Eluent
The liquid or gas entering the chromatographic bed and used to effect a separation by elution.

8.7 Carrier gas
The term normally used for the *eluent* in gas chromatography.

8.8 Stationary phase
The non-mobile phase in the chromatographic bed, on which the separation depends. For example, in gas–solid chromatography and liquid–solid chromatography the active solid is the stationary phase, and in gas–liquid and liquid–liquid chromatography the liquid, but not the solid support, is the stationary phase.

8.9 Active solid
A solid with sorptive properties.

8.10 Modified active solid
An active solid, the adsorptive properties of which have been changed by treatment with a gas, liquid or another solid.

8.11 Solid support
A solid that holds the stationary liquid phase.

8.12 Support plate
The plate that supports the thin layer in thin-layer chromatography.

8.13 Gradient layer or gradient packing
A layer or column packing with continuous change of property affecting the separation, e.g. pH gradient.

8.14 Sample injector
A device by which a sample is introduced into the eluent (carrier gas) or the column.

8.15 Bypass injector
A sample injector by means of which the eluent (carrier gas) may be temporarily diverted through a sample chamber so that the sample is carried to the column.

8.16 Chamber saturation
Uniform distribution of the eluent vapour throughout the chamber prior to chromatography.

8.17 Layer equilibration
Saturation of the stationary phase with the mobile phase via the vapour phase.

8.18 Eluate
The effluent from a chromatographic bed emerging when elution is carried out.

8.19 Detection
The process by which the presence of chromatographically separated substances is recognized.

8.20 Differential detector
A detector whose response is dependent on the instantaneous difference in composition between the column effluent and the eluent (carrier gas).

8.21 Integral detector
A detector whose response is dependent on the total amount of a component that has passed through it.

8.22 Solvent front
The front line of the eluent.

8.23 Solvent migration-distance
The distance travelled by the solvent front.

8.24 Separation temperature (often column temperature in column chromatography)
The temperature of the chromatographic bed.

8.25 Injection temperature
The temperature at the injection point.

8.26 Initial and final temperatures
The range of separation temperatures in temperature-programmed chromatography.

9 TERMS RELATING TO QUANTITATIVE EVALUATION AND THE THEORY OF CHROMATOGRAPHY

9.1 Column volume, X
The volume (empty) of the part of a column that contains the packing. It is recommended that the column dimensions be given as the inner diameter and the height or length of the column occupied by the stationary phase under the applied chromatographic conditions. If swelling changes occur, the conditions under which the height is determined should be specified.

9.2 Bed volume
Synonymous with *column volume* for a packed column.

9.3 Interstitial volume, V_i
The volume occupied by the mobile phase in the packed section of a column. In gas chromatography the gas occupying the interstitial volume

expands to a volume V_I/j at the outlet pressure, where measurements are normally made (see Item 9.11).

9.4 Interstitial fraction, ε_I

The interstitial volume per unit volume of a packed column:

$$\varepsilon_I = V_I/X$$

9.5 Volume of the stationary phase, V_S

The volume of the stationary liquid phase or of the active solid or of the gel in the column. The volume of any solid support is not included.

9.6 Stationary-phase fraction, ε_S

The volume of the stationary phase per unit volume of a packed column:

$$\varepsilon_S = V_S/X$$

9.7 Phase ratio

The ratio of the volume of the mobile phase to that of the stationary phase in a column.

9.8 Hold-up volume, V_M

The volume of eluent required to elute a component the concentration of which in the stationary phase is negligible compared to that in the mobile phase. The *hold-up volume* corresponds to the distance OA, *Figure 1*, and includes any volumes contributed by the sample injector and the detector.

9.9 Gas hold-up volume, V_M

Synonymous with *hold-up volume* in gas chromatography. The volume of carrier gas (eluent) is specified at the same temperature and pressure as the total retention volume (see Item 9.23).

9.10 Dead volume, V_d

The volume between the effective injection point and the effective detection point, less the column volume X.

9.11 Pressure-gradient correction-factor, j

A factor, applying to a homogeneously filled column of uniform diameter, that corrects for the compressibility of the mobile phase; the values of the measured quantities obtained after multiplication by the factor j are independent of the pressure drop in the column. In practice, these quantities include contributions arising from the column inhomogeneities making up the dead volume but since these are small in comparison with retention volumes the consequent errors are normally ignored. In gas chromatography, if p_i, p_o are respectively the pressures of the carrier gas at the inlet and outlet of the column:

$$j = \frac{[3\ (p_i/p_o)^2 - 1]}{[2\ (p_i/p_o)^3 - 1]}$$

9.12 Peak base

The interpolation, in a differential chromatogram, of the baseline between the extremities of the peak (the line CD, *Figure 1*).

9.13 Peak area

The area (CHEJD, *Figure 1*) enclosed between the peak and the peak base.

9.14 Peak maximum

The point on the peak at which the distance to the peak base, measured in a direction parallel to the axis representing detector response, is a maximum (E, *Figure 1*).

9.15 Peak height

The distance between the peak maximum and the peak base, measured in a direction parallel to the axis representing detector response (the distance BE, *Figure 1*).

9.16 Peak width

The segment of the peak base intercepted by tangents to the inflection points on either side of the peak (the distance FG, *Figure 1*) projected onto the axis representing time or volume if the baseline is not parallel to this axis.

9.17 Peak width at half height

The length of the line parallel to the peak base that bisects the peak height and terminates at the intersections with the two limbs of the peak (the distance PQ, *Figure 1*) projected onto the axis representing time or volume if the baseline is not parallel to this axis.

9.18 Volumetric flowrate, F_c

The volumetric flowrate of the mobile phase ($cm^3\ min^{-1}$). In gas chromatography, the flowrate is normally specified at the column temperature and outlet pressure, although the measurement may be made at ambient temperature and must be corrected accordingly (and possibly also for water vapour present in the flowmeter).

9.19 Nominal linear flow, F

The volumetric flowrate of the mobile phase divided by the area of the cross section of the column ($cm\ min^{-1}$), i.e. the linear flowrate in a part of the column not containing packing.

9.20 Interstitial velocity, u (u_0 at the outlet pressure in gas chromatography)

The linear velocity of the mobile phase inside a packed column calculated as the average over the entire cross section. This quantity can, under idealized conditions, be calculated from the equation,

$$u = F/\varepsilon_t$$

9.21 Mean interstitial velocity of the carrier gas, $\bar{u}$

The interstitial velocity of the carrier gas multiplied by the pressure-

gradient correction-factor:

$$\bar{u} = Fj/\varepsilon_I$$

9.22 Retention volumes

Retention measurements (and measurements of hold-up volume and peak width) may be made in terms of times, e.g. t_R, t'_R analogous to V_R, V'_R (see Items 9.23 and 9.25), or chart distances as well as volumes. If flow and recorder speeds are constant, the volumes are directly proportional to the times and chart distances. The definitions given here are drawn up in terms of volume, and it is recommended that theoretical discussion should be couched in the same terms whenever possible. However, the proportionality between volumes, times and chart distances is implied in the references to *Figures 1* and *2*.

9.23 Total retention volume, V_R

The volume of eluent (carrier gas) entering the column between the injection of the sample and the emergence of the peak maximum of the specified component (OB, *Figure 1*). It includes the hold-up volume. In gas chromatography the volume of carrier gas is specified at the outlet pressure and the temperature of the column.

Note:

The word *total* in this definition allows *retention volume* to be used as a general term when specification of a particular quantity is not required.

9.24 Peak elution volume, $\bar{V}$

The volume of eluent entering the column between the start of the elution and the emergence of the peak maximum. The term applies only to liquid chromatography. It does not include the effluent obtained when the sample is introduced into the column nor the volume of the detector, if used.

Sometimes the column is washed with a liquid, before the elution is started, but after application of the sample, to displace components that are not retained. The effluent obtained during the washing process is not included in the peak elution volume unless the solutes are moved during the washing (see Item 6.5).

9.25 Adjusted retention volume, V'_R

The total retention volume less the hold-up volume (corresponding to the distance AB, *Figure 1*), i.e.

$$V'_R = V_R - V_M = \bar{V} - V_I$$

9.26 Net retention volume, V_N

The adjusted retention volume multiplied by the pressure gradient correction factor:

$$V_N = jV'_R$$

9.27 Specific retention volume, V_g

The net retention volume per gram of stationary liquid, active solid or solvent-free gel. In liquid chromatography, except when conducted at very high pressures, the compression of the mobile phase is negligible, and the adjusted and net retention volumes are identical; the specific retention volume is then the adjusted retention volume per gram of stationary liquid, active solid or solvent-free gel. It is recommended that, when appropriate, authors specify the drying conditions.

9.28 Relative retention, $r_{A/B}$

The adjusted retention volume of a substance related to that of a reference compound obtained under identical conditions. If subscripts A and B refer to the substance and the reference compound respectively, then

$$r_{A/B} = \frac{V_{g,A}}{V_{g,B}} = \frac{V_{N,A}}{V_{N,B}} = \frac{V'_{R,A}}{V'_{R,B}}$$

Note that $r_{A/B}$ is not equal to $V_{R,A}/V_{R,B}$ nor $\bar{V}_A/\bar{V}_B$.

9.29 Retention temperature

The column temperature (see Item 8.24) when the peak maximum for a component has been reached in temperature-programmed chromatography.

9.30 R_f value

The ratio of distance travelled by the centre of a zone to the distance simultaneously travelled by the mobile phase. In paper and thin-layer chromatography, R_f may be determined from the distance moved by the eluent front.

9.31 R_B value

The ratio of the distance travelled by a zone to the distance simultaneously travelled by a reference substance B.

9.32 Distribution constant, K_D

The ratio of the concentration of a component in a single definite form in the stationary phase to its concentration in the same form in the mobile phase at equilibrium. Both concentrations are calculated per unit volume of the phase.

This term is recommended in preference to *partition coefficient* which has been used with the same meaning.

In chromatography a component may be present in more than one form; these forms are generally not specified (and may not be known), and it will therefore usually be more appropriate for specification of conditions in the column to use one of the following terms, which are defined by the analytical concentration (or amount) of the component, the analytical concentration (or amount) referring to its total concentration (or amount) without regard to its possible existence in associated or dissociated forms.

9.33 Concentration distribution ratio, D_c

The ratio of the analytical concentration of a component in the stationary phase to its analytical concentration in the mobile phase:

$$D_c = \frac{\text{amount of component/cm}^3 \text{ of stationary phase}}{\text{amount of component/cm}^3 \text{ of mobile phase}}$$

9.34 Distribution coefficients, D_g, D_v, D_s

The amount of a component in a specified amount of stationary phase, or in an amount of stationary phase of specified surface area, divided by the analytical concentration in the mobile phase. The subscripts g, v, s indicate as follows the way in which the stationary phase is specified:

$$D_g = \frac{\text{amount of component/gram of dry stationary phase}}{\text{amount of component/cm}^3 \text{ of mobile phase}}$$

applicable in ion-exchange and gel chromatography, where swelling occurs, and in adsorption chromatography with adsorbents of unknown surface area,

$$D_v = \frac{\text{amount of component in the stationary phase/cm}^3 \text{ of bed volume}}{\text{amount of component/cm}^3 \text{ of mobile phase}}$$

applicable when it is not practicable to determine the weight of the solid phase, and

$$D_s = \frac{\text{amount of component/m}^2 \text{ of surface}}{\text{amount of component/cm}^3 \text{ of mobile phase}}$$

applicable in adsorption chromatography with a well-characterized adsorbent of known surface area.

9.35 Mass distribution ratio, D_m

The fraction $(1 - R)$ of a component in the stationary phase divided by the fraction (R) in the mobile phase:

$$D_m = \frac{\text{amount of component in stationary phase}}{\text{amount of component in mobile phase}}$$

This term is recommended in preference to the term *capacity factor* frequently used in gas chromatographic literature.

Note:

The subscripts in D_c, D_m, D_g, D_v, D_s may be omitted when there is no possibility of confusion of one term with another.

Values of these quantities, defined in Items 9.33–9.35, which allow the equilibrium between two phases to be specified, may be determined by static equilibrium measurements. They may also be related to retention volumes, and measurements of the latter frequently provide the most convenient experimental route for their determination.

9.36 Separation factor, $\alpha_{A/B}$

The ratio of the distribution ratios or coefficients, D_A/D_B for two substances A and B measured under identical conditions. By convention α is usually greater than unity.

9.37 Peak resolution, R_s

The separation of two peaks in terms of their average peak width (*Figure 2*):

$$R_s = 2y/(y_A + y_B)$$

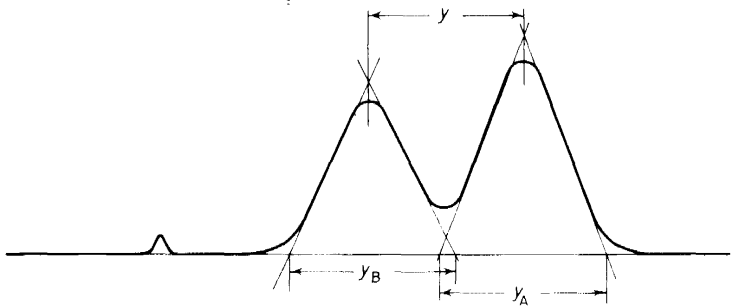

Figure 2

9.38 Theoretical plate number, *n*

A number indicative of column performance calculated from the equation

$$n = 16 \text{ (Peak elution volume/peak width)}^2$$

In gas chromatography and some types of liquid chromatography the volumes of the sample injector and of the detector are negligible, and the expression for n can then be written as

$$n = 16 \text{ (Total retention volume/peak width)}^2$$

In these expressions the units for the quantities inside the brackets must be consistent so that their ratio is dimensionless, i.e. if the numerator is a volume then peak width must be expressed in terms of volume also.

9.39 Effective theoretical plate number, *N*

A number indicative of column performance when resolution is taken into account:

$$N = 16\, R_s^2/(1 - \alpha)^2$$

9.40 Height equivalent to a theoretical plate, HETP, ***h***

The column length divided by the theoretical plate number.

9.41 Height equivalent to an effective theoretical plate, HEETP, ***H***

The column length divided by the effective theoretical plate number.

9.42 Retention index, *I*

A number, obtained by logarithmic interpolation, relating the adjusted retention volume of a component A to the adjusted retention volumes of the normal paraffins. Each n-paraffin is arbitrarily alotted by definition

an index one hundred times its carbon number. The index I_A of substance A is then given by

$$I_A = 100N + 100n \left(\frac{\log V'_R(A) - \log V'_R(N)}{\log V'_R(N+n) - \log V'_R(N)} \right)$$

where $V'_R(N+n)$ and $V'_R(N)$ are the adjusted retention volumes of n-paraffins of carbon number N and $(N+n)$ that are respectively smaller and larger than $V'_R(A)$ the adjusted retention volume of A.

APPENDIX. LIST OF SYMBOLS

Symbol	*Item no.*	*Meaning*
A, B	9.28, 9.36	Components A and B
D_c	9.33	Concentration distribution ratio
D_g	9.34	Distribution coefficient
D_m	9.35	Mass distribution ratio
D_s	9.34	Distribution coefficient
D_v	9.34	Distribution coefficient
F	9.19	Nominal linear flow
F_c	9.18	Volumetric flowrate
H	9.41	Height equivalent to an effective theoretical plate, HEETP
h	9.40	Height equivalent to a theoretical plate, HETP
I	9.42	Retention index
j	9.11	Pressure-gradient correction-factor
K_D	9.32	Distribution constant
N	9.39	Effective theoretical plate number
n	9.38	Theoretical plate number
p_i, p_o	9.11	Pressure of carrier gas at inlet and outlet of column
R	9.35	Fraction of component in the mobile phase
R_f	9.30	R_f value
R_B	9.31	R_B value
R_s	9.37	Peak resolution
$r_{A/B}$	9.28	Relative retention (of component A relative to component B)
u	9.20	Interstitial velocity
$\bar{u}$	9.21	Mean interstitial velocity
u_o	9.20	Interstitial velocity at the column outlet
$\bar{V}$	9.24	Peak elution volume
V_d	9.10	Dead volume
V_g	9.27	Specific retention volume
V_I	9.3	Interstitial volume
V_M	9.8, 9.9	Hold-up volume, gas hold-up volume

Symbol	*Item no.*	*Meaning*
V_N	9.26	Net retention volume
V_R	9.23	Total retention volume
V'_R	9.25	Adjusted retention volume
V_S	9.5	Volume of the stationary phase
X	9.1	Column volume
$\alpha_{A/B}$	9.36	Separation factor
ε_I	9.4	Interstitial fraction
ε_S	9.6	Stationary-phase fraction

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