**Chromatography**

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  (Redirected from [Chromatograph](http://en.wikipedia.org/w/index.php?title=Chromatograph&redirect=no))

[](http://en.wikipedia.org/wiki/File:Gas_chromatograph.jpg)

Pictured is a sophisticated gas chromatography system. This instrument records concentrations of [acrylonitrile](http://en.wikipedia.org/wiki/Acrylonitrile) in the air at various points throughout the chemical laboratory.

**Chromatography** (from [Greek](http://en.wikipedia.org/wiki/Greek_language) χρῶμα *chroma* "color" and γράφειν *graphein* "to write") is the collective term for a set of [laboratory techniques](http://en.wikipedia.org/wiki/Laboratory_techniques) for the [separation of mixtures](http://en.wikipedia.org/wiki/Separation_of_mixtures). The mixture is dissolved in a fluid called the "mobile phase", which carries it through a structure holding another material called the "stationary phase". The various constituents of the mixture travel at different speeds, causing them to separate. The separation is based on differential partitioning between the mobile and stationary phases. Subtle differences in a compound's [partition coefficient](http://en.wikipedia.org/wiki/Partition_coefficient) result in differential retention on the stationary phase and thus **changing** the separation.

Chromatography may be preparative or analytical. The purpose of preparative chromatography is to separate the components of a mixture for further use (and is thus a form of purification). Analytical chromatography is done normally with smaller amounts of material and is for measuring the relative proportions of analytes in a mixture. The two are not mutually exclusive.

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**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=1)**] History**

Main article: [History of chromatography](http://en.wikipedia.org/wiki/History_of_chromatography)

Thin layer chromatography is used to separate components of a plant extract, illustrating the experiment with plant pigments that gave chromatography its name

Chromatography, literally "color writing", was first employed by Russian scientist Michael Tsvet in 1900. He continued to work with chromatography in the first decade of the 20th century, primarily for the separation of plant [pigments](http://en.wikipedia.org/wiki/Pigments) such as [chlorophyll](http://en.wikipedia.org/wiki/Chlorophyll), [carotenes](http://en.wikipedia.org/wiki/Carotene), and [xanthophylls](http://en.wikipedia.org/wiki/Xanthophyll). Since these components have different colors (green, orange, and yellow, respectively) they gave the technique its name. New types of chromatography developed during the 1930s and 1940s made the technique useful for many [separation processes](http://en.wikipedia.org/wiki/Separation_processes).

Chromatography technique developed substantially as a result of the work of [Archer John Porter Martin](http://en.wikipedia.org/wiki/Archer_John_Porter_Martin) and [Richard Laurence Millington Synge](http://en.wikipedia.org/wiki/Richard_Laurence_Millington_Synge) during the 1940s and 1950s. They established the principles and basic techniques of partition chromatography, and their work encouraged the rapid development of several chromatographic methods: [paper chromatography](http://en.wikipedia.org/wiki/Paper_chromatography), [gas chromatography](http://en.wikipedia.org/wiki/Gas_chromatography), and what would become known as [high performance liquid chromatography](http://en.wikipedia.org/wiki/High_performance_liquid_chromatography). Since then, the technology has advanced rapidly. Researchers found that the main principles of Tsvet's chromatography could be applied in many different ways, resulting in the different varieties of chromatography described below. Advances are continually improving the technical performance of chromatography, allowing the separation of increasingly similar molecules.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=2)**] Chromatography terms**

* The **analyte** is the substance to be separated during chromatography.
* **Analytical chromatography** is used to determine the existence and possibly also the concentration of analyte(s) in a [sample](http://en.wikipedia.org/wiki/Sample_%28material%29).
* A **bonded phase** is a stationary phase that is covalently bonded to the support particles or to the inside wall of the column tubing.
* A **chromatogram** is the visual output of the chromatograph. In the case of an optimal separation, different peaks or patterns on the chromatogram correspond to different components of the separated mixture.

Plotted on the x-axis is the retention time and plotted on the y-axis a signal (for example obtained by a [spectrophotometer](http://en.wikipedia.org/wiki/Spectrophotometry), [mass spectrometer](http://en.wikipedia.org/wiki/Mass_Spectrometry) or a variety of other detectors) corresponding to the response created by the analytes exiting the system. In the case of an optimal system the signal is proportional to the concentration of the specific analyte separated.

* A **chromatograph** is equipment that enables a sophisticated separation e.g. gas chromatographic or liquid chromatographic separation.
* **Chromatography** is a physical method of separation in which the components to be separated are distributed between two phases, one of which is stationary (stationary phase) while the other (the mobile phase) moves in a definite direction.
* The **eluate** is the mobile phase leaving the column.
* The **eluent** is the solvent that will carry the analyte.
* An [**eluotropic series**](http://en.wikipedia.org/wiki/Eluotropic_series) is a list of solvents ranked according to their eluting power.
* An **immobilized phase** is a stationary phase which is immobilized on the support particles, or on the inner wall of the column tubing.
* The **mobile phase** is the phase which moves in a definite direction. It may be a liquid (LC and CEC), a gas (GC), or a supercritical fluid (supercritical-fluid chromatography, SFC). The mobile phase consists of the sample being separated/analyzed and the solvent that moves the sample through the column. In the case of [HPLC](http://en.wikipedia.org/wiki/High-performance_liquid_chromatography) the mobile phase consists of a non-polar solvent(s) such as hexane in normal phase or polar solvents in reverse phase chromotagraphy and the sample being separated. The mobile phase moves through the chromatography column (the stationary phase) where the sample interacts with the stationary phase and is separated.
* **Preparative chromatography** is used to purify sufficient quantities of a substance for further use, rather than analysis.
* The **retention time** is the characteristic time it takes for a particular analyte to pass through the system (from the column inlet to the detector) under set conditions. See also: [Kovats' retention index](http://en.wikipedia.org/wiki/Kovats_retention_index)
* The **sample** is the matter analyzed in chromatography. It may consist of a single component or it may be a mixture of components. When the sample is treated in the course of an analysis, the phase or the phases containing the analytes of interest is/are referred to as the sample whereas everything out of interest separated from the sample before or in the course of the analysis is referred to as waste.
* The **solute** refers to the sample components in partition chromatography.
* The **solvent** refers to any substance capable of solubilizing other substance, and especially the liquid mobile phase in LC.
* The **stationary phase** is the substance which is fixed in place for the chromatography procedure. Examples include the [silica](http://en.wikipedia.org/wiki/Silica) layer in [thin layer chromatography](http://en.wikipedia.org/wiki/Chromatography#Thin_layer_chromatography)

Chromatography is based on the concept of partition coefficient. Any solute will partition between two immissible solvents. When we make one solvent immobile (by adsorption on a solid support matrix) and another mobile it results in most common applications of chromatography. If matrix support is polar (e.g. paper, silica etc.) it is forward phase chromatography, and if it is non polar (C-18) it is reverse phase.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=3)**] Techniques by chromatographic bed shape**

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=4)**] Column chromatography**

For more details on this topic, see [Column chromatography](http://en.wikipedia.org/wiki/Column_chromatography).

Column chromatography is a separation technique in which the stationary bed is within a tube. The particles of the solid stationary phase or the support coated with a liquid stationary phase may fill the whole inside volume of the tube (packed column) or be concentrated on or along the inside tube wall leaving an open, unrestricted path for the mobile phase in the middle part of the tube (open tubular column). Differences in rates of movement through the medium are calculated to different retention times of the sample.[[1]](http://en.wikipedia.org/wiki/Chromatograph#cite_note-0)

In 1978, W. C. Still introduced a modified version of column chromatography called **flash column chromatography** (flash).[[2]](http://en.wikipedia.org/wiki/Chromatograph" \l "cite_note-1)[[3]](http://en.wikipedia.org/wiki/Chromatograph#cite_note-HarwoodMoodyEOCPAP-2) The technique is very similar to the traditional column chromatography, except for that the solvent is driven through the column by applying positive pressure. This allowed most separations to be performed in less than 20 minutes, with improved separations compared to the old method. Modern flash chromatography systems are sold as pre-packed plastic cartridges, and the solvent is pumped through the cartridge. Systems may also be linked with detectors and fraction collectors providing automation. The introduction of gradient pumps resulted in quicker separations and less solvent usage.

In [expanded bed adsorption](http://en.wikipedia.org/wiki/Expanded_bed_adsorption), a fluidized bed is used, rather than a solid phase made by a packed bed. This allows omission of initial clearing steps such as centrifugation and filtration, for culture broths or slurries of broken cells.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=5)**] Planar chromatography**

**Planar chromatography** is a separation technique in which the stationary phase is present as or on a plane. The plane can be a paper, serving as such or impregnated by a substance as the stationary bed ([paper chromatography](http://en.wikipedia.org/wiki/Paper_chromatography)) or a layer of solid particles spread on a support such as a glass plate ([thin layer chromatography](http://en.wikipedia.org/wiki/Thin_layer_chromatography)). Different [compounds](http://en.wikipedia.org/wiki/Chemical_compound) in the sample mixture travel different distances according to how strongly they interact with the stationary phase as compared to the mobile phase. The specific [Retention factor](http://en.wikipedia.org/wiki/Retention_factor) (Rf) of each chemical can be used to aid in the identification of an unknown substance.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=6)**] Paper chromatography**

For more details on this topic, see [Paper chromatography](http://en.wikipedia.org/wiki/Paper_chromatography).

Paper chromatography is a technique that involves placing a small dot or line of sample solution onto a strip of [*chromatography paper*](http://en.wikipedia.org/wiki/Chromatography_paper). The paper is placed in a jar containing a shallow layer of [solvent](http://en.wikipedia.org/wiki/Solvent) and sealed. As the solvent rises through the paper, it meets the sample mixture which starts to travel up the paper with the solvent. This paper is made of cellulose, a polar substance, and the compounds within the mixture travel farther if they are non-polar. More polar substances bond with the cellulose paper more quickly, and therefore do not travel as far.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=7)**] Thin layer chromatography**

For more details on this topic, see [Thin layer chromatography](http://en.wikipedia.org/wiki/Thin_layer_chromatography).

Thin layer chromatography (TLC) is a widely employed laboratory technique and is similar to [paper chromatography](http://en.wikipedia.org/wiki/Paper_chromatography). However, instead of using a stationary phase of paper, it involves a stationary phase of a thin layer of [adsorbent](http://en.wikipedia.org/wiki/Adsorbent) like [silica gel](http://en.wikipedia.org/wiki/Silica_gel), [alumina](http://en.wikipedia.org/wiki/Aluminium_oxide), or [cellulose](http://en.wikipedia.org/wiki/Cellulose) on a flat, inert [substrate](http://en.wikipedia.org/wiki/Substrate_%28chemistry%29). Compared to paper, it has the advantage of faster runs, better separations, and the choice between different adsorbents. For even better resolution and to allow for quantification, [high-performance TLC](http://en.wikipedia.org/wiki/HPTLC) can be used.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=8)**] Displacement chromatography**

The basic principle of [displacement chromatography](http://en.wikipedia.org/wiki/Displacement_chromatography) is: A molecule with a high affinity for the chromatography matrix (the displacer) will compete effectively for binding sites, and thus displace all molecules with lesser affinities.[[4]](http://en.wikipedia.org/wiki/Chromatograph#cite_note-3) There are distinct differences between displacement and elution chromatography. In elution mode, substances typically emerge from a column in narrow, Gaussian peaks. Wide separation of peaks, preferably to baseline, is desired in order to achieve maximum purification. The speed at which any component of a mixture travels down the column in elution mode depends on many factors. But for two substances to travel at different speeds, and thereby be resolved, there must be substantial differences in some interaction between the biomolecules and the chromatography matrix. Operating parameters are adjusted to maximize the effect of this difference. In many cases, baseline separation of the peaks can be achieved only with gradient elution and low column loadings. Thus, two drawbacks to elution mode chromatography, especially at the preparative scale, are operational complexity, due to gradient solvent pumping, and low throughput, due to low column loadings. Displacement chromatography has advantages over elution chromatography in that components are resolved into consecutive zones of pure substances rather than “peaks”. Because the process takes advantage of the nonlinearity of the isotherms, a larger column feed can be separated on a given column with the purified components recovered at significantly higher concentrations.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=9)**] Techniques by physical state of mobile phase**

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=10)**] Gas chromatography**

For more details on this topic, see [Gas chromatography](http://en.wikipedia.org/wiki/Gas_chromatography).

Gas chromatography (GC), also sometimes known as Gas-Liquid chromatography, (GLC), is a separation technique in which the mobile phase is a gas. Gas chromatography is always carried out in a column, which is typically "packed" or "capillary" (see below) .

Gas chromatography (GC) is based on a [partition equilibrium](http://en.wikipedia.org/wiki/Partition_equilibrium) of analyte between a solid stationary phase (often a liquid silicone-based material) and a mobile gas (most often Helium). The stationary phase is adhered to the inside of a small-diameter glass tube (a capillary column) or a solid matrix inside a larger metal tube (a packed column). It is widely used in [analytical chemistry](http://en.wikipedia.org/wiki/Analytical_chemistry); though the high temperatures used in GC make it unsuitable for high molecular weight biopolymers or proteins (heat will denature them), frequently encountered in [biochemistry](http://en.wikipedia.org/wiki/Biochemistry), it is well suited for use in the [petrochemical](http://en.wikipedia.org/wiki/Petrochemical), [environmental monitoring](http://en.wikipedia.org/wiki/Environmental_monitoring) and [remediation](http://en.wikipedia.org/wiki/Environmental_remediation), and [industrial chemical](http://en.wikipedia.org/wiki/Chemical_industry) fields. It is also used extensively in chemistry research.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=11)**] Liquid chromatography**

Preparative HPLC apparatus

Liquid chromatography (LC) is a separation technique in which the mobile phase is a liquid. Liquid chromatography can be carried out either in a column or a plane. Present day liquid chromatography that generally utilizes very small packing particles and a relatively high pressure is referred to as [high performance liquid chromatography](http://en.wikipedia.org/wiki/High_performance_liquid_chromatography) (HPLC).

In HPLC the sample is forced by a liquid at high pressure (the mobile phase) through a column that is packed with a stationary phase composed of irregularly or spherically shaped particles, a [porous monolithic layer](http://en.wikipedia.org/wiki/Monolithic_HPLC_column), or a porous membrane. HPLC is historically divided into two different sub-classes based on the polarity of the mobile and stationary phases. Methods in which the stationary phase is more polar than the mobile phase (e.g. toluene as the mobile phase, silica as the stationary phase) are termed normal phase liquid chromatography (NPLC) and the opposite (e.g. water-methanol mixture as the mobile phase and C18 = octadecylsilyl as the stationary phase) is termed reversed phase liquid chromatography (RPLC). Ironically the "normal phase" has fewer applications and RPLC is therefore used considerably more.

Specific techniques which come under this broad heading are listed below. It should also be noted that the following techniques can also be considered [fast protein liquid chromatography](http://en.wikipedia.org/wiki/Fast_protein_liquid_chromatography) if no pressure is used to drive the mobile phase through the stationary phase. See also [Aqueous Normal Phase Chromatography](http://en.wikipedia.org/wiki/Aqueous_Normal_Phase_Chromatography).

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=12)**] Affinity chromatography**

For more details on this topic, see [Affinity chromatography](http://en.wikipedia.org/wiki/Affinity_chromatography).

Affinity chromatography[[5]](http://en.wikipedia.org/wiki/Chromatograph" \l "cite_note-4) is based on selective non-covalent interaction between an analyte and specific molecules. It is very specific, but not very robust. It is often used in biochemistry in the purification of [proteins](http://en.wikipedia.org/wiki/Protein) bound to tags. These [fusion proteins](http://en.wikipedia.org/wiki/Fusion_protein) are labeled with compounds such as [His-tags](http://en.wikipedia.org/wiki/His-tag), [biotin](http://en.wikipedia.org/wiki/Biotin) or [antigens](http://en.wikipedia.org/wiki/Antigen), which bind to the stationary phase specifically. After purification, some of these tags are usually removed and the pure protein is obtained.

Affinity chromatography often utilizes a biomolecule's affinity for a metal (Zn, Cu, Fe, etc.). Columns are often manually prepared. Traditional affinity columns are used as a preparative step to flush out unwanted biomolecules.

However, HPLC techniques exist that do utilize affinity chromatogaphy properties. Immobilized Metal Affinity Chromatography (IMAC) is useful to separate aforementioned molecules based on the relative affinity for the metal (I.e. Dionex IMAC). Often these columns can be loaded with different metals to create a column with a targeted affinity.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=13)**] Supercritical fluid chromatography**

For more details on this topic, see [Supercritical fluid chromatography](http://en.wikipedia.org/wiki/Supercritical_fluid_chromatography).

Supercritical fluid chromatography is a separation technique in which the mobile phase is a fluid above and relatively close to its critical temperature and pressure.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=14)**] Techniques by separation mechanism**

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=15)**] Ion exchange chromatography**

For more details on this topic, see [Ion exchange chromatography](http://en.wikipedia.org/wiki/Ion_exchange_chromatography).

Ion exchange chromatography (usually referred to as ion chromatography) uses an ion exchange mechanism to separate analytes based on their respective charges. It is usually performed in columns but can also be useful in planar mode. Ion exchange chromatography uses a charged stationary phase to separate charged compounds including [anions](http://en.wikipedia.org/wiki/Anion), [cations](http://en.wikipedia.org/wiki/Cation), [amino acids](http://en.wikipedia.org/wiki/Amino_acid), [peptides](http://en.wikipedia.org/wiki/Peptide), and [proteins](http://en.wikipedia.org/wiki/Protein). In conventional methods the stationary phase is an [ion exchange resin](http://en.wikipedia.org/wiki/Ion_exchange_resin) that carries charged [functional groups](http://en.wikipedia.org/wiki/Functional_group) which interact with oppositely charged groups of the compound to be retained. Ion exchange chromatography is commonly used to purify proteins using [FPLC](http://en.wikipedia.org/wiki/Fast_protein_liquid_chromatography).

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=16)**] Size-exclusion chromatography**

For more details on this topic, see [Size-exclusion chromatography](http://en.wikipedia.org/wiki/Size-exclusion_chromatography).

Size-exclusion chromatography (SEC) is also known as **gel permeation chromatography** (GPC) or **gel filtration chromatography** and separates molecules according to their size (or more accurately according to their hydrodynamic diameter or hydrodynamic volume). Smaller molecules are able to enter the pores of the media and, therefore, molecules are trapped and removed from the flow of the mobile phase. The average residence time in the pores depends upon the effective size of the analyte molecules. However, molecules that are larger than the average pore size of the packing are excluded and thus suffer essentially no retention; such species are the first to be eluted. It is generally a low-resolution chromatography technique and thus it is often reserved for the final, "polishing" step of a purification. It is also useful for determining the [tertiary structure](http://en.wikipedia.org/wiki/Tertiary_structure) and [quaternary structure](http://en.wikipedia.org/wiki/Quaternary_structure) of purified proteins, especially since it can be carried out under native [solution](http://en.wikipedia.org/wiki/Solution) conditions.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=17)**] Special techniques**

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=18)**] Reversed-phase chromatography**

For more details on this topic, see [Reversed-phase chromatography](http://en.wikipedia.org/wiki/Reversed-phase_chromatography).

Reversed-phase chromatography is an elution procedure used in liquid chromatography in which the mobile phase is significantly more polar than the stationary phase.

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**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=19)**] Two-dimensional chromatography**

In some cases, the chemistry within a given column can be insufficient to separate some analytes. It is possible to direct a series of unresolved peaks onto a second column with different physico-chemical ([Chemical classification](http://en.wikipedia.org/wiki/Chemical_classification)) properties. Since the mechanism of retention on this new solid support is different from the first dimensional separation, it can be possible to separate compounds that are indistinguishable by one-dimensional chromatography. The sample is spotted at one corner of a square plate,developed, air-dried, then rotated by 90° and usually redeveloped in a second solvent system.

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**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=20)**] Simulated moving-bed chromatography**

For more details on this topic, see [Simulated moving bed](http://en.wikipedia.org/wiki/Simulated_moving_bed).

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**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=21)**] Pyrolysis gas chromatography**

Pyrolysis gas chromatography mass spectrometry is a method of chemical analysis in which the sample is heated to decomposition to produce smaller molecules that are separated by gas chromatography and detected using mass spectrometry.

Pyrolysis is the thermal decomposition of materials in an inert atmosphere or a vacuum. The sample is put into direct contact with a platinum wire, or placed in a quartz sample tube, and rapidly heated to 600–1000 °C. Depending on the application even higher temperatures are used. Three different heating techniques are used in actual pyrolyzers: Isothermal furnace, inductive heating (Curie Point filament), and resistive heating using platinum filaments. Large molecules cleave at their weakest points and produce smaller, more volatile fragments. These fragments can be separated by gas chromatography. Pyrolysis GC chromatograms are typically complex because a wide range of different decomposition products is formed. The data can either be used as fingerprint to prove material identity or the GC/MS data is used to identify individual fragments to obtain structural information. To increase the volatility of polar fragments, various methylating reagents can be added to a sample before pyrolysis.

Besides the usage of dedicated pyrolyzers, pyrolysis GC of solid and liquid samples can be performed directly inside Programmable Temperature Vaporizer (PTV) injectors that provide quick heating (up to 30 °C/s) and high maximum temperatures of 600–650 °C. This is sufficient for some pyrolysis applications. The main advantage is that no dedicated instrument has to be purchased and pyrolysis can be performed as part of routine GC analysis. In this case quartz GC inlet liners have to be used. Quantitative data can be acquired, and good results of derivatization inside the PTV injector are published as well.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=22)**] Fast protein liquid chromatography**

For more details on this topic, see [Fast protein liquid chromatography](http://en.wikipedia.org/wiki/Fast_protein_liquid_chromatography).

Fast protein liquid chromatography (FPLC) is a term applied to several chromatography techniques which are used to purify proteins. Many of these techniques are identical to those carried out under high performance liquid chromatography, however use of FPLC techniques are typically for preparing large scale batches of a purified product.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=23)**] Countercurrent chromatography**

For more details on this topic, see [Countercurrent chromatography](http://en.wikipedia.org/wiki/Countercurrent_chromatography).

An example of a HPCCC system

Countercurrent chromatography (CCC) is a type of liquid-liquid chromatography, where both the stationary and mobile phases are liquids. The operating principle of CCC equipment requires a column consisting of an open tube coiled around a bobbin. The bobbin is rotated in a double-axis gyratory motion (a cardioid), which causes a variable gravity (G) field to act on the column during each rotation. This motion causes the column to see one partitioning step per revolution and components of the sample separate in the column due to their partitioning coefficient between the two immiscible liquid phases used. There are many types of CCC available today. These include HSCCC (High Speed CCC) and HPCCC (High Performance CCC). HPCCC is the latest and best performing version of the instrumentation available currently.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=24)**] Chiral chromatography**

Chiral chromatography involves the separation of stereoisomers. In the case of enantiomers, these have no chemical or physical differences apart from being three-dimensional mirror images. Conventional chromatography or other separation processes are incapable of separating them. To enable chiral separations to take place, either the mobile phase or the stationary phase must themselves be made chiral, giving differing affinities between the analytes. [Chiral chromatography HPLC columns](http://en.wikipedia.org/wiki/Chiral_column_chromatography) (with a chiral stationary phase) in both normal and reversed phase are commercially available.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Chromatography&action=edit&section=25)**] See also**

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