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Commentary

# Advantages and Disadvantages of Displacement Chromatography

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## DESCRIPTION

Displacement chromatography is a type of chromatography in which a sample is deposited on the column's head and then displaced by a solute that is more strongly sorbed than the original mixture's components. As a result, rather than solvent-separated "peaks," the components are resolved into sequential "rectangular" zones of highly concentrated pure substances. When compared to other modes of chromatography, it is largely a preparative technique; better product concentration, purity, and throughput can be achieved.

The underlying idea of displacement chromatography is that there are only a finite number of binding sites for solutes on the matrix, and once one molecule has occupied a site, it is unavailable to other molecules. Equilibrium is formed between molecules of a specific sort bonded to the matrix and those of the same kind free in solution, as in any chromatography. Because the number of binding sites is limited, when the concentration of molecules free in solution is high compared to the dissociation constant for the sites, those sites will be predominantly occupied. Solutes separated in displacement mode generate sharp-edged zones rather than spreading peaks, as opposed to elution chromatography. In displacement chromatography, zone borders self-sharpen: if a molecule goes ahead of its band for some reason, it enters a zone where it is more strongly held, and then runs more slowly until its zone catches up. Furthermore, because displacement chromatography takes advantage of the isotherms' non-linearity, loadings are intentionally high; more material may be separated on a single column in a given amount of time, with purified components recovered at substantially greater concentrations. The retention conditions can still be changed, but the solute migration rate is controlled by the displacer. The displacer is chosen to have a higher affinity for the stationary phase than any of the solutes being separated, and its concentration is adjusted to approach stationary phase saturation while maintaining the appropriate concentration wave migration rate. Because the displacer ensures removal of all solutes of interest in the prescribed run period, high-retention conditions can be used without gradient operation.

Displacement chromatography is particularly suited to purify components from dilute feed streams due to the concentrating impact of loading the column under high-retention conditions. However, material from a dilute stream can be concentrated at the head of a chromatographic column before switching conditions to elute the adsorbed material in traditional isocratic or gradient modes. As a result, this method is not exclusive to displacement chromatography, however the higher loading capacity and lower dilution in displacement mode allow for higher concentration. Non-idealities always result in an overlap zone between each pair of components in displacement chromatography; this mixed zone must be collected separately for recycling or trash to protect the purity of the separated elements. When suitable, easily removable spacers are found, the method of introducing spacer molecules to generate zones between the components has been examined and could be useful. Another downside is that for contiguous zones, the raw chromatogram, such as a plot of absorbance or refractive index versus elution volume, can be difficult to read, particularly if the displacement train is not fully established. Additional chemical analysis may be required for documentation and troubleshooting to determine the distribution of a certain component. Another issue is that regeneration takes time, which restricts throughput.

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