Roundtable Session - Table 1 - Forgotten CE Technologies: CGE, ITP, Affinity CE, Taylor Dispersion, MEKC

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Abstract:

Early version of CGE (capillary gel electrophoresis) used capillary column filled with "solid" gel. It was a powerful tool for DNA separation. However, it has some difficulties, such bubbles and gel contamination after multiple use. Late, the gel was replaced by "replicable gel". It is now adapted by CE-SDS method for proteins. Even for DNA samples.

ITP (isotachophoresis) is a unique electrophoresis technology. At the end of separation, all separate zones of the components in samples stack each other like a train, with no separation buffer between the zones. Since all the zones have the same conductivity, low concentration components are concentrated. The separation mode fits MS very well since no idle time for the MS and sample may be concentrated. But, the method is not easy to run (I personally spent few months working on the method). The technology has never been widely used.

Affinity CE is a good tool to study biological interactions between proteins like receptors, enzymes or plasma proteins with other components such as carbohydrates and nucleic acids. A common way is immobilizing ligands in the gel filled in the capillary column. By observing the changes in analytes' mobility, the interaction between the analytes and the ligands can be measured.

Taylor Dispersion in a narrow capillary can be considered as the one-dimensional diffusion. The diffusion of a molecule is related to the molecule's size/molecular weight.

MEKC (micellar electrokinetic chromatography) makes separate neutral molecules possible in regular CE instruments with high resolution. In some applications, it replaced some revise-phase chromatography.

CEC (capillary electrokinetic chromatography) uses EOF to drive its mobile phase. Its separation column is packed with ultra fine beads stationary phase. The conventional HPLC pumps can not pump through the fine beads packed capillary column. CEC showed super high resolution in separation. But it was killed by uHPLC in recent 10 years.

Notes:

Isotachophoresis (ITP) - One key benefit is its ability to concentrate dilute samples, making it attractive for trace analysis and coupling with mass spectrometry. The group noted that

despite its impressive sensitivity advantages, the technique can be difficult to develop and optimize, which likely contributed to its limited adoption in routine laboratories.

Affinity CE: A useful method for studying biological interactions, including protein-protein, protein-carbohydrate, and protein-nucleic acid binding. By monitoring changes in analyte migration in the presence of a ligand, binding interactions can be quantified. While other technologies such as SPR and BLI became more common, Affinity CE still offers a valuable orthogonal approach for studying biomolecular interactions using very small sample volumes.

Taylor Dispersion Analysis (TDA) uses molecular diffusion in a capillary to estimate molecular size and hydrodynamic radius. Because diffusion is directly related to molecular size, the technique can be used to characterize proteins, polymers, and nanoparticles. The discussion centered on whether TDA could see renewed interest given today's emphasis on characterizing complex biologics, gene therapy products, and lipid nanoparticles.

MEKC was described as one of the most innovative CE modes because it allows separation of neutral compounds that cannot normally be resolved by standard capillary electrophoresis. Surfactant micelles act as a pseudo-stationary phase, creating chromatographic-like selectivity within a CE system. Historically, MEKC competed with reverse-phase HPLC for certain applications, but widespread HPLC adoption ultimately limited its use despite its excellent resolution and versatility.

CEC combines features of both capillary electrophoresis and liquid chromatography by packing stationary phase, producing extremely high separation. CEC generated significant excitement in the separation science community years ago, but the emergence and commercialization of UHPLC largely overshadowed its development. Several attendees questioned whether advances in column manufacturing and microfluidics could spark renewed interest in technology.

An overwhelming message that was talked about towards the tail end of the discussion focused around preserving the science that these types of CE techniques offer. Concern within the community focused on companies looking to achieve the easy fix and solution, and maybe not always the correct one. We must continue to build our CE community and encourage our fellow scientists to push the boundaries every day.