Czech Chemical Society Lecture

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Development of novel separation media and instrumental setups in analytical chemistry

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Since Tswett invented chromatographic separation more than 120 years ago, the expected development has spread through instrumentation, separation columns, and stationary phase fields. Polymer-based monolithic stationary phases joined this process 35 years ago and immediately became one of the most important discoveries in the field. With their straightforward preparation and simple post-polymerization surface modification, they represent versatile materials with possible applications in any field of analytical chemistry. Polymer monoliths can be and have been used as chromatographic stationary phases for separating both small and large molecules, enzymatic reactors, and solid-phase extraction units, to name only a few examples.

With the aim of post-polymerization hypercrosslinking modification, the high surface area materials applicable in separating small molecules were prepared. However, we have demonstrated that these stationary phases also proved beneficial in separating peptides in the bottom-up proteomic protocol, especially when very narrow separation capillaries are involved.

Combining monolithic capillary columns with miniaturized electrochemical detection allowed the preparation of a multifunctional analytical unit, simultaneously separating one sample on four different separation columns with integrated electrochemical detection. Such units provide cheap yet robust alternatives to commercially available instrumentations and further extend the applicability of polymer monoliths in designing affordable analytical instruments.

The versatility of polymer-based monolithic materials is coupled with the easy surface modification providing, for example, enzymatic reactors. We have demonstrated that polymer-based enzymatic reactors working strictly in an organic environment can be easily prepared and utilized to synthesize fatty acid methyl esters, i.e., biodiesel. Furthermore, combined with previously developed proteolytic reactors, we have prepared phosphopeptide enrichment units that can be integrated into an online sample preparation proteomics workflow.

The separation power of conventional one-dimensional liquid chromatography might not be enough to separate complex metabolomic and proteomic samples. In our group, we focus on developing unorthodox combinations of separation mechanisms in two-dimensional liquid chromatography. We recently introduced two-dimensional separation, which combines spatial and temporal separation. We currently utilize the developed enzymatic reactors as a modulator between two separation dimensions, combining top-down and bottom-up proteomics protocols.

These are only a few milestones I would like to address during my lecture. Their main aim is to summarize my contribution to the field with its framing to the current state of the art. Still, they can also be considered only iceberg peaks describing my research journey.