Paper-Based Devices for Ultrasensitive Mass Spectrometry

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Mass spectrometry is a powerful tool for identifying and quantifying molecules, but detecting trace compounds in complex samples often requires extensive sample preparation and chromatographic separation. Our research aims to simplify mass spectrometry analysis by using electric fields to concentrate molecules directly on porous substrates, which are also used for MS ionization. The porous substrate, often paper or some porous polymer, therefore acts as the medium for sample enrichment, crude separation, and MS ionization. The porous materials are positioned within simple 3D-printed cartridges to make assembly and analysis easier. By controlling the surface chemistry of the porous material, electroosmotic flow, and electrophoretic migration, we can concentrate analytes from dilute solutions into narrow bands through a process called electrokinetic stacking. These concentrated bands are then transported to the tip of the substrate, where they are ionized directly into the mass spectrometer. Applications include detecting environmentally important PFAS compounds in water at sub-parts-per-trillion concentrations, measuring synthetic opioids in biological fluids, and improving the characterization of proteins, peptides, and therapeutic antibodies.