Chip Electrochromatographic Systems: Novel Vertically Aligned Carbon Nanotube and Silica Monoliths based Separations

by

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ABSTRACT

Miniaturized chemical analysis systems, also know as 'lab-on-a-chip' devices have been rapidly developing over the last decade. Capillary electrochromatography (CEC), a multidimensional separation technique combining capillary electrophoresis (CE) and liquid chromatography (LC) has been of great interest for chip based applications.

Preliminary work has been undertaken to develop vertically aligned carbon nanotubes and photopolymerizable silica solgel as novel stationary phase materials for 'chip CEC' separations. Patterned growth of CNTs in a specific location of the channel has been carried out using a solid phase Fe- Al catalyst as well as a vapor deposited ferrocene catalyst. Characterization of the CNT "forests" was achieved using optical microscopy, secondary electron microscopy, high resolution tunneling electron microscopy and Raman spectroscopy. Proof-of-concept applications were demonstrated using reversed phase CEC separations as well as solid phase extraction of a glycosylated protein using concanavilin A immobilized onto the CNT bed.

Photopolymerizable silica solgel materials were developed as stationary phase for microfluidic electrochromatographic separations in disposable polydimethylsiloxane (PDMS) chip devices. Effect on morphology and pore size of gels were studied as function of UV and solgel polymerization conditions, porogen, salt additives, geometry and hydrolyzable methoxy-ies**.** Structural morphologies were studied with Secondary Electron Microscopy (SEM). Pore size and pore volumes were characterized by thermal

porometry, nitrogen BET adsorptions and differential scanning calorimetry. Computational fluid dynamics and confocal microscopy tools were employed to study the transport of fluids and model analytes. These investigations were directed towards evolving improved strategies for rinsing of uncrosslinked monomers to form porous monoliths as well as to effect a desired separation under a set of electrochromatograhic conditions Glycidyloxypropyltrimethoxysilane (GPTMS) mixed with MPTMOS was used as a generic platform to attach affinity ligands such as biotin, boronic acid and cibacron blue to the functionalizable epoxide groups. The binding capacities of target molecules to corresponding affinity ligands were studied by batch binding assays. Preliminary work with corresponding FITC tagged proteins and their interactions with the derivatized and native GPTMOS/MPTMOS under various electrochromatographic conditions have been undertaken.

Research and innovations were also carried out in optical detection systems, hydrophilization of PDMS and induced pressure driven flow systems to support our efforts towards microfluidic chip electrochromatographic systems.