# Adsorptive characterization and applications of carbon-silica composite materials


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Recently proposed carbon-silica composite materials (CSM) were expected to bridge a gap between mesoporous and microporous materials by using properties of both structured mesoporous silica and broadly applicable carbonaceous materials. CSM were prepared from mesoporous silica MCM-41 impregnated with furfuryl alcohol, subsequently polymerized and pyrolyzed inside the pores at elevated temperatures of around 1073K. Synthesis parameters were varied systematically and the CSM studied with various adsorptive characterization techniques. In the low coverage region, the enthalpies and entropies were more comparable to those for a MFI microporous zeolite and very different from those of mesoporous materials (MCM-41, MCM-48). Unexpected shape selectivity was demonstrated at low coverage, but also breakthrough experiments as well as vapor phase gravimetry showed an increased shape selectivity of linear versus branched alkanes at high carbon loadings and high pyrolysis temperatures. Polarity was investigated by water vapor phase adsorption isotherms and adsorption isotherms of heptanol from heptanes in the liquid phase and indicated the presence of polar surface groups. Clearly not all silica surface was covered with carbon resulting in mixed behavior of carbon nano-particles inside the silica pores. Ammonia treated and nitrogen plasma treated materials were investigated for their carbon dioxide adsorption and carbon dioxide/methane separation properties. The resulting carbon dioxide capacity is stable around 1 mmol/g but the separation factor varies from 1 up to more than 11 depending on the synthesis conditions, which is high in comparison to many adsorbent materials. HPLC grade particles were synthesized by the pseudomorphic transformation of uniform silica particles and pulse liquid chromatography of homologous series of alkylbenzenes, polyaromatic hydrocarbons showed that the stationary phase retention resembles a normal phase behavior with high interaction towards phenyl groups and shape selective effects. Given their unique shape selectivity and carbon nature, CSM could be applied in applications in catalytic reactions as well as in adsorptive separations.