Solution-processed nanostructured overcoats for renewable catalysis

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Thanks to its wide availability and relatively low cost, lignocellulosic biomass is an attractive source of renewable carbon. However, unlike petroleum, biomass-derived molecules are highly oxygenated, have low volatility, and are often produced in dilute-aqueous streams. Heterogeneous catalysts – the workhorses of the chemical and fuel industries – are often sensitive to water and contain many metals that easily sinter and leach in liquid-phase conditions.

Catalyst overcoating presents a potential solution to this problem. Recent breakthroughs using catalyst overcoating with atomic layer deposition (ALD) showed that base metal catalysts can be stabilized against sintering and leaching in liquid phase conditions. However, ALD is ill suited for commercial catalyst production, creates dramatic drops in activity due to excessive surface coverage and forms an overcoat that is difficult to tune.

To address these limitations, we are developing layer-by-layer solution-processed catalyst overcoating methods to stabilize heterogeneous catalysts. We achieve the deposition of oxide coatings with nanometer-level control by using subsequent injections of stoechiometically-limited amounts of alkoxide precursors and water. By depositing these solution processed overcoats over Cu/Al_2O_3, we were able to stabilize this base metal catalysts for use in liquid phase biomass conversion reactions while maintaining a much higher access to the metal sites. Furthermore, liquid phase processing chemistry offers several parameters for controlling the overcoat properties including the chosen solvent, the stoichiometric ratio of precursors, the use of acid catalysts, post synthesis treatments, etc. By tuning synthesis parameters, we hope to both improve stability and introduce shape-selectivity on metal nanoparticle catalysts.