Understanding zeolite-binder interactions in shaped catalyst bodies

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When applied in industry, zeolite catalysts are often shaped with the aid of binders and other additives into practical millimetre-sized forms.[1] The interaction of the component phases during the shaping and subsequent application can alter the type, amount, distribution, and accessibility of active sites, which can beneficially or detrimentally impact the catalyst performance compared to the pure zeolite powders typically studied in early development stages.[2] Although several mechanisms, such as the neutralization of acid sites *via* the migration of exchangeable cations, the insertion, substitution, or removal of framework metals, and the physical obstruction of micropores have been cited, the exact nature and extent of these effects are not well understood. By developing strategies to isolate the interface between common binders and zeolite crystals, we aim to correlate the morphological, compositional, and structural changes that occur under the conditions experienced by the catalyst in practice. For this purpose, approaches to representatively sample zeolite extrudates or to construct model interfaces, controlled (hydro)thermal treatments, catalytic evaluation in the conversion of methanol to olefins, and state-of-the-art characterization are coupled with the visualization through advanced microscopic and spectroscopic techniques (**Figure 1**). In particular, energy dispersive X-ray spectroscopy, electron energy-loss spectroscopy, and atom probe tomography are applied to map chemical interactions between the zeolite and binder phases, while the crystalline structure at the interface is tracked by electron diffraction. The attained insights have clear implications for advancing the understanding and development of novel porous solids in diverse industrial applications.

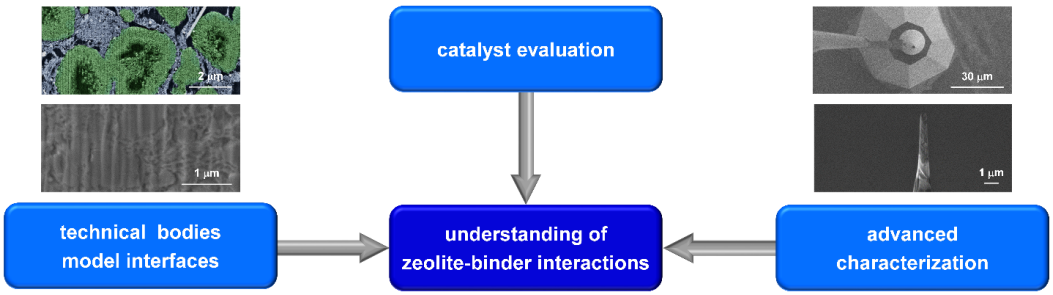

Figure 1 Approach to rationalize the effects of binder in shaped zeolite catalysts.

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