Deactivation of Fluid Catalytic Cracking Catalysts, a Three-Dimensional View of Structural Changes

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Since its commercial introduction three-quarters of a century ago fluid catalytic cracking has proven to be one of the most important conversion processes in the petroleum industry. In this process porous composites composed of zeolite and clay crack the heavy fractions in crude oil into transportation fuel and petrochemical feedstocks. Yet, over time the catalytic activity of these particles decreases. Here we report on resonant ptychographic and fluorescence tomography measurements complemented by electron microscopy to elucidate the structural changes that lead to catalyst deactivation. In combination, acquired tomograms reveal zeolite amorphization and distinct structural changes to the particle exterior as the driving forces behind catalyst deactivation. Amorphization of zeolites, in particular, close to the particle exterior results in a reduction of catalytic capacity. A concretion of the outermost particle layer into a dense amorphous silica-alumina shell further reduces the mass transport to the active sites within the composite. The results provide a complementary explanation to currently suggested deactivation mechanisms driven by feed and reactor impurities.