

X-ray Tomography Studies of Wax Formation during the Fischer-Tropsch Reaction: Lab and Synchrotron-Based Imaging Insights

*Reihaneh Pashminehazar¹, Srashtasrita Das¹, Anna Zimina^{1,2}, Thomas Sheppard²,
Jan Dierk Grunwaldt^{1,2}*

*¹ Institute of Catalysis Research and Technology; ² Institute for Chemical Technology
and Polymer Chemistry, Karlsruhe Institute of Technology, Germany*

During the Fischer-Tropsch (FT) reaction, a mixture of CO and H₂ is converted into high hydrocarbons, including waxes with highly effective catalysts. Visualizing wax formation in the FT reaction using X-ray tomography provides an excellent opportunity to study product distribution in a spatially resolved manner and link it to reaction dynamics to understand catalyst deactivation. Detecting wax with X-ray micro-computed tomography (micro-CT) poses challenges, such as low X-ray attenuation in highly loaded catalytic materials and resolution limits for thin or diffuse deposits, which might be overcome using synchrotron based X-ray tomography. In this study, support grains (70–90 µm) of amorphous silica loaded with catalytically active Co nanoparticles were scanned before and after the FT reaction using lab- and synchrotron-based micro-CT to analyze the wax distribution between the support grains and to explore the feasibility of the methods to detect the wax inside the grains and any morphological/topological changes in the support structure. Lab CT scans are suitable for preliminary analyses and revealed wax formation but struggled with segmentation due to insufficient contrast between wax and air (Fig. 1). In contrast, synchrotron CT offers superior capabilities, including sub-micrometer resolution and enhanced material contrast with monochromatic X-rays, enabling more accurate segmentation of wax, air, and diffused wax within the catalyst support. Furthermore, synchrotron-based scanning is extremely fast, making it possible to perform real-time dynamic scanning of catalyst systems during the dewaxing process.

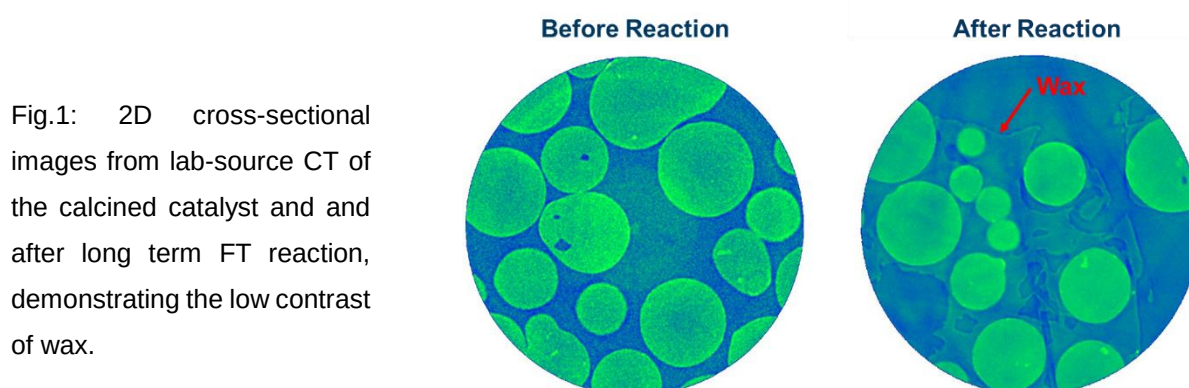


Fig.1: 2D cross-sectional images from lab-source CT of the calcined catalyst and after long term FT reaction, demonstrating the low contrast of wax.