

## **Can operando methodologies bridge the gaps towards rational catalyst design?**

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Heterogeneous catalysis plays vital roles in the production of chemicals and fuels, environmental protection and as enabler of future technologies for sustainable and circular development. However only a minute fraction of such technologies sees the commercial light after a long R&D of a few decades. The necessity to accelerate the development of catalytic technologies is obvious to cope with the environmental and energy issues we face. To understand better catalytic materials and reactions, in situ and operando spectroscopic methods are widely employed with the aim to rationally develop and improve catalysts. The question is: do these methods help us reach our goal? In this talk, the major challenges and gaps, to the view of the speaker, are described, followed by introducing promising operando methodologies and associated approaches to fill the gaps. Some examples in C1 chemistry with a focus on CCU and automotive catalysis are described to elucidate the reaction mechanisms directly relevant to understand catalytic performance, with a discussion on where we could move forward further.