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Applying Nanoparticle@MOF Interface to Activate and Monitor Chemical Reactions at Ambient Conditions

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Abstract

Gas reactions are prevalent in the industry and in our everyday lives. However, these processes are typically slow and difficult to monitor owing to the low molecular concentration of gas. While gas reactions and detections can be achieved at high temperatures and pressures, these operations are unsustainable because they demand a huge amount of energy input. Here, we achieve efficient gas-based reactions and sensing at ambient conditions by concentrating gas molecules at the interface formed between a functional solid and a metal-organic framework (MOF). Our strategy utilizes the excellent gas sorptivity of MOF to continuously accumulate gas molecules onto functional solid surfaces with plasmonic and/or catalytic properties. Using surface-enhanced Raman spectroscopy (SERS), we are able to directly observe the concentration of gas molecules into a quasi-condensed phase at the nanoscale solid@MOF interface, even at ambient operations.^[1] We further leverage on this unique molecular phenomenon to activate a CO₂ carboxylation of an arene that is otherwise inert at 1 atm and 298 K.^[2] Our solid@MOF design thus offers enormous opportunities in relevant fields including chemistry, heterogeneous catalysis, greenhouse gases removal and gas-to-fuel conversions.

Fig. 1: Using SERS to unravel the molecular events occurring at the nanoparticle@MOF interface during gas sorption and reaction.

Keywords: surface-enhanced Raman spectroscopy (SERS), metal-organic framework (MOF), reaction monitoring, nanoparticle, carbon dioxide

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