Chemistry Europe
European Chemical Societies Publishing

ChemCatChem
Volume 13, Issue 2 p. 664-673
Full Paper

Highly Active and Stable Palladium Catalysts Supported on Surface-modified Ceria Nanowires for Lean Methane Combustion

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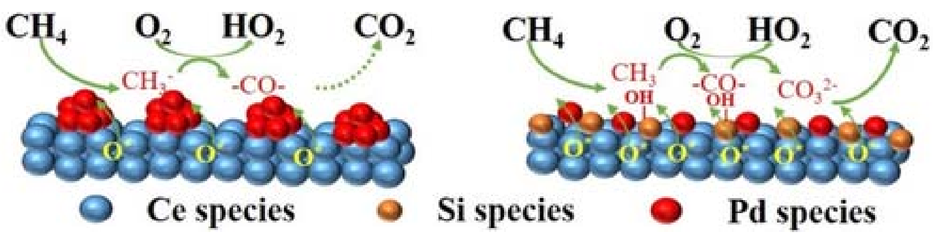
First published: 28 October 2020
https://doi.org/10.1002/cctc.202001438

Graphical Abstract

Methane combustion: The silicon-modified ceria nanowires can prominently improve the dispersion of palladium species and strengthen the concentration of active surface oxygen species, resulting in excellent catalytic activity for methane combustion.



Abstract

An efficient strategy was presented to synthesize highly active palladium catalyst supported on ceria nanowires modified by organosilanes (abbreviated as $Pd/CeO_2NWs@SiO_2$) for lean methane combustion. It is found that such a surface-modified strategy can significantly improve the dispersion of surface palladium species and strengthen the concentration of active surface-adsorbed oxygen species via reconstructing the surface microenvironment, invoking an efficient performance for methane oxidation. Under the space velocity of 60,000 $mLg^{-1}h^{-1}$, 0.5 wt% $Pd/CeO_2NWs@SiO_2$ displayed extraordinary catalytic activity with 90 % conversion rate at a temperature of around 327 °C, far lower than that of pristine Pd/CeO_2NWs (378 °C) under the same conditions. What's more, unexpected stability was observed under high temperature and the presence of water vapor conditions owing to the intense metal support interaction of $Pd/CeO_2NWs@SiO_2$ catalyst. The possible reaction mechanism of lean methane oxidation was probed by in situ DRIFT spectra. It is observed that the pivotal intermediate products (carbonate and carbon oxygenates) generated on $Pd/CeO_2NWs@SiO_2$ surface are more readily decomposed into CO_2. Importantly, the silicon hydroxyl groups (Si−OH) formed during the reaction can efficiently restrict the generation of the stable $Pd(OH)_x$ phase and release more active sites to facilitate the catalytic performance. This study provides a convenient method to design the highly reactive and durable palladium-based catalyst for methane combustion.

Conflict of interest

The authors declare no conflict of interest.

References

Citing Literature

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