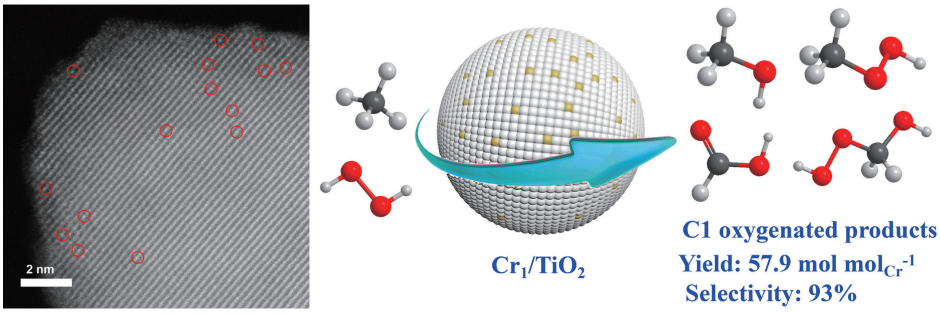
# Single Chromium Atoms for Direct Methane Conversion

Basic Research

Methane is one of the most promising building blocks for producing basic chemicals because of it is abundant and inexpensive. However, methane is the most inert hydrocarbon owing to the strong C-H bond strength (434 kJ $mol^{-1}$) and its tetrahedral structure. Activation of methane is a big challenge and has been regarded as the holy grail in catalysis.




HAADF-STEM image of $Cr_1/TiO_2$ and its catalytic property for $CH_4$ oxidation. (Image by Prof. SONG Weiguo)

Recently, a joint research group from the Institute of Chemistry of Chinese Academy of Sciences (ICCAS), led by Prof. SONG Weiguo, reported single chromium atoms supported on titanium dioxide nanoparticles are an efficient heterogeneous catalyst for direct methane oxidation to C1 oxygenated products with $H_2O_2$ as oxidant under mild conditions. The work entitled "Single Chromium Atoms Supported on Titanium Dioxide Nanoparticles for Synergic Catalytic Methane Conversion under Mild Conditions" was published in *Angew. Chem. Int. Ed.*

With optimized catalyst, the highest yield for C1 oxygenated products of 57.9 mol $mol_{Cr}^{-1}$ can be reached with a high selectivity of around 93% at 50°C for 20 h, which is significantly higher than those of most reported catalysts. The superior catalytic performance can be attributed to the synergistic effect between Cr single atoms and $TiO_2$ support. Combining catalytic kinetics, electron paramagnetic resonance and control experiment results, a possible reaction pathway for methane conversion with $Cr_1/TiO_2$ catalyst is proposed as: CH4 is first oxidized through a radical pathway to form $CH_3OH$ and $CH_3OOH$, and then the generated $CH_3OH$ is further oxidized to $HOCH_2OOH$ and HCOOH. This study provides a new non-noble metal single-site catalyst with superior catalytic performance for direct conversion of methane under mild conditions.

This work was financially supported by the National Key Research and Development Program of China, National Natural Science Foundation of China, and the Youth Innovation Promotion Association of CAS.

(ICCAS)

**Contact:**
Prof. SONG Weiguo
Institute of Chemistry, CAS
Email: wsong@iccas.ac.cn

**Reference**

Qikai Shen, Changyan Cao, Runkun Huang, Lei Zhu, Xin Zhou, Qinghua Zhang, Lin Gu, Weiguo Song, (2020) Single chromium atoms supported on titanium dioxide nanoparticles for synergic catalytic methane conversion under mild conditions. *Angewandte Chemie International Edition* 59, 1216. doi: 10.1002/anie.201913309.