Gold-phosphorus nanosheets catalyzes natural gas to greener energy selectively

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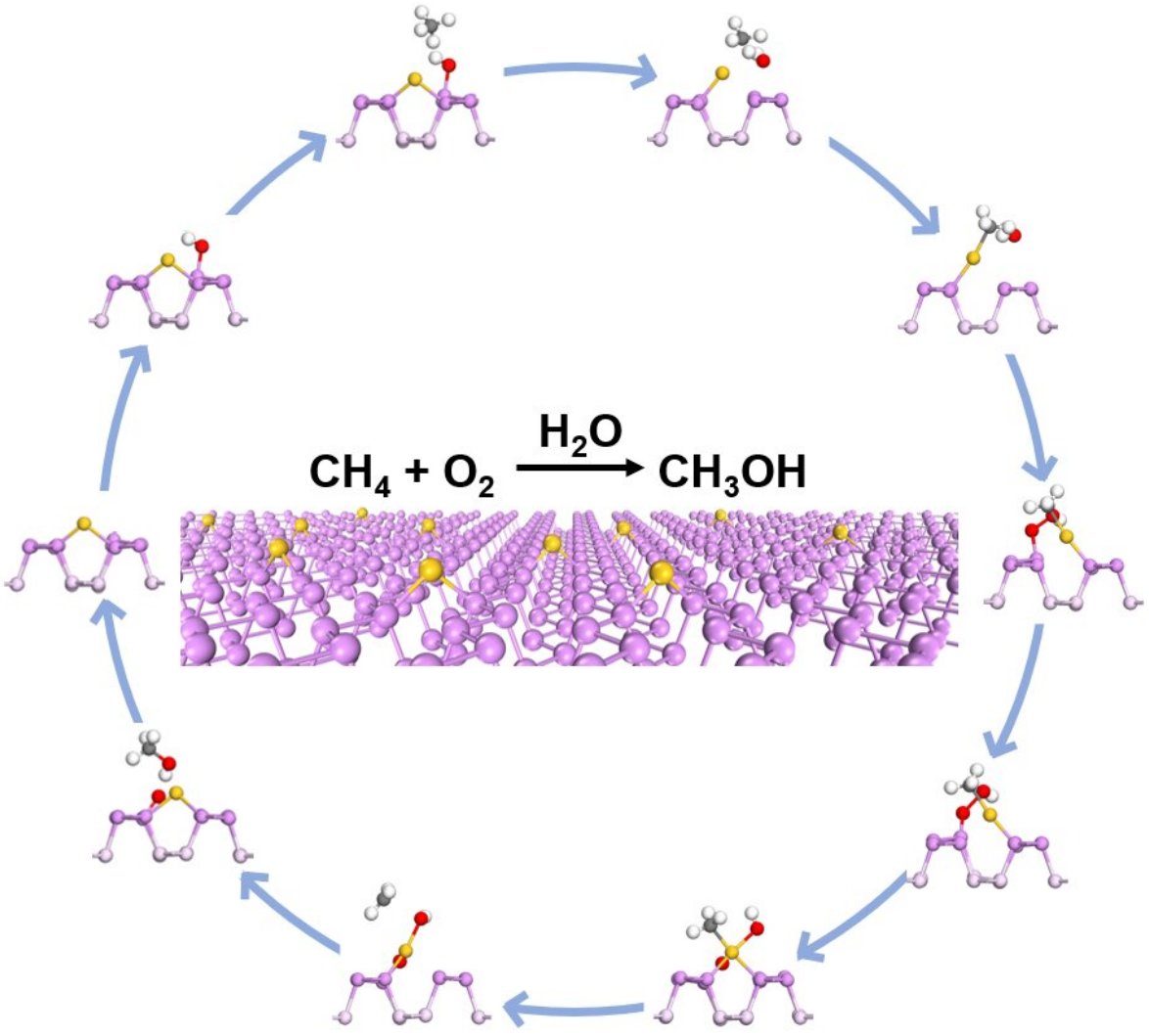

Schematic diagram of the reaction pathway for methane oxidation over Au1/BP nanosheets. Credit: LUO Laihao

Advances in hydraulic fracturing technology have enabled discovery of large reserves of natural gas which primarily contains methane, and which is mainly burned directly, potentially causing global warming. Upgrading methane to greener energy such as methanol through aerobic oxidation is an ideal way to solve the problem.

Yet the difficulties lie in activating methane and preventing methanol from over-oxidation. Methane takes a stable non-polar tetrahedral structure with high dissociation energy of the C-H bond, which requires high energy to be activated. Meanwhile methanol can be easily over-oxidized to carbon dioxide during the process. The activation and directional transformation of methane is regarded as the 'holy grail' of catalysis.

A recent work published in *Nature Communications* by a research team led by Prof. Zeng Jie and LI Weixue from Hefei National Laboratory for Physical Sciences at the Microscale marks new progress. They designed and fabricated Au single atoms on black phosphorus (Au_1/BP) nanosheets for methane selective oxidation into methanol under mild conditions with >99% selectivity.

Au_1/BP nanosheets was able to catalyze methane oxidation reaction with oxygen as oxidant under irradiation conditions. Based on mechanistic studies, water and O_2 were activated on Au_1/BP nanosheets to form reactive hydroxyl groups and OH radicals under light irradiation. The reactive hydroxyl groups enabled mild oxidation of methane into CH_3 species, followed by oxidation of CH_3 via OH radicals into methanol.

Since water is consumed to form hydroxyl groups and produced via reaction of hydroxyl groups with methane, water here is completely recycled and thus can also be regarded as a catalyst.

This study provides insight into the activation mechanism of oxygen and

methane in methane selective oxidation, and offers a new understanding of the role of water in the reaction process.

More information: Laihao Luo et al, Water enables mild oxidation of methane to methanol on gold single-atom catalysts, *Nature Communications* (2021). DOI: 10.1038/s41467-021-21482-z

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