# Recent advances in built-in electric-field-assisted photocatalytic dry reforming of methane

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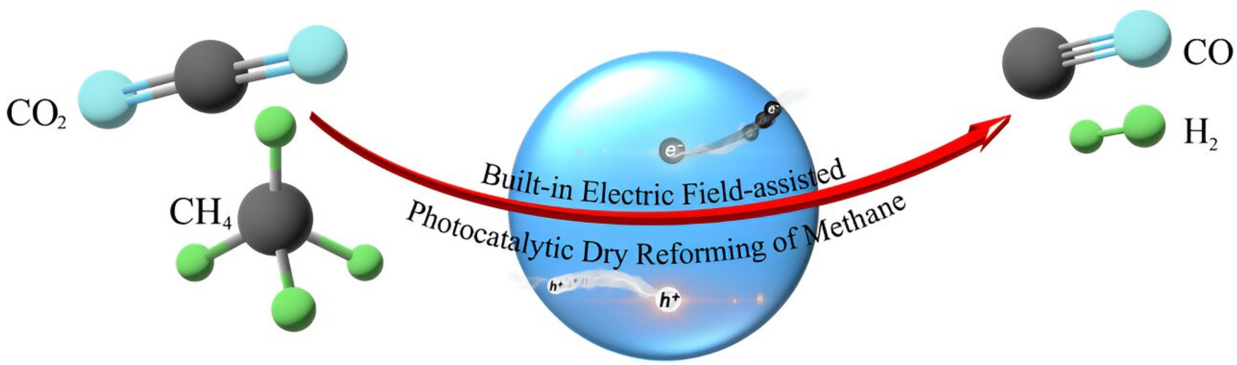


This review summarizes recent advances that enhance the photocatalytic dry reforming of methane by introducing built-in electric fields. The main challenges and corresponding strategies are discussed, thereby encouraging in-depth research in this field. Credit: *Chinese Journal of Catalysis*

Methane ($CH_4$) and carbon dioxide ($CO_2$) are the two main greenhouse gases that cause global warming. Dry reforming of methane (DRM) technology can simultaneously utilize two greenhouse gases to produce hydrogen ($H_2$) and carbon monoxide (CO), meaning DRM is one of the ideal strategies for reducing the greenhouse effect.

However, $CH_4$ and $CO_2$ have high thermodynamic stability, so the conventional thermal DRM process always requires high thermal energy to activate $CH_4$ and $CO_2$. The development of photocatalytic technology provides more opportunities for initiating DRM reactions under mild conditions.

However, due to the rapid recombination of photoexcited charge carriers, the photocatalytic efficiency is still unsatisfactory. It has been reported that the construction of built-in electric fields in photocatalysts is a reliable strategy to enhance charge transfer dynamics. Hence, designing photocatalysts with internal electric fields to control the charge transfer behavior is expected to deal with the above challenge.

Recently, the research teams led by Prof. Huimin Liu from Liaoning University of Technology, China, and Dr. Jordi García-Antón from Universitat Autònoma de Barcelona (UAB) reported a review article, introducing the recent advances of built-in electric-field-assisted photocatalytic dry reforming of methane. This review was published in *Chinese Journal of Catalysis*.

This article first introduces the fundamental reaction mechanism of DRM and traditional thermal catalysts for DRM. Subsequently, the advantages and potential photocatalytic materials for photocatalytic DRM (PDRM) application were summarized, focusing on three types of photocatalysts with built-in electric fields:

(1) Ferroelectric materials-based photocatalysts, which generate built-in electric fields by permanent spontaneous polarization from ferroelectric effects.

(2) Photocatalysts with heterojunction structures, which trigger an internal electric field at the heterointerface. Due to the staggered gap structure in type–II heterojunctions, an internal electric field is formed at the interface, resulting in the separated oxidation and reduction processes over different semiconductor surfaces. In addition, the Z-

scheme heterojunction can maintain charge carriers with high redox through an interface electric field to recombine charges with low redox ability. Thus, the PDRM efficiency could be improved by different heterojunction structures.

(3) Photocatalysts with built-in thermoelectric fields generated by Local surface plasmon resonance (LSPR). Metal nanoparticles are suitable candidates for accelerating charge transfer and activating reactants through resonance, leading to discontinuous electronic structures in metals that create local electric fields between the metal nanoparticles and visible-near-infrared (Vis-NIR) light.

Several studies have shown that the activity and selectivity of a specific product are increased by plasmon-assisted photocatalysis, which highlights the great potential of LSPR for improving photocatalytic (or photothermal-catalytic) efficiency. In addition to the above photocatalysts, the development of PDRM technology leads to more requirements for understanding the reaction mechanism or elucidating the role of specific components in photocatalysts.

Therefore, this review also introduces advanced in-situ characterization technology and theoretical calculations, providing basic knowledge for young researchers engaged in this field at the early stages.

Although many efforts have been made in the PDRM area, there are still some challenges that need to be overcome. Based on existing research results, finally, this review summarizes the main challenges and proposes feasible strategies, encouraging more in-depth investigations in this field in the future.

**More information:** Yiming Lei et al, Recent advances in the built-in electric-field-assisted photocatalytic dry reforming of methane, *Chinese Journal of Catalysis* (2023). DOI: 10.1016/S1872-2067(23)64520-6

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