Basic Research

Novel Carbon-based Catalyst Developed for Efficient Photo-driven CO_2 Cycloaddition

Prof. CHEN Liang's group and Prof. LU Zhiyi's group at the Ningbo Institute of Materials Technology and Engineering (NIMTE) of Chinese Academy of Sciences (CAS) proposed a highly-active carbon-based catalyst, which can directly utilize renewable energy (*e.g.*, solar energy) to improve the efficiency of photo-driven CO_2 cycloaddition effectively. The study was published in *Advanced Materials*.

The increasing greenhouse gas (mainly CO_2) emissions have exacerbated global warming and ocean acidification. To achieve peak CO_2 emissions before 2030 and carbon neutrality by 2060, the elimination of CO_2 based on the capture and conversion of CO_2 is urgently required. Among many strategies to do so, the cycloaddition of CO_2 with epoxides to generate cyclic carbonates has attracted extensive attention thanks to the diverse application of products.

By a versatile molecule-confined pyrolysis strategy, researchers at NIMTE proposed and synthesized a semiconductive Al-N-C catalyst possessing high density of atomically dispersed Al-N_4 motifs.

The Al and N species serve as Lewis acid and base sites, respectively, which are combined to facilitate the substrate activation for the photo-driven CO_2 cycloaddition reactions.

Under light irradiation, the synthesized Al–N–C catalyst showed excellent catalytic performance (≈95% conversion, reaction rate = 3.52 mmol g^{-1} h^{-1}) for the CO_2 cycloaddition reaction.

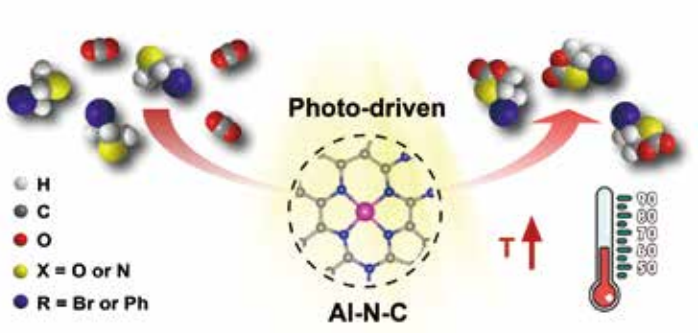

Photo-driven catalytic process based on the Al–N–C catalyst. (Image by NIMTE)

In addition, both experimental and theoretical analyses revealed that light irradiation facilitates the photo-generated electron transfer from the semiconductive Al–N–C catalyst to the epoxide reactant, contributing to the high-efficiency formation of a ring-opened intermediate through the rate-limiting step. It, therefore, constitutes a new activation mechanism for CO_2 cycloaddition reaction.

Hence, this study has provided a novel approach for high-efficiency CO_2 cycloaddition by integrating atomically dispersed Al species and photothermal effect, and may inspire advanced catalyst design.

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Reference
Q. Yang, H. Peng, Q. Zhang, X. Qian, X. Chen, X. Tang, . . . L. Chen, (2021) Atomically dispersed high-density Al-N_4 sites in porous carbon for efficient photodriven CO_2 cycloaddition. *Advanced Materials* 33, e2103186. doi: 10.1002/adma.202103186.