Ambient Methane Functionalization Initiated by d0 Metal-Oxo Electrocatalyst

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SUMMARY

UCLA researchers in the Department of Chemistry and Biochemistry have developed a new strategy to electrochemically functionalize methane at low activation energies under ambient conditions.

BACKGROUND

Natural gas resources are abundant, yet their wide geological distribution, often in remote locations, results in undesirable methane loss through flaring or direct emission into the atmosphere. One strategy to mitigate this loss is to convert methane into other chemicals at the emission source – which for such remote situations might best be done under ambient condition with minimal reliance on an industrial infrastructure. This catalytic conversion requires low activation energy and high turnover numbers to accommodate the low thermal energy and partial pressure of methane substrates under ambient conditions. A variety of methane functionalization processes, such as using methane monooxygenases (MMO) to activate the gas, have been investigated, but these processes operate at high pressure and/or elevated temperature. Thus, there remains a need for methane activation with low activation energy at ambient pressures and temperatures to realize the widespread conversion of natural gas emissions.

INNOVATION

Researchers at UCLA have demonstrated the electricity-driven functionalization of methane at ambient condition with a low activation energy and large turnover numbers. Selective two-electron oxidation of methane was achieved electrochemically with an activation energy as low as 10.8 kcal/mol and a turnover frequency up to 1300 hr^{-1}. This water-tolerant catalyst liquifies natural gas mixture under ambient conditions over 240 hours with 90% selectivity and turnover numbers exceeding 100,000. Moreover, the catalyst remains active and is tolerant to impurities typically present in a natural gas mixture. The similar turnover frequency values among CH_4, C_2H_6, and C_3H_8 minimizes the upstream separation.Additional fundamental and engineering investigation will allow this strategy to convert CH_4 into commodity chemicals with minimal infrastructure support at remote locations, which will lead to the more efficient usage of green-house gases and reducing their emission into the atmosphere.

APPLICATIONS

- Methane gas conversion
- Electrocatalysis
- Greenhouse gas emission reduction
- Recycling, chemical conversion

ADVANTAGES

- Low activation energy and high turnover frequency
- Operated at ambient conditions
- Tolerant to impurities
- Minimal upstream separation

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	11,993,856	05/28/2024	2020-127

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OTHER INFORMATION

KEYWORDS

Natural gas, catalysis, methane functionalization, electrocatalysis, d0 metal-oxo electrocatalyst, electrochemistry, turnover frequency

CATEGORIZED AS

- **Energy**
  - Hydrocarbon
- **Materials & Chemicals**
  - Chemicals

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