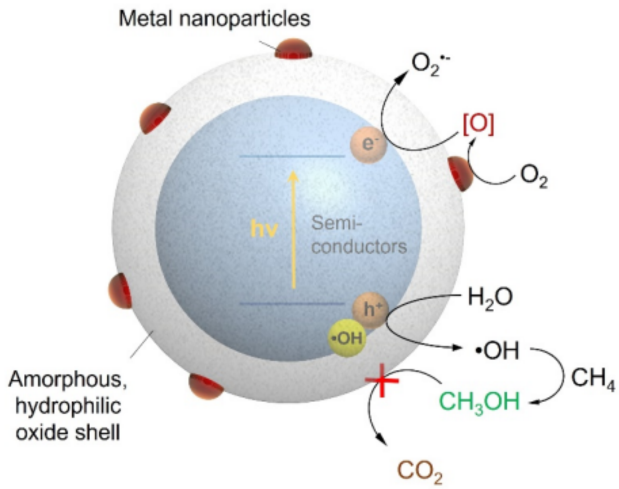
Docket #: S22-115

Transport-Mediated Photocatalysts for Selective Partial Oxidation of Alkanes

Stanford researchers led by Dr. Arun Majumdar have developed photocatalysts combining transport- and reaction-selective nanostructures for direct methanol production. Acting synergistically, this architecture achieves **high selectivity and conversion efficiency for partial oxidation of methane to form methanol and other oxygenates at room temperature**. Direct conversion of methane to methanol and other partial oxidation products is one of the most scientifically challenging problems in chemistry that, if solved, has significant implications for the clean energy economy. With millions of tons of methane being wasted through venting and flaring, its conversion to valuable chemicals and liquid fuels and its ability to displace carbon-rich fuels such as coal, jet fuel, diesel and gasoline could **substantially reduce greenhouse gas emissions**. However, methane's high C-H bond strength, negligible electron affinity and low polarizability pose a high activation barrier. In addition, partially oxygenated products such as methanol and formaldehyde are more reactive than methane and thus are prone to over-oxidation to CO_2. Consequently, direct methane to methanol conversion is often faced with a **trade-off** between CH_4 conversion efficiency and methanol selectivity. **New catalysts** that can directly convert methane to methanol and other oxygenates under mild conditions with both high conversion and selectivity would greatly reduce the carbon footprint of the current industrial two-step methanol production process.



Structure of the new photocatalysts for methane partial oxidation at room temperature. The researchers have shown that enclosing photocatalysts with transport selective structures is a generalizable strategy to achieve high selectivity and activity simultaneously in photochemical alkane oxidation reactions. (image credit: the inventors)

Stage of Development
The researchers have shown that oxygenates production **exceeds state-of-the-art photocatalysts**, despite experiments being performed at lower CH4 pressure.

Applications

- The photocatalysts can combine with different modular photoreactor configuration to produce **liquid fuels and value-added chemicals** including methanol, formaldehyde and formic acid with minimal CO2 production, **directly from vented natural gas**.
- Design can be **generalized** to other alkane oxidation (e.g., ethane oxidation; methane oxidation) using other oxidants such as H2O2.

Advantages

- Successful partial oxidation of methane could lead to **significant reductions** in fugitive emissions while still retaining the value as a fuel or chemical feedstock.
- High conversion and selectivity

- Mild conditions

Patents

- Published Application: WO2023177975

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