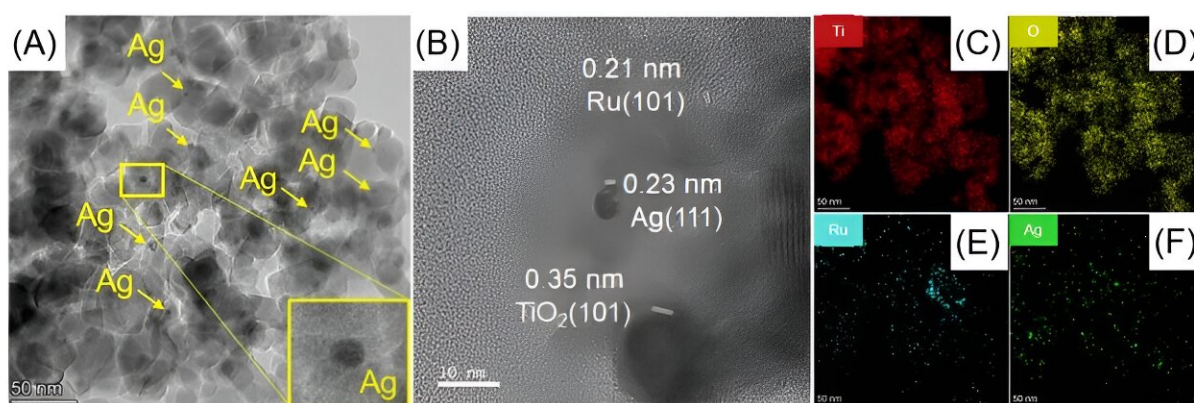


# Team develops eco-friendly high-efficiency photocatalysts that convert atmospheric carbon dioxide into fuel

September 20 2023



Credit: DGIST

The team led by Professor In Soo-Il in the Department of Energy Engineering at DGIST has developed a high-efficiency photocatalyst capable of converting carbon dioxide ( $\text{CO}_2$ ), a major contributor to global warming, into the energy resource methane. The research team optimized the composition of nanoparticle co-catalysts and ruthenium doping to maximize the optical and electrical properties of the photocatalyst.

Simultaneously, they improved the methane conversion efficiency by enhancing  $\text{CO}_2$  adsorption through hydroxy surface treatment. The

research team expects this technology to be applicable to [carbon capture](#) and utilization, making it possible to control the steadily increasing concentration of atmospheric CO<sub>2</sub> while converting it into methane resources.

In 2022, the global CO<sub>2</sub> concentration surpassed 420ppm, the highest level in 4.1 million years. Unprecedented increases in atmospheric CO<sub>2</sub> concentrations have led to [climate-related disasters](#) worldwide, including 20 billion USD (approximately 25.4 trillion KRW) in [economic losses](#) due to droughts in Europe and record-breaking torrential rains on the Korean Peninsula.

To address this issue, the concentration of CO<sub>2</sub>, the cause of climate disasters, should be reduced. The World Economic Forum has identified "solar compounds" capable of converting CO<sub>2</sub>, a major contributor to [global warming](#), into various fuels using [solar energy](#) as one of the top ten promising technologies of 2020.

Among solar compound technologies, photocatalysts that convert highly stable CO<sub>2</sub> into fuels such as methane using only sunlight and photocatalysts through gas-phase reactions are drawing attention as key technologies for the future chemical industry, with the aim to reduce atmospheric CO<sub>2</sub> and produce fuel simultaneously.

However, currently commercialized photocatalysts like P25 have limitations, such as a large bandgap that prevents the absorption of visible light and slow charge transfer. Several studies have attempted to solve these issues. However, challenges in achieving high-efficiency photocatalyst development have persisted due to inherent problems like low CO<sub>2</sub> adsorption and conversion efficiency in gas-phase reactions.

The research team at DGIST led by Professor In Soo-Il developed a high-efficiency photocatalyst by attaching silver nanoparticle co-catalysts to

P25 made of [titanium dioxide](#), and improving charge transfer performance with ruthenium doping. They also resolved the issue of a low CO<sub>2</sub> concentration on the catalyst surface during gas-phase reactions by forming hydroxy groups on the surface of the photocatalyst through hydrogen peroxide treatment.

The research team demonstrated that electrons accumulate in an intermediate state of the P25 band structure through ruthenium doping. These accumulated electrons are then transferred to the silver nanoparticle co-catalyst, converting CO<sub>2</sub> into methane.

The team also identified the optimal composition to efficiently produce methane from CO<sub>2</sub> by analyzing the silver nanoparticle co-catalyst and ruthenium doping. Furthermore, by measuring the amount of adsorbed CO<sub>2</sub>, they proved that the photocatalyst surface adsorbed more acidic CO<sub>2</sub> when it was alkalized with hydrogen peroxide.

Professor In Soo-Il from DGIST stated, "The newly developed [photocatalyst](#) improves visible light absorption, CO<sub>2</sub> adsorption, and electron transfer capabilities simultaneously. It converts 135 times more methane with 95% selectivity compared to the currently commercialized P25 photocatalysts and maintains over 96% stability even after 24 hours of continuous operation. We will conduct follow-up research to improve the stability and selectivity of hydrocarbons for the practical application of this technology."

The results of this research were published in *Carbon Energy*.

**More information:** Chaitanya B. Hiragond et al, Surface-modified Ag@Ru-P25 for photocatalytic CO<sub>2</sub> conversion with high selectivity over CH<sub>4</sub> formation at the solid–gas interface, *Carbon Energy* (2023). [DOI: 10.1002/cey2.386](https://doi.org/10.1002/cey2.386)

Provided by DGIST

Citation: Team develops eco-friendly high-efficiency photocatalysts that convert atmospheric carbon dioxide into fuel (2023, September 20) retrieved 27 April 2024 from <https://techxplore.com/news/2023-09-team-eco-friendly-high-efficiency-photocatalysts-atmospheric.html>

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