Catalysis chemistry, Petroleum chemistry, Carbon neutral

Development of advanced catalytic technology for utilization of carbon dioxide using light energy

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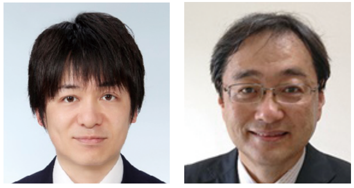


Abstract

Carbon dioxide (CO_2) is considered to be the main cause of global warming, and efforts have been devoted to reduce its emissions on a global scale. Carbon monoxide (CO), which is obtained by hydrogenation of CO_2, is a useful chemical raw material for liquid hydrocarbons such as alcohol, gasoline, jet fuel, etc. The reaction of CO_2 with hydrogen (H_2) to obtain CO (reverse water-gas shift reaction) conventionally requires a temperature higher than 500℃. We have discovered that CO can be obtained efficiently and selectively from CO_2 and H_2 at around 140℃ using a catalyst consisting of platinum (Pt) nanoparticles supported on a molybdenum and tungsten composite oxide. Furthermore, we found that the reaction rate significantly increased when the catalyst was irradiated with light.

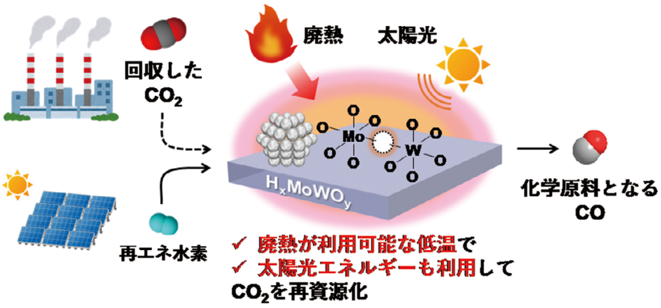
Background & Results

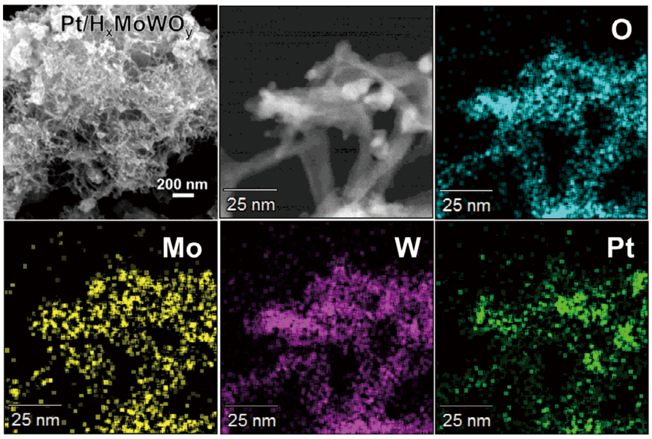
CO_2 is considered to be a major contributor to global warming, and efforts have been devoted to reduce its emissions on a global scale. Japanese government declared an intention to achieve zero emissions of greenhouse gases including CO_2 by 2050. To achieve this goal, development of technologies to recover CO_2 as a carbon resource and utilize it as a useful material (CO_2 capture and utilization technology) has been required. If CO_2 can be efficiently converted to CO, it will be possible to produce useful substances while reducing CO_2 emissions, thereby contributing to the problems of global warming and depletion of fossil resources. However, the reaction to produce CO by reacting CO_2 with H_2 (reverse water-gas shift reaction, equation: ($CO_2 + H_2 = CO + H_2O$) conventionally requires a high temperature of 500℃ or higher, and only a low reaction rate can be obtained at low temperatures due to equilibrium constraints.

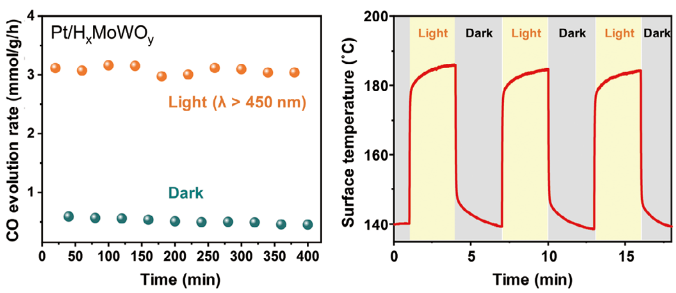
We have found that CO can be selectively and efficiently generated even at a lower temperature of 140°C, a much lower temperature than that reported earlier, when a molybdenum and tungsten composite oxide catalyst loaded with platinum (Pt) nanoparticles is used for the reverse water-gas shift reaction, because of the lattice oxygen defects formed in the composite oxide. Furthermore, the reaction rate is dramatically enhanced when the catalyst is irradiated with visible light. Molybdenum and tungsten composite oxides have excellent photothermal conversion properties, thereby the catalyst is locally heated under light irradiation, to promote the reverse water-gas shift reaction, resulting in a high CO production rate.

Significance of the research and Future perspective

The catalyst has abilities to operate even near the temperature of waste heat emitted from industry and to increase the reaction rate using inexhaustible solar energy. Since CO_2 can be converted into industrially useful substances using waste heat and solar energy, this technology is expected to be a clean CO_2 conversion technology for the realization of a carbon-neutral society.







Patent: Japanese Patent Application No. 2020-093711

Treatise:
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Keyword: CO_2 capture and utilization, CO_2 reutilization, molybdenum oxide, light energy utilization