Applications of Photocatalysis from Earth to Space

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Photocatalysts as photo-functional materials are able to convert photo energy to chemical one, thus the property gives wide range applications. In this presentation, new applications of photocatalysis in the field of earth and space are reported.

1) Development of switchable biodegradable plastics using photocatalysts. As marine pollution caused by microplastics intensifies, biodegradable plastics that can be decomposed by microorganisms are attracting attention. However, the biodegradability of plastics is in a trade-off relationship with durability, forcing an issue where biodegradable plastics are not suitable for long-term use. To overcome this, it is necessary to develop new biodegradable plastics that have a "switch function", whose plastics should remain stable and not degrade during use, but once they leak into the ocean or similar environments after use, this "switch" activates to promote their biodegradation. In this study, we focused on g-C_3N_4 (GCN) photocatalysts. GCN is a metal-free photocatalyst with high safety and exhibits antibacterial activity under visible light. Therefore, when GCN is applied to biodegradable plastics, it is expected to have a "switch function" that inhibits biodegradation under visible light due to the antibacterial activity of GCN, but promotes biodegradation in dark places such as sea and seafloor where the antibacterial activity does not occur because of dark environment. In this work, we have succeeded to develop new bio-plastics using GCN, showing anti-bacterial activity and less degradation ability for the bio-plastics, that is expected for switchable bio-plastics.

2) Synthesis and characterization of ZnO/CeO_2 photocatalyst for complete decomposition of methane under ambient condition. On the International Space Station, various organic compounds are generated from astronauts and equipment, with CH_4 being one of the most produced. Currently, it is being adsorbed and removed by activated carbon. However, for future long-term manned space exploration, a new material that can completely decompose CH_4 into harmless CO_2, without generating intermediate products and is reusable, is required. Photocatalysts, which can decompose organic chemicals by light irradiation under ambient conditions, are attracting attention from the perspective of safety and reusability. However, the current reported photocatalysts are not suitable for manned space exploration due to their low decomposition efficiency of CH_4. Therefore, a new photocatalyst that can decompose CH_4 with high efficiency is needed. Among many photocatalysts, ZnO has been reported to have an appropriate band structure for CH_4 decomposition and a characteristic that can activate the C-H bond of CH_4. Therefore, in this research, we focused on the porosification of ZnO and composition with CeO_2 as means to synthesize a ZnO-based photocatalyst that can efficiently decompose CH_4. And, we considered the use of oxalate-based co-precipitation as a way to achieve both. In this method, gases such as CO_2 are generated during calcination, thus it is expected to form fine pores that are believed to be useful for adsorbing CH_4. Furthermore, there are few examples of the composite of ZnO and CeO_2 by this method, and the detailed CH_4 decomposition activity are not clear. In this research, we have succeeded to synthesize a ZnO/CeO_2 photocatalyst using oxalate-based co-precipitation and clarify the CH_4 decomposition activity with high efficiency.

3) Air purification system using photocatalysis in the international space station. Currently, the Environmental Control and Life Support System (ECLSS) on the International Space Station operates devices that regenerate air and water, recycling and reusing resources. However, these devices are heavy and take up space, thus there is a demand for the development of lighter, more compact, and more efficient devices. We have succeeded to develop air purification system using photocatalysis and launched to the international space station.