News Release
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NEDO (New Energy and Industrial Technology Development Organization)
Microwave Chemical Co. Ltd.

Japan's First Large-Scale, General-Purpose Chemical Recycling Demonstration Facility Using Microwaves –Contributing to a Circular Economy Through Plastic Waste Recycling

Microwave Chemical Co. Ltd. is now engaged in the "development of a new microwave-based chemical recycling technology for plastics". The project is being carried out as part of the Practical Application Development Phase under NEDO's "Strategic Innovation Program for Energy Conservation Technologies". By using microwave technology, which is capable of transferring energy directly to plastics, the company aims to achieve energy savings of approximately 50% compared to conventional pyrolysis processes.

Microwave Chemical has recently completed Japan's first general-purpose microwave demonstration facility with a processing capacity of 1 ton per day. In 2021, the company developed a small-scale pilot facility with a processing capacity of about 5 kg per hour and now, through developing a novel high-temperature complex permittivity measurement system, has completed a large-scale, general-purpose demonstration facility.

This demonstration facility will be in full operation and pilot tests will be conducted on a variety of plastic materials including general-purpose resins, within fiscal 2022. In collaboration with companies such as chemical manufacturers, Microwave Chemical plans to further scale up its recycling capacity to 10,000 tons per year, with the goal of achieving social implementation by 2025. Through this project, the company aims to establish the PlaWave® microwave plastic depolymerization technology bringing energy savings of 39,000 kl (crude oil equivalent) to Japan by 2030 and making a positive contribution to realizing a circular economy.

Figure 1: The newly completed demonstration facility

1. Summary

A circular economy through resource recycling is required as a solution to solve the problem of plastic waste and to build a decarbonized society. Currently, chemical recycling technology is considered to be an effective means of realizing this goal, as this technology decomposes plastic waste back to basic chemical raw materials which then can be used to make new products. However, as existing technology requires external thermal processes which use fossil fuels and other energy sources, it poses certain issues with regards to energy consumption, carbon dioxide (CO_2) emissions, cost, and safety.

Microwave Chemical is developing a variety of processes using microwaves*[1], which directly and selectively heat the target substance and are considered to be highly energy efficient. The microwave process is a chemical process which involves heating substances, using the same principle as a microwave oven.

This is an important technology for realizing the "industrial electrification*[2]" essential to achieving carbon neutrality. In addition, microwaves are generated by renewable energy to decompose plastic waste, enabling virtually CO_2-free recycling. In that sense, microwave technology will not only help achieve carbon neutrality but also support a circular economy.

Since fiscal 2020, Microwave Chemical has been working on the “Development of a new microwave based chemical recycling technology” in the Practical Application Development Phase under NEDO’s (The New Energy and Industrial Technology Development Organization) “Strategic Innovation Program for Energy Conservation Technologies” *[3] (hereinafter referred to as the "Project”). By using microwave technology, which is capable of transferring energy directly to plastics, we aim to achieve approximately 50% energy savings compared to conventional pyrolysis processes, achieving 39,000 kl (crude oil equivalent) energy efficiency in Japan by 2030.
In September 2021, the company completed a small pilot facility (with a processing capacity of about 5 kg per hour) intended for developing a technology for the decomposition of general-purpose plastics using microwave processes*[4]. Through improving the scalability of the facility, we have now completed a general-purpose demonstration facility for chemical recycling with a processing capacity of 1 ton per day – the first of its kind in Japan. (Figure1)

2. What we achieved

(1) The development of a high-temperature complex permittivity system

In case of microwave ovens, the optimum microwave frequency to be absorbed by water molecules is selected for irradiation. Applying the same principle, for the plastic recycling process, it is necessary to select a frequency which is efficiently absorbed by plastic waste, as well as filler materials which are mixed with plastic waste. In order to increase the variety of target plastics and adoption to a wider range of applications, a precise measurement of the “complex dielectric constant,” which indicates the capability of the target material to absorb microwaves, becomes essential.
Based on the existing unique high-temperature complex dielectric constant measurement method, we developed a new system which uses a CO_2 laser which can be used for various types of plastics, so that we can increase the number of target materials. By using a CO_2 laser with a wavelength of 10.6 micrometers (μm, where μ is one-millionth of a meter) as a heat source, we have succeeded in precisely measuring complex permittivity of a few grams of plastic material required for measurement, while simultaneously heating up the sample to a maximum of about 1000°C (Figure 2). This system can be used to measure not only plastic samples, but also catalyst materials such as inorganic filler and liquid samples which are used during the heating process and thus demonstrates a strong capability for usage across a very wide range of applications.

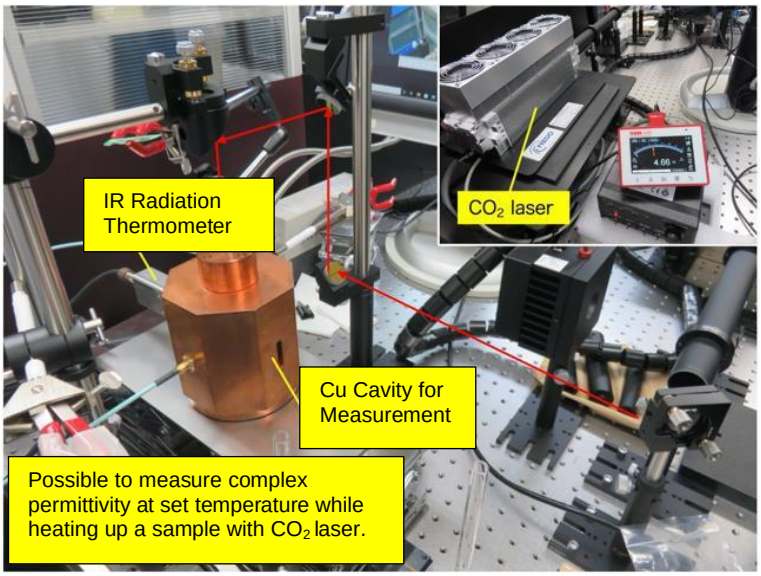

Figure 2. Outer appearance of the newly developed high-temperature complex permittivity measurement system

(2) Scaling up the pilot facility and carrying out a plastic decomposition demonstration

In this project, Microwave Chemical has scaled up the small pilot facility developed in 2021 and completed a large demonstration facility with a processing capacity of 1 ton per day. Furthermore, the company has begun pilot tests using this facility. The pilot test aims to recover waste plastics as raw materials (monomers), for which polypropylene and polystyrene have been set as model verification targets. In the pilot test of the decomposition of polystyrene, styrene monomer was recovered as the main component, and it was confirmed that the recovered styrene monomer could be purified and re-polymerized to be converted back into plastic (Figure 3).

Figure 3 Polystyrene chemically recycled using a small pilot unit
(left: decomposed oil / middle: recovered styrene monomer / right: recycled polystyrene)

3. Future Plans

Through this project, Microwave Chemical was able to refine the microwave-based plastic depolymerization technology "PlaWave®*[5]". Now, our ambition is to establish this technology as a global standard. With this technology, we present a path to carbon neutrality by 2050, and make a positive contribution towards the reduction of greenhouse gas emissions in the industrial sector*[6]. Specifically, the company plans to start the full-scale operation of this demonstration facility by the end of fiscal 2022 and will continue to conduct pilot tests, including Japan's first microwave-based polystyrene monomerization. After the completion of the project, we aim to proceed with further pilot tests with the goal of achieving social implementation by 2025.

Figure 4 PlaWave® logo