RECENT RESEARCH ACTIVITIES

Development of microwave irradiation applicators for sustainable chemistry

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Microwave heating has been expected as one of the energy-and-cost-saving processes for chemical reactions and other applications, owing to its features of rapid and selective heating. Numerous studies on microwave processing of biomass for bioenergy production have been reported [1], and woody biomass conversion by using microwave irradiation has been studied for producing bioenergy and value-added chemical products as an interdisciplinary study in RISH. Here we introduce microwave irradiation applicators for chemical reactions recently developed by our laboratory.

Figure 1 shows a wideband microwave applicator used within the 915 MHz and 2.45 GHz ISM (Industrial, Scientific and Medical) frequency bands [2]. The applicator structure incorporated a coaxial cable, and a liquid sample (volume: 360 ml) was placed in the space between the inner and outer conductors. A truncated cone-shaped polytetrafluoroethylene (PTFE) device was inserted for reducing microwave reflection over a wide frequency range. Microwave heating experiments using the applicator showed that it could heat liquid samples of water or NaOH solution at 915 MHz, 1.7 GHz and 2.45GHz, with estimated microwave absorption efficiencies varying between 28 and 66% depending on the frequency, sample type and heating duration.

Figure 2 shows a downsized microwave applicator (volume: 20 ml) for chemical reactions [3]. The key component of the applicator is a tapered section composed of PTFE and alumina. Insertion of the tapered section between the input port and the applicator vessel realizes reduction of reflected power from the applicator. From microwave heating experiments, the heating rate of the applicator was roughly estimated as 63 to 69 K for a 5-minute 2.45-GHz microwave irradiation at the input power of 100 W. These developed applicators will contribute to the next generation of green and sustainable chemistry.

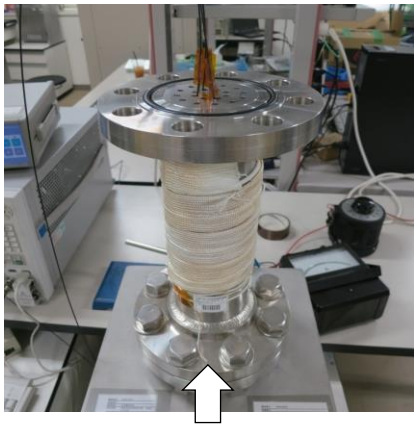

Figure 1. Wideband microwave applicator.

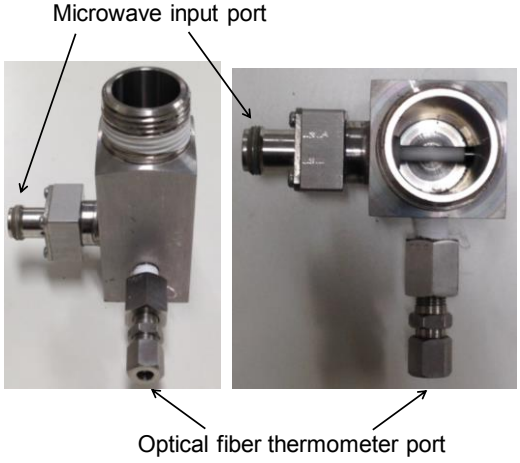

Figure 2. Downsized microwave applicator.

References

[1] T. Mitani, “Recent Progress on Microwave Processing of Biomass for Bioenergy Production”, *Journal of the Japan Petroleum Institute*, vol. 61, no. 2, pp. 113-120, 2018.

[2] T. Mitani, N. Hasegawa, R. Nakajima, N. Shinohara, Y. Nozaki, T. Chikata, T. Watanabe, “Development of a wideband microwave reactor with a coaxial cable structure”, *Chemical Engineering Journal*, vol. 299, pp. 201-216, 2016.

[3] T. Mitani, R. Nakajima, N. Shinohara, Y. Nozaki, T. Chikata, T. Watanabe, “Development of a Microwave Irradiation Probe for a Cylindrical Applicator”, *Processes*, vol. 7, no. 3, paper no. 143, 2019.