§4. Regeneration of Honeycomb Type Synthetic Zeolite by Means of Microwave Magnetic Field Heating

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Tritium is a radioactive hydrogen isotope that decays to 3He by emitting a beta particle with a maximum energy of 18.6 keV. Therefore, this radioactive material must be handled in a multi-confinement system. However, if tritium is accidentally released into the atmosphere, it must be rapidly removed. The most widely used atmospheric tritium removal technique is to oxidize the tritium using catalytic oxidation reactors and adsorb the tritiated water using adsorbents such as silica gel and zeolites. To reuse the adsorbent, it must be regenerated periodically to remove the water. In the conventional temperature swing regeneration method, the adsorbent is exposed to dry air heated to more than 500 K. The adsorbent is then cooled with a cold gas stream. These processes are lengthy and require large amounts of energy. However, water is a polar solvent that absorbs microwave energy efficiently, and therefore, microwave heating has been used for adsorbent regeneration. Some of the advantages of microwave heating over conventional heating are rapid internal heating, high energy efficiency, high temperatures, and selective heating depending on the absorption characteristics. In a previous report, we investigated microwave heating by the interaction of an electric field with type 5A honeycomb zeolite. It was found that the hydrated synthetic zeolite was easily heated to over 200 °C by dielectric heating. In this case, the microwave energy was consumed by desorption of water in the sample. The adsorbed water acted as a heating agent during the initial period of microwave heating. After the regeneration process was complete, the synthetic zeolite itself played a key role in the microwave heating.[1] In this report, we focused on the effect of microwave magnetic field heating in the single-mode cavity and carried out microwave irradiation to clarify the heating mechanism of synthetic zeolite containing water.

Figure 1 shows the water desorption process at the maximum magnetic field point in the single mode resonance cavity system at 2.46 GHz. The input power setting of the magnetron, Ib, which stands for the anode current, was gradually increased to 250 W. The input power estimated from Ib is approximate and should be used for reference only. The actual power absorbed by the sample was calculated based on the signal from a dual directional coupler. The maximum absorbed power was less than 15 W. The temperature of the sample was increased by raising the power setting. The "top" temperature, which indicates the temperature of the sample center, was approximately the same as that of the “up” portion on the side of the sample. The maximum temperature reached was 71 °C at the top of the sample. The load cell signal, which indicates the sample weight, decreased with increasing temperature. The difference in the load cell signal before and after microwave irradiation experiment was approximately 0.03 V. It corresponds to a weight loss of 0.5 g. The total weight of adsorbed water should be approximately 1 g. Therefore, the regeneration process was not complete via the magnetic field heating alone.

In this report, the sample was placed under the maximum magnetic field point in the single-mode microwave cavity. However, because synthetic zeolite is an insulator, it is difficult to absorb the microwave energy at the maximum magnetic field point and heat the sample via induction heating. Although the electric field is zero at the center of the sample, which is the maximum magnetic field point in the cavity, the electric field increases with increasing distance from the center of the sample. This is because the 2 cm diameter of the sample constitutes one-third of the half-wave length of approximately 6.1 cm of microwaves at 2.46 GHz. Therefore, the outer edge of the sample was slightly heated by dielectric heating and the temperatures of “up” and “top” were roughly equal. The maximum sample temperature was no more than 71 °C. As a result, the regeneration process of zeolite was not complete over a period of 6000 s because the temperature was lower than the required regeneration temperature. This suggests that the regeneration process by microwave irradiation was particularly beneficial in the dielectric heating process.

1). Tanaka, M., et al., Jpn. J. Appl. Phys., **52**, (2013) 11NJ11.

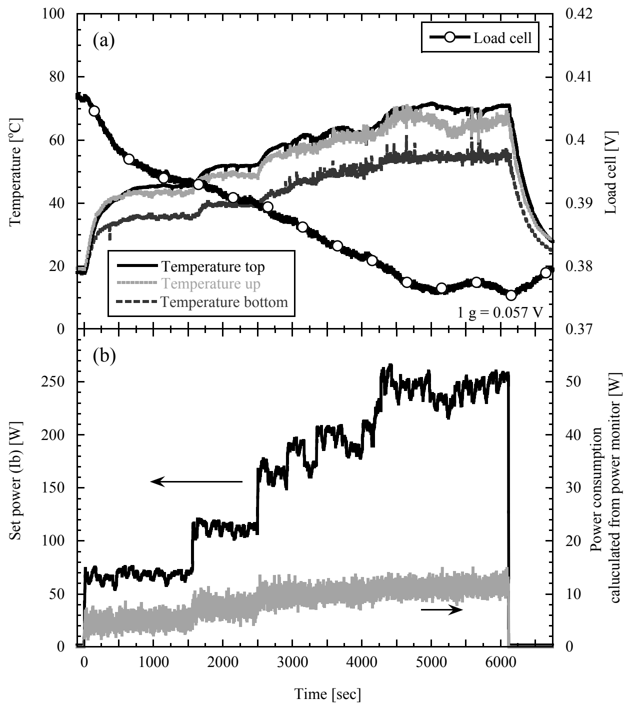

Fig. 1. Water desorption process in single-mode resonance cavity system with matching impedance at 2.46 GHz. (a) Temperature change and load cell signal, and (b) power consumption (calculated from dual directional coupler) and power setting of magnetron microwave generator.