論 文 の 要 旨

Application of Microwave Heating to Thermogravimetric Analysis and Synthesis of Functional Particulate Materials

(熱重量分析と機能性粉体材料合成へのマイクロ波加熱法の利用)

氏　名　Achmad Dwitama Karisma

Microwave heating technology has an increasing attention for miscellaneous purposes, especially in the material synthesis field, because of their advantages in rapidly heating rate, selectivity material in heating process, and improving the quality of product. The interaction between electromagnetic energy and the materials in the microwave heating process is related to the dielectric properties and the characteristics of the materials. It is expected that the dielectric properties of the materials are changed by the temperature condition during the microwave heating process. Therefore, the understanding in the mechanism of the microwave heating and its application in the material synthesis should be clarified. In this dissertation, the application of microwave heating to thermogravimetric analysis and the functional particulate materials synthesis was investigated. The potassium-type zeolite, NiCuZn ferrite, and Cu-Ce-Zr oxide nanoparticles were synthesized by microwave heating method.

Chapter 1 describes the background and the motivation of current research. Basic theoretical explanation of microwave heating technology and microwave dielectric properties were provided. Chapter 2 explains the mechanism of the microwave heating process throughout the development of the single-mode type microwave heating thermogravimetry (MWTG) apparatus. The temperature distribution, microwave absorption efficiency, and permittivity loss of copper oxide (CuO) pellet heated by microwave irradiation were investigated to clarify the validation of the developed single-mode type MWTG apparatus. The result shows that the numerically determined dependency of the CuO microwave absorption efficiency and permittivity loss at various temperature condition were found to be in good agreement with the published data.

In chapter 3 to chapter 5, the application of the microwave heating to the synthesis of functional particulate materials was investigated. Chapter 3 investigates the synthesis of potassium-type zeolite (K-zeolite) from the coal fly ash and biomass incineration fly ash by microwave heating hydrothermal treatment. It was found that the zeolite crystal formation rate obtained by microwave heating method was higher than that by the external heating method. Further, the ammonium adsorption capacity of the K-zeolite synthesized by both method was almost the same.

Chapter 4 explain the synthesis of NiCuZn ferrite nanoparticle by the microwave direct denitration reaction (MDD) method. $Ni_{0.5}Cu_{0.1}Zn_{0.4}Fe_2O_4$ could be synthesized from a mixture of metal nitrate hydrate solutions. The result shows that MDD method could provide the single phase of NiCuZn ferrite powder with an average particle diameter of about 30 nm at a reaction temperature of 900 °C. The particle diameter was less than one-fifth of that by the solid state reaction (SSR) method from the mixture of metal oxide powder at the same reaction temperature. The magnetic properties analysis result suggests that the MDD method could provide more attractive magnetic characteristics of NiCuZn ferrite nanoparticle to the product powder.

The MDD method was also applied to the synthesis of Cu-Ce-Zr oxide, which investigated in chapter 5. As a result, the CCZ catalyst could be obtained below 20% of Cu doping ratio. The MDD method could provide the larger specific surface area of CCZ catalyst product than those by the citric acid method, i.e. 68.0 m^2/g and 30 m^2/g, respectively. However, the CCZ nanoparticles synthesized by citric acid method had a little higher oxygen storage capacity (OSC) value than those by MDD method.