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Article / Book Information

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（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	Chemical Science and Engineering	系 コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of	（Engineering）
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要旨（和文 2000 字程度）
Thesis Summary（approx.2000 Japanese Characters ）

The objective of this research is to investigate effects of the microwave induced plasma on catalyst preparation. In this thesis, two types of reactors including a fixed bed and a spouted bed were used. The plasma jet generated by microwave discharge was directly irradiated to the particle bed in the former reactor, while the latter used the plasma jet for spouting particles. Three kinds of catalysts and catalyst support were chosen as model preparations: alumina (Chapter 2), Ni/alumina (Chapter 3), and Pd/alumina (Chapter 4). For comparison, typical heat treatment using an electric furnace was also applied. A novel process as an advantageous substitute for the typical thermal treatment of particles can be developed and optimized, leading to provide the insight into the plasma applied industry.

Chapter 1: Introduction, describes a background of the thesis, the principles of the plasma, plasma generation techniques by electric discharges, the application of non-thermal plasmas for catalyst preparation, the microwave induced plasma under atmospheric pressure, the spouted bed, and the objectives. The structure of the thesis is also introduced. The microwave induced plasma is presented as an advantageous substitute for typical thermal heating.

Chapter 2: Treatment of aluminum hydroxide with microwave induced plasma jet, describes the experimental study of the microwave induced plasma for particles treatment. Aluminum hydroxide was chosen as a model particle. Aluminum hydroxide has various decomposition pathway depending on several factors such as types of particle, heating rate and pressure etc. The performance of the microwave induced plasma combined with the spouted bed (PS) and the fixed bed (PF) were investigated for the treatment of aluminum hydroxide. For comparison, the conventional thermal treatment using the electric furnace (CM) was applied. As a result, the crystal structure analysis by XRD proved new discovery of the decomposition pathway of aluminum hydroxide when the plasma was used. Typically, θ-alumina is an essential intermediate in the transition pathway from γ-alumina to α-alumina (CM), however, a direct decomposition pathway of alumina (γ→α) without θ-alumina was observed in the plasma treated samples (PS, PF).

Chapter 3: Preparation of Ni/Al_2O_3 catalyst with microwave induced plasma jet, describes the experimental study of the microwave induced plasma applied for the catalyst preparation. As the most widely used catalyst, Ni-based catalyst was prepared from aluminum hydroxide and precursor by the microwave induced plasma treatment (PS and PF). For comparison, the catalyst also prepared using the electric furnace (CM). Catalyst characterizations were carried out by SEM, XRD, TEM, and H_2 chemisorption. From the analyzed results, the plasma treated catalyst was successfully reduced in a short treatment time. Ethylene hydrogenation was chosen as a model catalyst reaction for the catalyst evaluation. In the catalytic reaction, the plasma treated Ni/Al_2O_3 catalysts (PF-1 and PS) showed great performance in the conversion of ethylene hydrogenation than those of CM samples. For methane selectivity for PF-1 and PS, they resulted in different tendencies.

Chapter 4: Preparation of Pd/Al_2O_3 with microwave induced plasma jet, describes the experimental study for the microwave induced plasma applied for the Pd/Al_2O_3 catalyst preparation. At first, Pd metal was impregnated on the alumina support and treated by the plasma spouted bed. For the evaluation of the Pd/Al_2O_3 catalyst, the hydrogenation of acetylene was conducted. SEM, XRD, TEM, and H_2 chemisorption analyses were also carried out for the catalyst characterizations. The effects of the microwave power, the spouting condition, and the distance between the waveguide and the particle on the properties of the catalyst were experimentally investigated. The condition with the best performance among the PS samples was chosen for comparing with PF and CM for Pd/Al_2O_3 catalyst preparation. PS and PF showed the enhancement of catalytic activity in acetylene conversion as compared with CM. PS showed the best performance in ethylene selectivity, while a remarkably high hydrogenation of ethylene was observed in PF-1. Significant difference between the fixed bed and spouted bed was a temperature fluctuation on each particle. Considering these facts, it was suggested that PF could develop the formation of different crystal phases with an intensive effect of the plasma in the proximity, on the other hand PS could control those effects by modulating temperature fluctuations.

Chapter 5: Conclusion, summarizes the findings of this study and provides future prospects. It was clearly confirmed that the treatment of the microwave induced plasma had an effect on the decomposition pathway of the catalyst support and the enhancements of the catalyst properties as compared with those by the typical thermal treatment. The plasma methods can be an alternative to conventional processes as it resolves issues with the enhancement of the catalyst properties.