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著者(和文)	ParkYoon Sik
Author(English)	Yoon Sik Park
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（博士課程）
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論 文 要 旨

THESIS SUMMARY

専攻： Department of	Chemical Engineering 専攻	申請学位（専攻分野）： Academic Degree Requested	博士 (Engineering) Doctor of
学生氏名： Student's Name	朴 胤植 (Park Yoon Sik)	指導教員（主）： Academic Supervisor(main)	Hidetoshi Sekiguchi
		指導教員（副）： Academic Supervisor(sub)	

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

The objective of this research work is to investigate the specific features of the particles prepared by an electrical discharge under liquid nitrogen and to understand particle formation phenomena in liquid nitrogen discharge. Various plasma power sources and metal electrodes were used to develop the particle preparation system in liquid nitrogen discharge. For comparison with the liquid nitrogen medium, submerged discharge in deionized water was performed. As power sources, AC, DC, and pulsed power supply were applied to optimize the particle preparation. Four kinds of metal electrodes including aluminum (Al), copper (Cu), titanium (Ti), and zinc (Zn) were chosen in the process. The effect of process parameters such as applied current and applied voltage related to the electrical discharge behaviors on the particle formation was investigated. Based on the experimental results, the particle formation mechanism was proposed. The contents of the thesis are structured as follows:

Chapter 1: Introduction, describes and explains plasma technology, previous research about in-liquid plasma for particle preparation, and the motivation for employing liquid nitrogen as a medium. The research objectives and research approaches were also presented in this chapter.

Chapter 2: An experimental study on submerged electrical discharge in deionized water, describes the particle preparation using submerged discharge in deionized water. Nano-size of copper oxide particles were synthesized using a copper electrode without any electrolyte. The needle-like and clipped nail-like shapes of the copper oxides are synthesized at low-power mode and high-power mode, respectively. At the low-power mode, the obtained fine particles were considered to be generated on the electrode surface, which implies the electrochemical reaction occurred between the water and copper surface. In the high-power mode, in addition to the chemical process, the physical process in which the particles were generated by melting and evaporation of the copper electrode was considered to proceed simultaneously.

Chapter 3: Effect of power supplies on Cu particle preparation using liquid nitrogen discharge, describes the experiment of electrical discharges under liquid nitrogen for Cu particle preparation using AC, DC, and bipolar pulsed power supplies. The results indicated that micro-size spherical metallic copper particles were obtained, while nano-size copper particle seems to be oxidized. The produced particle had a spherical shape in common when

the discharge occurred in liquid nitrogen. The particle formation was considered to be caused by local melting and partial vaporization of the electrode. The micro-size spherical coarse particles might be directly detached from the molten surface of the electrode. The nano-size spherical fine particles could be generated by partial vaporization from the electrode. DC power supply showed excellent performance on particle production as compared with AC and bipolar pulse power supply.

Chapter 4: Variation in metal electrodes for particle preparation using liquid nitrogen discharge, studies the feasibility of the particle preparation process with different types of metal electrodes using liquid nitrogen discharge. Electrodes made of Al, Ti, and Zn were chosen for the study. The characteristics of prepared particles were investigated by changing applied current as an experimental parameter. According to the XRD patterns, nitride phases were confirmed in all the experimental conditions using Al, Ti, and Zn electrodes. Moreover, applied current influenced the crystallinity of the synthesized particles. According to the experimental results of different metal electrode configurations, it was confirmed that the anode generated most of the particles in this process. The XRD results showed that the metal alloy was not formed. It was shown that the Ti electrode produced TiN particles, while the Cu electrode produced Cu particles. Based on this result, it was concluded that each of the electrodes performed an independent role without interfering with another electrode in the particle generation step.

Chapter 5: Mechanism of Particle formation, discussed on the particle formation mechanism using liquid nitrogen discharge. The synthesis of nitride fine particles was explained by calculating Gibbs' standard free energy. The thermodynamic calculations indicated that the nitridation of Al and Ti electrodes took place spontaneously. The roles of the cathode and anode were discussed based on the experimental observations described in the previous chapters. At first, the interaction between the cathode and arc discharge was discussed from the viewpoints of the physical properties of the electrode materials and the stability of continuous arc discharge. The Ti electrode showed the best stable properties for sustaining arc discharge. Based on the SEM observations of the anodes and synthesized particles, the particles deposited on the anode surface and the morphology of the produced particle correspond to each other, suggesting that the particle formation was mainly caused on the anode. During the discharge, the dissociated atomic nitrogen reacted with the metal vapor, resulting in the synthesis of the nitrides similarly to CuO particle formation using deionized water discharge.

Chapter 6: Conclusion, summarizes the findings obtained from this study and provides recommendations for future prospects. The proposed particle preparation process using electrical discharge in liquid nitrogen shows potential for a simple preparation process of nitride fine particles.