論文 / 著書情報
Article / Book Information

題目(和文)	超臨界乾燥によるリチウム空気電池の炭素電極作製
Title(English)	Supercritical drying process for fabricating carbon electrodes for Li-air battery
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出典(和文)	学位:博士(工学), 学位授与機関:東京工業大学, 報告番号:甲第12426号, 授与年月日:2023年3月26日, 学位の種別:課程博士, 審査員:下山 裕介,関口 秀俊,久保内 昌敏,多湖 輝興,松本 秀行
Citation(English)	Degree:Doctor (Engineering), Conferring organization: Tokyo Institute of Technology, Report number:甲第12426号, Conferred date:2023/3/26, Degree Type:Course doctor, Examiner:,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	応用化学 系 / 応用化学 コース	申請学位（専攻分野）： Academic Degree Requested	博士 （ 工学 ） Doctor of Engineering
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Supercritical drying is known for fabricating highly porous materials. However, the mechanism of this method is still unknown. Therefore, our research mainly focused on the fundamental experiment and the factors possibly affecting the method by investigating organic solvent expansion and homogenous phase formation in supercritical CO_2 using view cell equipment.

Furthermore, recent studies show that Li-air batteries have great potential to substitute gasoline due to their theoretical high energy density. Researchers are currently studying further improving this battery, such as investigating electrolytes, anodes, and cathodes. However, one of the current problems of this battery is the discharge products that accumulate inside the cathode, which can block air from entering the battery system and reduce its performance. Therefore, a highly porous cathode is desired to afford more ideal space for them. In our research group, supercritical drying was proven to produce highly porous electrodes that can improve the specific capacity of Li-air batteries. In this research, supercritical drying was applied to fabricate carbon electrodes for Lithium-air batteries to prove the fact obtained from the fundamental experiment. Moreover, carbon nanofiber was applied to the battery and compared to carbon black, which was initially used to improve the battery cycle.

For the fundamental experiment, 1-Methyl-2-pyrrolidone (NMP), 1-butanol, ethanol, and acetone were investigated under different drying parameters. Each solvent shows various expansion rates and time to form a homogenous phase. NMP forms the slowest, homogenous phase with the lowest expansion rate. Acetone significantly expands and forms a homogenous phase faster than other solvents. Under different temperatures (40, 60, and 80 ^{o}C), acetone and ethanol expansion rates differ for each temperature. Acetone and ethanol expand more at a low temperature (40 ^{o}C) and expand less at a high temperature (80 ^{o}C), while the NMP expansion rate does not show significant change.

The electrodes were fabricated with carbon as conductive materials, PVDF or cellulose acetate as binders and NMP or acetone as organic solvents. Carbon nanofiber electrodes fabricated by supercritical drying show high porosity, more than 90%, with a thicker cross-section compared to an electrode made by a conventional method, evaporation drying. The absence of surface tension and capillary stress can maintain the pores inside the electrode by fabricating the electrode by supercritical drying the opposite; evaporation drying with the presence of surface tension and capillary stress can reduce the electrode porosity. Moreover, carbon nanofiber electrodes show approximately 2.7 times more specific capacity than carbon black electrodes and can withstand ten cycles when carbon black cannot.

The result of fabricating electrodes is aligned with the fundamental experiment where the electrode with acetone as solvent shows excellent porosity. At the same time, the performance of the batteries was similar. This result means that using acetone as a solvent and cellulose acetate as a binder can be an alternative for the CNF/PVDF/NMP electrode. Furthermore, using acetone as solvent also gives another advantage such as faster electrode production where NMP needs 6 hours to dry and acetone only needs 1.5 hours to dry. In addition, fabricating electrodes with acetone as a solvent at lower pressure just above the CO_2 critical point (7.5 MPa) gives a comparable result with electrodes fabricated at high pressure (20 MPa). This phenomenon shows more advantages in using acetone as a solvent to reduce energy consumption to increase pressure.