学 位 論 文 概 要

題 目　Development of bis(triethoxysilyl)ethane (BTESE)-derived organosilica membranes: thermal and oxidation stability, gas permeation properties, and application to membrane reactor
(有機無機オルガノ BTESE 膜の作製：耐熱性，耐酸性，ガス透過特性，および膜反応への応用)

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The overall objective of this research in doctor course is to study the preparation of bis(triethoxysilyl)ethane (BTESE)-derived membranes, and to evaluate the thermal, oxidation, and chemical stability. The brief descriptions of each chapter in this dissertation are shown below.

Chapter 1 is "**General introduction**" which summarizes the research background of separation processes and membrane processes, and gas permeation model of organosilica membrane. Also, the purpose of this study is presented in detail.

Chapter 2 is "**Network engineering of a BTESE membrane for improved gas performance via a novel pH-swing method**". Organosilica BTESE membranes were prepared in acid and pH-swing method. Gas permeation results showed that gases permeated the pH-swing membrane was twice the rate of the acid membrane. Additionally, pH-swing membrane also maintained similar permeance ratios, which was confirmed that pH-swing processing is an innovative method for improvement in the gas permeance of BTESE membranes.

Chapter 3 is "**Improved thermal and oxidation stability of bis(triethoxysilyl)ethane (BTESE)-derived membranes, and their gas-permeation properties**". It is the first time to fabricate BTESE membranes by coating of BTESE-derived sols and fired at much higher temperatures (550−700°C), which promises to enable future applications like gas separation under an oxidizing atmosphere at high temperatures. Gas permeance results showed that the higher calcination temperatures remained higher selectivity even after air treatment at 550°C, which indicated that the thermal and oxidation stability were further improved.

Chapter 4 is "**Chemical stability of SiO_2–based separation membrane and application to O_2/SO_3 separation**". SO_3 decomposition using a catalytic membrane reactor is a promising technology to improve the economic viability of thermochemical water-splitting Iodine-Sulfur (IS) process for hydrogen production. In my study, microporous membranes were proposed for SO_3/O_2 separation, that is, the membrane support was calcined by using α-Al_2O_3, the intermediate layer was prepared from silica-zirconia, and the top layer was prepared from BTESE. This microporous BTESE-derived membrane achieved an O_2/SO_3 selectivity of 10-12 (Knudsen selectivity: 1.6) while maintaining high O_2 permeance of 2.5×10^{-8} mol/(m^2 s Pa).

Chapter 5 is "**Conclusions and recommendations**". Main conclusions are summarized in this the chapter and recommendations are provided for further study.