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Boffa, Vittorio; Yue, Yuanzheng

Publication date:
2011

Document Version
Accepted author manuscript, peer reviewed version

[Link to publication from Aalborg University](#)

Citation for published version (APA):

Boffa, V., & Yue, Y. (2011). *Structure and thermal stability of ultramicroporous silica and niobia-silica membranes*. Abstract from The 9th International Meeting of Pacific Rim Ceramic Societies, Cairns, Australia.

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Structure and thermal stability of ultramicroporous silica and niobia-silica membranes

Vittorio Boffa and Yuanzheng Yue

Section of Chemistry, Aalborg University, DK-9000 Aalborg, Denmark.

e-mail: vb@bio.aau.dk

Ultramicroporous niobia-silica membranes are hydrothermally stable and highly permeable to H₂. At the same time they show high CO₂ retention. Thus, they offer great potential as separation units in hydrogen purification and CO₂ capture technologies. Despite that, it is not well understood yet how transition metal ions affect the structure of ultramicroporous silica networks. In the present work we investigate structure and stability of microporous silica and Nb₂O₅-silica membranes. The influence of thermal and hydrothermal exposures on porosity, silanol concentration, and phase transitions of pure silica and niobia-silica membranes is studied by means of gas sorption measurements, simultaneous thermal analyzer, and X-ray diffraction technique. The short and medium-range order structure of the membranes is probed by using the ²⁹Si nuclear magnetic resonance spectroscopy. We show the consequences of the high temperature treatment (up to 1270 °C) to both the microporous structure and the non-crystalline structure of the membrane materials. The results provide information on how Nb(V) ions stabilize microporous silica network.