Molecular vibrational energy difference induced high selective separation of $^{18}O_2$ from $^{16}O_2$ using nanoporous carbons

Sanjeev Kumar Ujjain[1]*, Ryusuke Futamura[1], Fernando Vallejos-Burgos[1], Masahiko Matsukata[2], Motomu Sakai[3], Yury Gogotsi[1,4], J. Karl Johnson[5], Akio Kodama[6] and Katsumi Kaneko[1]

[1] *Center for Energy and Environmental Science, Shinshu University, Nagano City, JAPAN*

[2] *School of Advanced Science and Engineering, Waseda University, Tokyo, JAPAN*

[3] *Research Organization for Nano and Life Innovation, Waseda University, Tokyo, JAPAN*

[4] *Department of Material Science and Engineering, and A.J. Drexel Nanomaterials Institute, Drexel University, Pennsylvania, USA*

[5] *Department of Chemical & Petroleum Engineering, University of Pittsburgh, Pennsylvania, USA*

[6] *Institute of Science and Engineering, Kanazawa University, Kanazawa, JAPAN*

*Presenting author's e-mail: skujjain@shinshu-u.ac.jp

^{18}O, a stable isotope with natural abundance of 0.204 atomic % can exit with other stable isotopes of oxygen ^{17}O (0.037 %) and ^{16}O (99.759 %) as $^{18}O^{18}O$, $^{18}O^{17}O$, $^{18}O^{16}O$ etc. Recently, ^{18}O has been extensively utilized for medical imaging techniques such as Positron Emission Tomography (PET) and several other applications involving reaction elucidating mechanisms in chemistry, environmental programs and basic sciences. Consequently, obtaining a supply of pure ^{18}O is crucial in achieving improvements in health care and sustainable society. However, with its scant abundance, it is a major challenge to efficiently separate oxygen isotope molecules from the starting material, which is principally composed of $^{16}O^{16}O$ ($^{16}O_2$). A novel, cost-effective separation method is desired for efficient separation of oxygen isotopes. Currently used cryogenic distillation-based separation methods are plagued by very low separation factors < 1.05 and high energy consumption, leading to very high cost.

In this report, we present a highly selective adsorption-based separation of $^{18}O^{18}O$ ($^{18}O_2$) having a separation factor of > 60 at a low temperature (112 K) utilizing cryogenic liquefied natural gas technology. The selective separation demonstrates high dependence on the nanoporous adsorbents pore geometry, temperature and dosing pressure. This remarkable adsorption selectivity is ascribed to the difference of molecular vibrational energy level of $^{18}O_2$ and $^{16}O_2$ by ~ 0.57 kJ mol^{-1}, which provides the observed marked difference in adsorption. The selective separation results can act as proof-of-concept for industrial scale separation of oxygen isotopes.