Electronic Supporting Information

for

Thermal Stability and Swelling Behaviors of Nanoscale Ionic Materials (NIMs) with Tuned Structure

Kun-Yi Andrew Lin\textsuperscript{a,b}, Youngjune Park\textsuperscript{a,c}, Camille Petit\textsuperscript{a,d}, and Ah-Hyung Alissa Park\textsuperscript{a,*}

\textsuperscript{a}Departments of Earth and Environmental Engineering \& Chemical Engineering, and Lenfest Center for Sustainable Energy, Columbia University, New York, NY 10027, USA

\textsuperscript{b}Department of Environmental Engineering, National Chung Hsing University, 402 Taiwan R.O.C.

\textsuperscript{c}SK Innovation, 325, Exporo, Yuseong-gu, Daejeon 305-712, Republic of Korea.

\textsuperscript{d}Department of Chemical Engineering, Imperial College London, SW7 2AZ, UK

*Corresponding author: Phone: +1-212-854-8989; Fax: +1-212-854-7081; E-mail: ap2622@columbia.edu
Figure S1. Schematic of the in-situ measurements of CO$_2$ capture capacity as well as thermally- and CO$_2$-induced swelling of NIMs. (1) FT-IR spectrometer (Nicolet 6700, Thermo Fisher Scientific Inc.); (2) ATR optics and high pressure fluid cell (Golden Gate$^{\text{TM}}$, Speca Ltd., UK); (3) Gas inlet; (4) Digital pressure gauge; (5) Gas cylinder; (6) Data acquisition system; (7) Temperature controller; (8) Vent; (9) Diamond crystal; (10) Mirrors; (11) Infrared light source.

Figure S2. Thermal stability of Ionized PEGs with various molecular weights and the corresponding PEGs determined using a TGA, in oxygen environment with a ramping rate 5 ºC/min.

Figure S3. Thermal stability of NIMs with various chain lengths and the corresponding PEGs determined using a TGA, in oxygen environment with a ramping rate 5 ºC/min.

Figure S4. Thermal stability of NIMs with various chain lengths and the corresponding Ionized PEGs determined using a TGA, in oxygen environment with a ramping rate 5 ºC/min.

Figure S5. Thermal stabilities of NIMs with the same core fraction but different chain lengths determined using a TGA, in oxygen environment with a ramping rate 5 ºC/min.

Figure S6. CO$_2$ capture capacity in NIMs with various chain lengths at 60 ºC and P$_{CO_2}$ = 4 – 55 atm.

Figure S7. Raman spectra in the $\nu_6$(CH$_2$) and $\nu_5$(CH$_2$) regions for PEGs and NIM-I-PEGs.
**Figure S1.** Schematic of the in-situ measurements of CO$_2$ capture capacity as well as thermally- and CO$_2$-induced swelling of NIMs. (1) FT-IR spectrometer (Nicolet 6700, Thermo Fisher Scientific Inc.); (2) ATR optics and high pressure fluid cell (Golden Gate$^\text{TM}$, Speca Ltd., UK); (3) Gas inlet; (4) Digital pressure gauge; (5) Gas cylinder; (6) Data acquisition system; (7) Temperature controller; (8) Vent; (9) Diamond crystal; (10) Mirrors; (11) Infrared light source.
Figure S2. Thermal stability of Ionized PEGs with various molecular weights and the corresponding PEGs determined using a TGA, in oxygen environment with a ramping rate 5 °C/min.
Figure S3. Thermal stability of NIMs with various chain lengths and the corresponding PEGs determined using a TGA, in oxygen environment with a ramping rate 5 °C/min.
Figure S4. Thermal stability of NIMs with various chain lengths and the corresponding Ionized PEGs determined using a TGA, in oxygen environment with a ramping rate 5 °C/min.
Figure S5. Thermal stabilities of NIMs with the same core fraction but different chain lengths determined using a TGA, in oxygen environment with a ramping rate 5 °C/min.
Figure S6. CO₂ capture capacity in NIMs with various chain lengths at 60 °C and PCO₂ = 4 – 55 atm.
Figure S7. Raman spectra in the $\nu_a$(CH$_2$) and $\nu_s$(CH$_2$) regions for PEGs and NIM-I-PEGs.