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ELECTRONIC SUPPLEMENTAL INFORMATION

High performance acid base junction flow battery using an asymmetric bipolar membrane with ion-channel aligned anion exchange layer

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1. Supporting figures



Fig. S. 1. Schematic diagram of the fabrication process of the aligned QPPO under the AC electric field.



Fig. S. 2. Preparation of the sample membrane under the electric field.



Fig. S. 3. Schematic diagram for polarization curve of the BPM in 0.5 N H_2SO_4 : (a) reversed bias up to 200 mA cm⁻², (b) forward bias up to -200 mA cm⁻² after the reversed bias.



Fig. S. 4. Potential of the fabricated membranes in 0.5 N H_2SO_4 and NaOH.

2. Supporting Experimental section and result

2.1. Chemical structure analysis of the synthesized SPPO and QPPO membrane in Fourier transform infrared (FT-IR) spectroscopy.

The SPPO and QPPO membrane were observed by introducing MiracleTM accessory (PIKE TECH. Inc., USA) in an FT-IR Spectrometer (FT/IR 460 Plus, Jasco, Japan). The wavenumber was assigned from 600 to 1800 cm⁻¹ in transmittance mode under a scan resolution of 8 cm⁻¹.



Fig. S. 5. FT-IR spectrum of the SPPO and QPPO membrane in transmittance mode.

The wavenumber was assigned from 600 to 1800 cm⁻¹ in transmittance mode under a scan resolution of 8 cm⁻¹.

As shown Fig. S. 5, the SPPO and QPPO membrane commonly show the peak of C-O-C (1190 cm⁻¹), CH₂ (1410 cm⁻¹) and C=C (1600 cm⁻¹) stretching because of the backbone. The specifically stretching vibrations of C-S and $-SO_3$ groups appear at 672, 1060 cm⁻¹ in the SPPO membrane, respectively.¹ In the QPPO membrane, distinct peaks at 930 and 720 cm⁻¹ occurred because of the C-N and C-Cl stretching, respectively.²

2.1. Observation of the delamination of the fabricated BPM according to the applied electric field under the wet state.

In order to observe the delamination, four types of the fabricated BPM were prepared according to the applied electric field in the AEL (0 Vm⁻¹, 31.3 Vm⁻¹, 62.6 Vm⁻¹ with 25 Hz and 62.6 Vm⁻¹ with 50 Hz). Thereafter, the ballooning phenomenon and delamination of the BPMs were observed with the photograph.



Fig. S. 6. Photograph of the BPMs soaked in water for a week: (a) Pristine, (b) 31.3 Vcm⁻¹, (c) 62.3 Vcm⁻¹, 25Hz and (d) 62.6 V cm⁻¹, 50 Hz.

As shown Fig. S. 6, the separation and ballooning phenomenon of the fabricated BPMs were not observed regardless of the applied electric field.

3. Reference

1. C. Gong, R. Guan, Y.-C. Shu, F.-S. Chuang and W.-C. Tsen, Polymers for Advanced Technologies, 2007, 18, 44-49.

2. K. H. Gopi, S. G. Peera, S. D. Bhat, P. Sridhar and S. Pitchumani, International Journal of Hydrogen Energy, 2014, 39, 2659-2668.