Supporting Information

Side-chain conducting and phase-separated polymeric binders for high-performance silicon anodes in lithium-ion batteries

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Figure S1. Lithiation-delithiation profiles of pure PPy and PPyE polymers on copper foil (vs. a lithium counter electrode) at constant current condition (0.02 mA/cm^2) between 0.01V and 1V. The delithiation capacities of pure PPy and PPyE polymers are 0.40 and 1.8 mAh/g, respectively. The polymer binders do not affect the overall capacities of Si/PPy and Si/PPyE cells.

Figure S2. CVs of (a) (a1) Si/PPy electrode and pure PPy polymer and (b) (b1) Si/PPyE electrode and pure PPyE polymer on copper foil (vs. a lithium counter electrode) at 0.2 mV/s between 0.01V and 1V. These results show that PPy and PPyE polymers are electrochemically stable in the range between a 0.01 V and 1 V cycling voltage. Also it confirms that the existence of the EO units in the PPyE does not affect the electrochemical stability of the PPy polymer.

Figure S3. Coulombic efficiency of Si/PPy and Si/PPyE electrodes at a C/10 rate.

Figure S4. Cycling performance of PPy/Si electrodes fabricated by PPy polymers with different molecular weights. (Red) $M_n = 25,000$ (PDI=3.35), (black) $M_n = 13,000$ (PDI=3.21). The electrodes consist of 5.0 % of PPy and 95 % of silicon nanoparticles. The cycling rate was C/10. Cycling data was plotted by (a) gravimetric and (b) areal capacities. Mass loading of silicon was 0.36 mg/cm^2 (red) and 0.40 mg/cm^2 (black).

Figure S5. Cycling performance of PPy/Si electrodes with different compositions, (a) shows the specific capacity and (b) shows the areal capacity.

Figure S6. The appearance of the PPy/Si electrode (a) before and (b) after long term cycling.

Figure S7. The high-loading Si electrodes based on Si/PPy, (a) areal capacity and (b) specific capacity. The cycling rate is 0.226 mA/cm² between 0.01V and 1V. The loading of the cell is 1.34 mg Si/cm². The first-cycle efficiency is 61.48%, the efficiency at 40th cycle is 98.76%.

Figure S8. Cycling performance of the Si electrode based on PPy with 50% triethylene glycol methyl ether methacrylate incorporated. The rate is C/10 (420 mA/g), with a Si loading of 0.34 mg Si/cm². The electrode laminate is composed of 33% binder and 67% Si, with a first-cycle coulombic efficiency of 68.08%, and an efficiency of 99.65% at 300th cycle.

Figure S9. Cycling performance of the graphite electrode based on PPy. The rate is C/25 (12.4 mA/g) for two cycles and then C/10 (31 mA/g). The loading is 4.2 mg graphite/cm². The first-cycle coulombic efficiency is 87.12%, the efficiency at 300th cycle is 99.89%.

Figure S10. Cell Impedance of the Si half cells based on PPy and PPyE binders.