Electronic Supplementary Material (ESI) for RSC Advances.

Supplemental Information

Oxidized Starch as a Superior Binder for Silicon Anodes in Lithium-ion Batteries

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Experimental

Preparation of electrodes

Silicon nanoparticles (50-200 nm, Alfa-Aesar), Super P (40nm, Timical) and binders were mixed in a 6:2:2 weight ratio in water. After stirred for 5 h, the slurry was coated on a Cu foil current then further dried at 70 °C in vacuum for 8 h. The foil was cut to Φ12 mm sheets to assemble cells. CMC was purchased from Aladdin and SA from Aldrich. OS was purchased from Dongguan Dongmei Starch Co. Ltd. For OS, polymer was firstly dissolved in water at 75 °C for 5 min before adding silicon nanoparticles and Super P.

Cells assembling and electrochemical tests

The electrochemical performances of the as-prepared anodes were tested via CR2016 coin cells with ENTEK ET20-26 as separator, and pure lithium foil as counter electrode. The cells were assembled in an argon-filled glove box (MB-10 compact, MBraun) using 1M $LiPF_6$/EC+DMC (1:1 by volume, ethylene carbonate (EC), dimethyl carbonate (DMC)) as electrolyte, including 10% Fluoroethylene carbonate (FEC). The cycling performances were evaluated on a LAND battery test system (Wuhan Kingnuo Electronics Co., Ltd., China) at 25 °C constant current densities with the cut-off voltage of 0.1/1.2 V vs Li/Li^+. The specific capacity was calculated on the basis of the weight of silicon nanoparticles in electrodes.

Morphology and structure characterization

The SEM images of the electrodes were observed by a FEI Nova SEM 230 ultra-high resolution FESEM. The Fourier transform infrared (FTIR) spectrum of the sample was recorded on a FTIR spectrometer (Bruker VECTOR22). To evaluate the binder strength of electrode film, an electrode sample in 20 mm width and 100 mm length was attached to 3M

tape (12mm wide), and the peeling strength of the electrode specimens was measured with a high-precision micromechanical test system (FMT-310A5, Alluris).

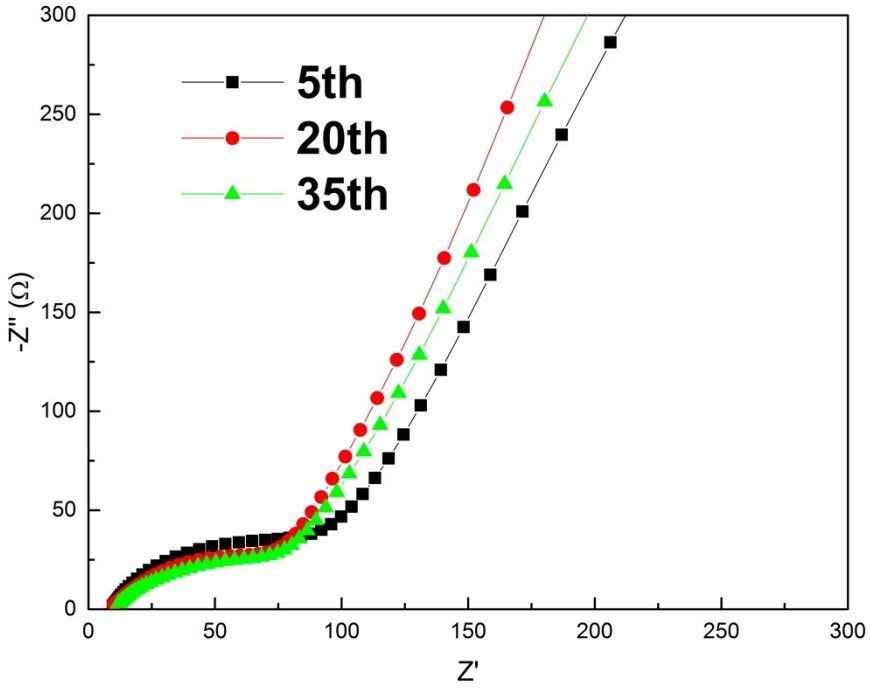

Figure S1 Nyquist plots of OS electrode after 5, 20 and 35 cycles with 0.5 A g^{-1} lithiation and 2.0 A g^{-1} delithiation.

Table S1 Comparison of the electrochemical performances for Si electrodes with different binders. (Si is short for commercial silicon nanoparticles)

Type of binder	Electrode composition	Active materials loading	Electrode performance	Areal capacity	Ref.
OS	60Si:20Super P:20binder	0.8mg cm^{-2}	1904 mA h g^{-1}@ 0.5 A g^{-1} lithiation+2 A g^{-1} delithiation,120th	1.52 mA h cm^{-2}	Our work
Ca^{2+}+ SA	53Si-C:18carbon black:29binder	Unknown	1822 mA h g^{-1}@ 0.42A g^{-1}, 120th	unknown	[1]
Self-healing binder	50SiMP:6.5carbon black:43.5binder	0.5-0.7 mg cm^{-2}	~2000 mA h g^{-1}@ 0.4 A g^{-1}, 100th	1.0-1.4 mA h cm^{-2}	[2]
NaPAA-g-CMC	60Si:20Super P:20binder	0.45 mg cm^{-2}	1816 mA h g^{-1},100th	0.817 mA h cm^{-2}	[3]
Gum arabic	50Si:25Super C65:25binder	0.3 mg cm^{-2}	~2500 mA h g^{-1}@ 0.4 A g^{-1}, 100th	0.75 mA h cm^{-2}	[4]
Pectin	60Si:20Super P:20binder	1 mg cm^{-2}	~1500 mA g^{-1}@ 3 A g^{-1}, 100th	1.5 mA h cm^{-2}	[5]

Guar gum	52Si:18conductive additive:29binder	1.1 mg cm^{-2}	~2000 mA g^{-1}@ 0.84 A g^{-1}, 30th	2.2 mA h cm^{-2}, 30th	[6]
PAA/pullulan	60Si:20carbon black:20binder	0.6 mg cm^{-2}	~1600 mA g^{-1}@ 0.2C lithiation+0.5C delithiation, 100th	0.96 mA h cm^{-2}	[7]
Xanthan Gum	60Si:20Super P:20binder	0.9 mg cm^{-2}	~1600 mA g-1@ 3.5A g^{-1}, 12th	1.44 mA h cm^{-2}, 12th	[8]
hyperbranched β-cyclodextrin polymer	60Si:20Super P:20binder	0.8 mg cm^{-2}	~1500 mA g^{-1}@1.5 A g^{-1}, 120th	1.2 mA h cm^{-2}	[9]

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