Electronic Supporting Information (ESI) for

Modified alginate dressing with high thermal stability as a new separator for Li-ion batteries

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Experimental section

Modification of alginate dressing

Alginate dressing pretreatment: Alginate Dressing (Biatain Alginate 3710, alginate/CMC ratio ~85/15) is a highly absorbent, fiber-free, non-adherent alginate dressing that forms a soft and protecting gel - ideal for highly exudating wounds [1] (Chemical structure see Figure S1). Alginate dressing soaked in anhydrous ethanol for 24 h, and then dried it in a vacuum oven at 50 ºC for 6 h. The thickness of dry alginate dressing is ~450 μm and it decreased to ~400 μm after pretreatment with anhydrous ethanol.

Alginate dressing modification: First preparing the mixed ethanol solution of polyacrylic acid (Aladdin, MW 3000) and lithium monohydroxide (Aladdin, 98%), where the solution is saturated for LiOH at room temperature and weight ratio of PAA and LiOH is about 1.72:1. Then soaking the above-dried alginate dressing in the mixed solution for 6 h. Finally using filter paper to clean the mixed solution on the alginate dressing and dried it in a vacuum oven at 50 ºC for 6 h.

For comparison, a 3-layer separator was selected as control sample (Celgard 2325 with a thickness of 25μm).

Tests for elemental analysis, thermal shrinkage, and adsorption/retention property

The elemental content analysis to alginate dressing were carried out by inductively coupled plasma optical emission spectroscopy (ICP-OES, Agilent 730). Fibers of alginate dressing were firstly digested in concentrated sulfuric acid and nitric acid, and then the mixed solution was diluted with distilled water into a transparent solution. The target elements include Ca, Na and Ag.

Tests for thermal shrinkage were referred to the method in UL 2591-2009 Outline of Investigation for Battery Separators. Typically, alginate dressing was nipped by two smooth pieces of glass and then add a 50 psi pressure on it (~0.344MPa simulate the pressure that a separator was experienced within a battery). Then put it an environment of 90 ºC for one hour or 120 ºC for one hour.

The modified alginate dressing and polyolefin separator were soaked in the electrolyte of 1mol/L LiPF6 in DEC-EC-DMC (volume ratio 1:1:1) for adsorption and retention tests. After 10 minutes, excess electrolyte on the membrane surface was scraped by a coating scraper, then was weighed after naturally drying for 0, 30, 60, and 90 min in a sealed box. Adsorption ratio (AR) and retention ratio (RR) were calculated using the following formula:

$$AR\% = [(W_a - W_0)/W_0]*100\%$$

$$RR\% = [(W_r - W_0)/W_0]*100\%$$

Where W_a is separator weight after fully adsorbing electrolyte, W_0 is original weight (before immersed in electrolyte), and W_r is the weight of adsorbed separator after drying a certain time.

Tests for electrochemical performances

All electrochemical performances were tested within CR2025 coin cell, which assembled in argon-filled glove box. 1 mol/L LiPF6 solution in a mixture solvent of EC/DMC/EMC (1:1:1 in volume ratio) was used as the electrolyte. Cathodes electrode consisted of $LiNi_{1/3}Co_{1/3}Mn_{1/3}O_2$ (70 wt.%), acetylene black (20 wt.%) and binder (polyvinylidene fluoride, 10 wt.%). Area mass loading of active materials was about 3 mg cm^{-2}. Lithium metal foil was used as anode. Galvanostatic charge/discharge curves were scanned on battery testing system (Land CT2001A battery tester, Wuhan Jinnuo Electronics Co. Ltd., China) with electrochemical window of 2.8 - 4.3 V.

Figure S1

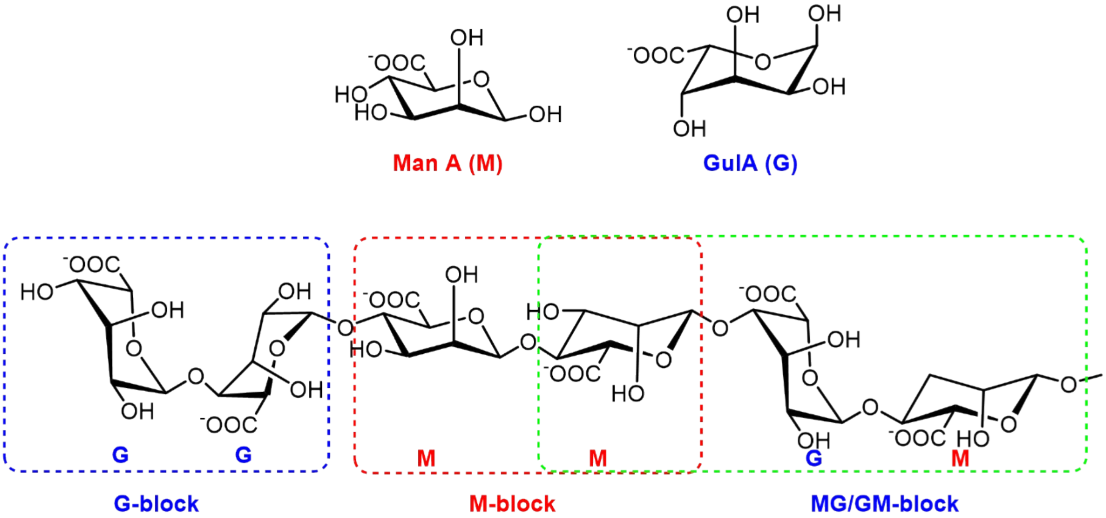

Fig S1 Chemical structure of alginate. The alginate monomers β–D–mannuronic acid (ManA; M) and α–L–guluronic acid (GulA; G) (From reference [2])

Figure S2

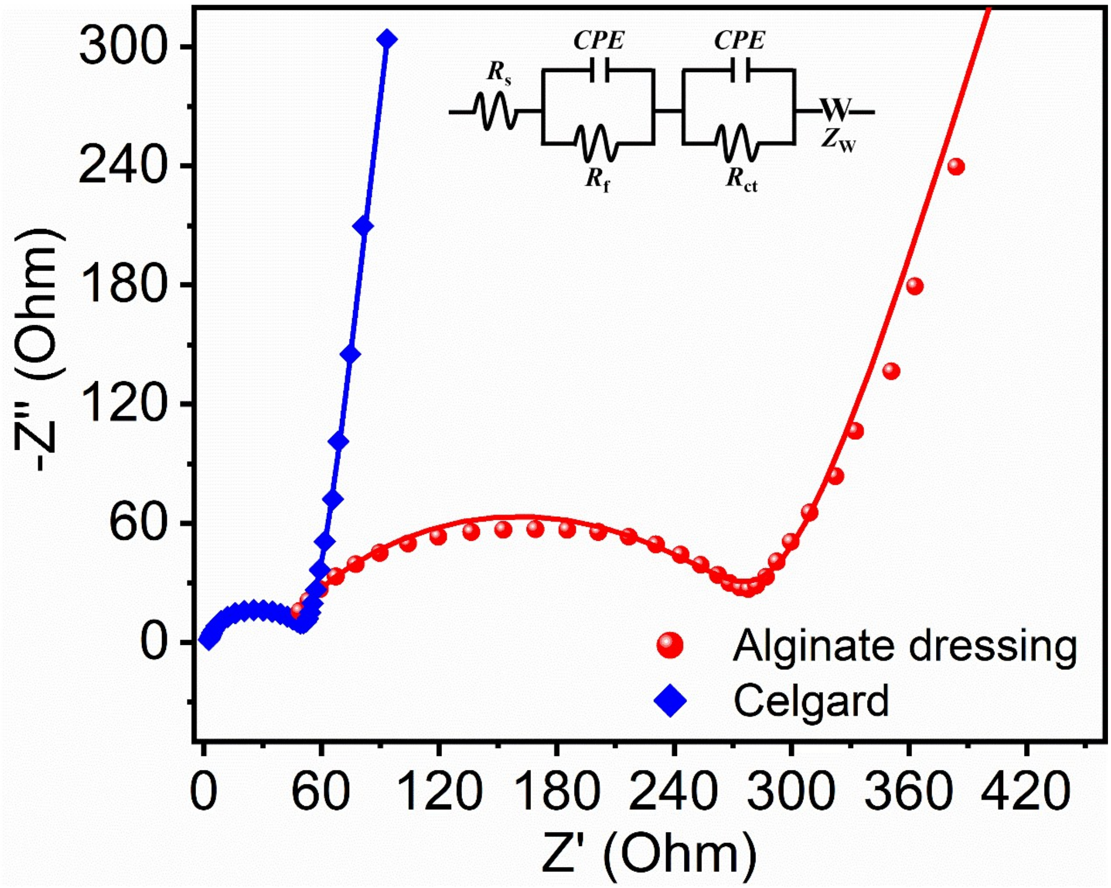

Fig S2 Nyquist plots and corresponding equivalent circuits of the half Li-ion batteries based on the separator of Alginate dressing and Polyolefin membrane

In the high-frequency region, the intercepts on the real axis are 48.89 and 2.52 Ω, respectively. According to reference [3], the calculated corresponding Li-ion conductivities of the cells are 7.24 and 8.78 mS cm^{-1} based on the thickness of alginate dressing (~400 μm) and Polyolefin membrane (~25 μm) according to the equcation in reference [4].

Table S1

Table S1 Fitting results of resistance based on equivalent circuits inserted in Figure S2

sample	Rs (Ω)	Rf (Ω)	Rct (Ω)
1	1.958	45.7	9460
2	34.05	244.9	7479

Reference

[1] PRODUCT DESCRIPTION for Alginate Dressing (Biatain Alginate 3710). https://www.woundcareshop.com/BiatainAlginate3710Single.aspx

[2] G.A. Martau, M. Mihai, D.C. Vodnar, The Use of Chitosan, Alginate, and Pectin in the Biomedical and Food Sector—Biocompatibility, Bioadhesiveness, and Biodegradability, *Polymers*, **2019**, 11, 1837

[3] B. Li, Y. Li, D. Dai, K. Chang, H. Tang, Z. Chang, C. Wang, X. Yuan, and H. Wang, Facile and Nonradiation Pretreated Membrane as a High Conductive Separator for Li-Ion Batteries, *ACS Appl. Mater. Interfaces*, **2015**, 7, 20184

[4] M. Yanilmaz, Y. Lu, M. Dirican, K. Fu, X. W. Zhang, Nanoparticle-on-Nanofiber Hybrid Membrane Separators for Lithium-Ion Batteries via Combining Electrospraying and Electrospinning Techniques. *J. Membr. Sci.* **2014**, 456, 57