Supplementing Information

Strength-enhanced solid-state electrolyte polyvinyl butyral film and its electrochromic application

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Experimental section

Polyvinyl butyral (PVB) was synthesized in our group, the key performance metrics are summarized in Table S1. Polymethyl methacrylate (PMMA, Mn = 500000), Lithium perchlorate ($LiClO_4$), N, N-dimethylformamide (DMF, AR) and acetone were purchased from Sigma-Aldrich Co. Ltd., Triethylene glycol di-2-ethylhexoate (3G8) was purchased from Guangdong Hongcheng Biotechnology Co. Ltd., ITO glass was purchased from Zhuhai Kaiwei Co. Ltd. All reagents were used without further purified.

Methods

Preparation of the Electrochromic Glasses: 1.5 g of PVB and 0.5 g of PMMA were dissolved in the solvent mixture with 6.3 g of DMF and 4.2 g of acetone under stirring at 80 °C for 12 h. Subsequently, 0.2 g of 3G8 was added to the solution with stirring and sonicating. PVB polymer fiber films, named BA, were produced by electrospinning at a voltage of 17.5 kV, a flowing rate of 1 ml/h, and a 17 cm distance between the tip of the needle (1.36 mm diameter) and the collector for a spinning time of 2 h. The PVB fiber films were immersed in different concentrations of $LiClO_4$ solution with concentrations for 24 h. Then the films were removed and placed in an oven at 50 °C for 12 h.

WO_3 and NiO thin films were deposited onto commercial ITO glass substrates via thermal evaporation using WO_3 and NiO granules as sources, respectively. The deposition was carried out at a rate of 1.1 Å/s, monitored in real-time by a quartz crystal microbalance (QCM). The final thicknesses were controlled to be 500 nm for the WO_3 layer and 50 nm for the NiO layer.

EC glasses with a glass/ITO/WO_3/PVB film/NiO/ITO/glass architecture were fabricated via hot pressing at 120 ± 1 °C for 5 min under vacuum (>100 kPa), yielding devices of 3.0 × 2.0 cm^2 active area. The WO_3 layer was uniformly deposited onto ITO substrates by thermal evaporation. These samples were labelled as BAL0 to BAL5.0, corresponding to the weight percent of $LiClO_4$ in the impregnation solution.

Characterization: The morphology of samples was observed by scanning electron microscope (SEM, JSM7610F, Japan). Fourier-transform infrared (FT-IR) spectra were

recorded on an IS50 spectrometer (Thermofisher Nicolet, USA) over wavenumbers ranging from 4000 to 400 cm^{-1}. Optical transmittance spectra were obtained on a UV-vis spectrophotometer (Agilent Cary 5000, USA) within the range of 200-1000 nm. The impact resistance test of the laminated glass was observed by Falling Ball Impact Tester (SHALA-KCJ-28) with a falling ball height of 160 cm and a ball weight of 20 g. The impedance was tested by an electrochemical workstation (CHI760E, CH Instruments Ins.) with an amplitude of 10 mV and a frequency scanning range of 0.1 - 100 KHz. Cyclic voltammetry was measured by an electrochemical workstation with a sweep rate of 200 mV/s. The color change test was performed with a MAISHENG adjustable DC power supply (MS-305D). Tensile tests were carried out on a QT-6201 S bond strength testing machine at 50 mm/min.

Table S1 key performance metrics PVB resin powder.

	Acetal degree (%)	Hydroxyl value (%)	Bulk density (g/ml)	Melt flow rate (g/10 min)
PVB powder	78.26	20.63	0.278	1.48

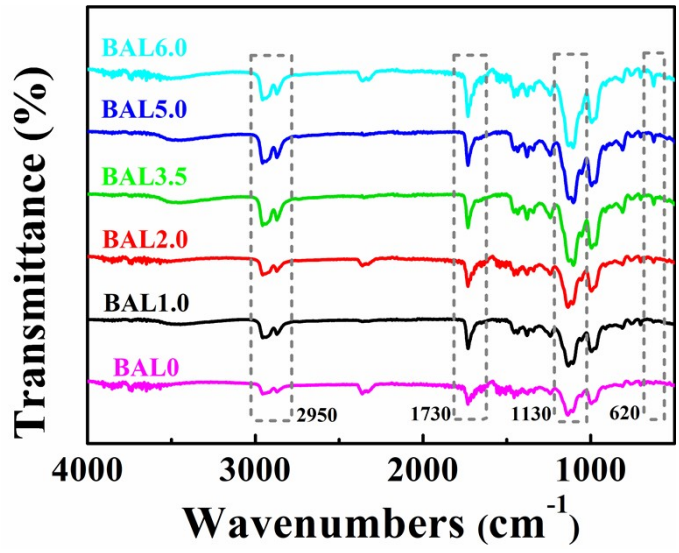

Figure S1. The FT-IR spectra of solid electrolyte film.

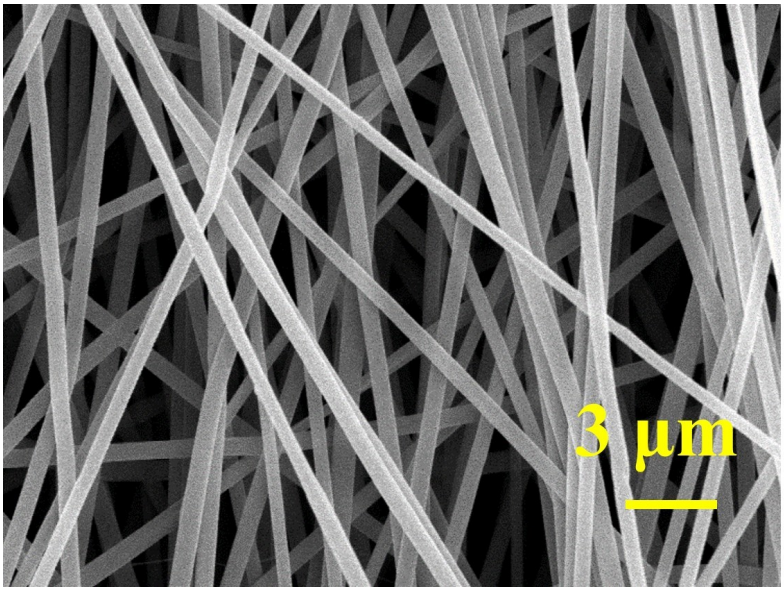

Figure S2. SEM images of PVB/PMMA electrolyte film.

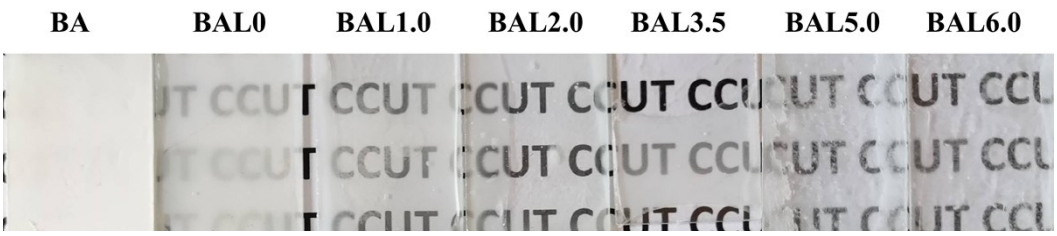

Figure S3. Photos of solid electrolyte polymer films.

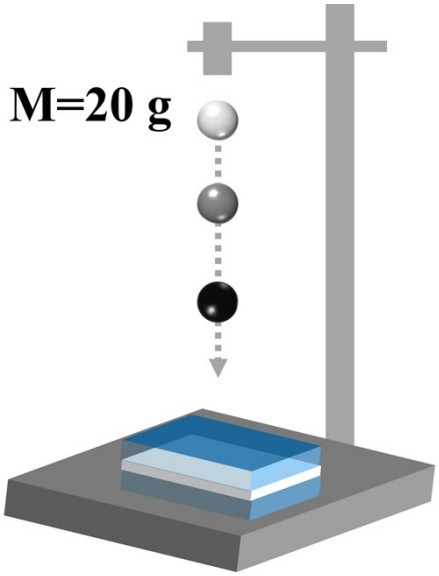

Figure S4. Falling ball test device.

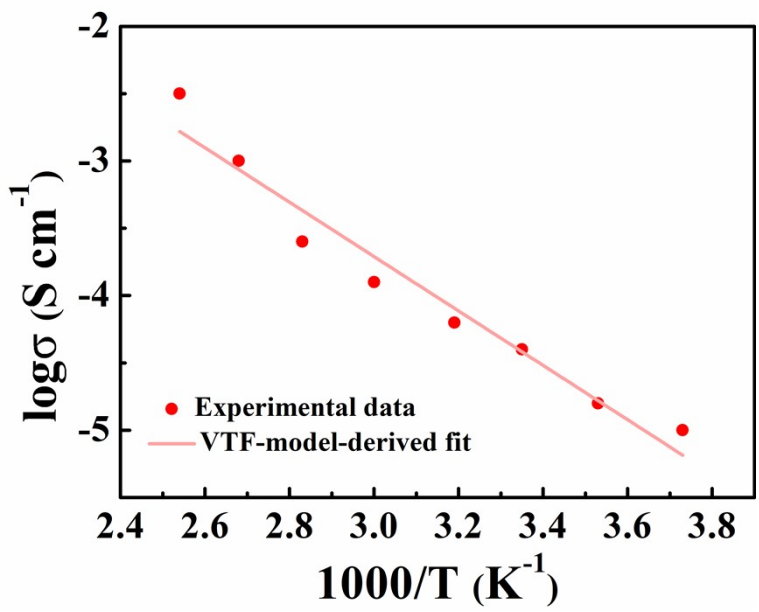

Figure S5. Reciprocal temperature dependence of segmental dynamics for BAL 2.0 films.

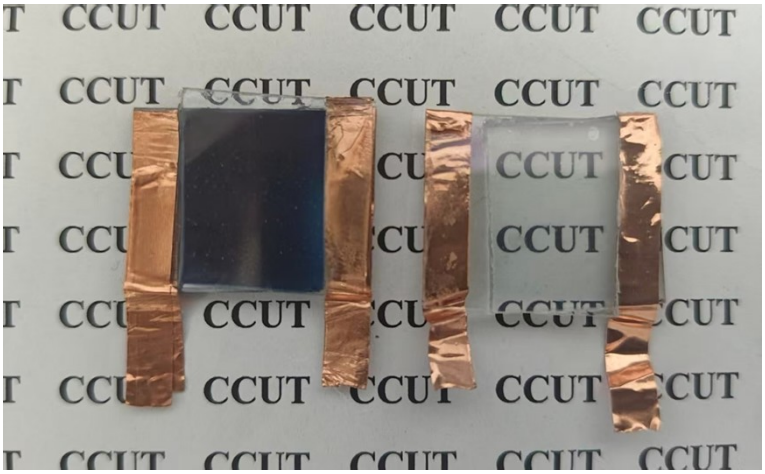

Figure S6. Photographs of the device in its coloured and bleached states.