Here we show the electrochemical raw data for a Li/ferroelectric Li-glass electrolyte/plasticizer/Li-rich, F doped LNMO coin cell where the plasticizer is succinonitrile-SN. The nominal composition of the active oxide-host cathode particles is Li$_{1.36}$Ni$_{0.49}$Mn$_{1.15}$O$_{3.28}$F$_{0.36}$ (LNMO) that disproportionated into 78 wt% spinel phase LiNi$_{1/2}$Mn$_{3/2}$O$_{3.8}$F$_{0.2}$ and 22 wt% Li-rich, F-doped layered phase containing Li$_2$MnO$_3$ planes separated by Li$^+$ and Ni$^{2+}$ ions. The Li$_{2.99}$Ba$_{0.005}$OCl electrolyte was synthesized and ground in ethanol. A cellulose matrix was dipped into the glass/ethanol slurry. This cell has been cycling for two years and six months. The electrochemical performance was firstly published in graphs after cycling the cell for about one year and three months [1]. The Li/LNMO CR2032 coin cell was assembled in an argon-filled glove box and electrochemically tested in a battery testing analyzer (LAND) at room temperature and at constant specific current densities and potentials between 2.5 and 4.8 V. Moreover, the cell’s cycling current is 23 mA g$^{-1}$ (active cathode). The data might be used by the electrochemical (in particular, battery), electrostatic and ferroelectric researchers and industrials for comparative analysis. Furthermore, it can be reused by anyone interested in solid-state devices that wants to calculate the maximum energy stored electrostatically in these devices.

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1. Data description

Electrochemical cycles were performed with a Li/Li-glass in cellulose/plasticizer/Li-rich, F doped LNMO cell as described in Ref. [1].

The graph of the potential difference between the terminals of the cell versus the specific capacity of the cathode active material is shown in Fig. 1a and the correspondent table with the raw data for cycles 1—3, 25, 50, 75, 90, 100, 110, 120, 125, 128, 130, 140, 150, 160, 170, 180, 181, 190, 200, 210, 216, 218, 220, 230, 240, 250, 252, 260, 270, 280, 308, 290, 300, 310, 320, 329, 340, 380, 400, 420, 440, 460, 480, 431, 466, 480, 500, 520, and 535 is presented in data_Fig. 1a.xlsx.

The coulombic efficiency, defined as \( \frac{Q_{\text{discharge}}}{Q_{\text{charge}}} \times 100\% \), versus the cycle number, is shown in Fig. 1b and the correspondent raw data for all the cycles are presented as a table in data_Fig. 1b.xlsx.

The specific capacity of the active cathode material as a function of the cycle number is shown in Fig. 1c and the correspondent raw data for all the cycles are presented as a table in data_Fig. 1c.xlsx.

The potential at middle capacity for each discharge and specific energy versus the specific capacity of the active cathode material is shown in Fig. 1d the correspondent raw data for all the cycles is presented as a table in data_Fig. 1d.xlsx.
2. Experimental design, materials, and methods

2.1. Synthesis of cathode host F-doped Li-rich spinel

Nominal Li\(_{x}\)Ni\(_{0.5-y}\)Mn\(_{1.5-z}\)O\(_{4-x}\)F\(_{x}\) with x = y + z = 0.36, δ = 0.36 (LNMO) was prepared. All chemical precursors utilized were 99.99% pure and purchased from Sigma Aldrich. The Ni\(_{0.5}\)Mn\(_{1.5}\)O\(_3\)·δ(OH)\(_1\)·δ (NMO) precursor was prepared by a solvothermal method. The transition metal acetates, Ni(CH\(_3\)COO)\(_2\)·4H\(_2\)O, Mn(CH\(_3\)COO)\(_2\)·4H\(_2\)O and urea (chelating agent) were dissolved in 50 ml ethanol (solvent). The homogeneous solution obtained was then transferred to a 90 ml Teflon-lined stainless-steel autoclave and heated in a muffle furnace at 200 °C for 24 h. After cooling to room temperature, the slurry obtained was centrifuged/washed several times with ethanol, and vacuum dried at 60 °C overnight. A stoichiometric amount of ground lithium carbonate (Li\(_2\)CO\(_3\)) to lithium fluoride (LiF, 10% excess) was mixed with the product and heated to 800 °C for 15 h in air.

2.2. Synthesis of a Ba-doped Li\(^+\)-glass electrolyte

Nominal dielectric amorphous-oxide (glass) Li\(^+\) electrolytes Li\(_{2.99}\)Ba\(_{0.005}\)Cl\(_{1-2x}\)O\(_{1+x}\) with 0 ≤ x < 1 were obtained in a wet synthesis as described previously [1,2] from commercial precursors LiCl (≥99%,
Merck), Li(OH) (98%, Alfa Aesar), and Ba(OH)$_2$·8H$_2$O (98.5%, Merck). The glass products were dried by evaporation of water at lower temperatures and the loss of the OH$^-$ as H$_2$O from the hydroxide crystalline precursor phases below 230 °C as previously shown [2]; the reaction leaves an amorphous solid glass containing Li$_2$O and LiO$^-$ electric dipoles. The samples obtained after synthesis were ground with an agate mortar and pestle while mixed in absolute ethanol. Non-woven paper separators of about 40–60 µm thick were immersed in the electrolyte-ethanol mixture and dried at about 180 °C in an argon-filled glove box (MBraun, Germany).

2.3. Preparation of the cathode

The cathode was prepared by mixing the LNMO particles with carbon Super P as conducting agent and polyvinylidene fluoride (Sigma-Aldrich) (PVDF) as a binder in the weight ratio of 8:1:1 with N-methyl-2-pyrrolidone (NMP) as solvent. The slurry was mixed in a plenary mixer (Kurabo Mazerustar, Japan) and coated on one side of double-sided carbon-coated aluminum foil. Finally, the cathode was dried at 120 °C overnight in a vacuum oven.

A mixture of succinonitrile (SN) plasticizer and LiClO$_4$ salt in a molar ratio of 20:1 was heated in an argon-filled glove box (MBraun, Germany) to get a transparent solution. The LiClO$_4$ was mixed into the SN, but the conductivity of the SN did not increase as much as expected [3] owing to not melting the LiClO$_4$ prior to mixing it with SN. The cathode was prepared by dropping the solution of succinonitrile-based material that was heated to $T \geq 57$ °C onto a prepared cathode surface that faced the glass electrolyte in a paper matrix. The prepared cathode consisted of oxide-host particles and carbon contacting the cathode current collector. The SN coated the entire surface of the active cathode particles without intruding into their contact with the cathode current collector. After cooling down to room temperature, the succinonitrile-coated cathode was flexible. The weight ratio of the cathode to the SN was 7:3. The loading of the active cathode material on the aluminum foil of the all-solid-state cell was 0.25 mg, which corresponds to about 0.35 mg cm$^{-2}$ (diameter: 0.95 cm) of active material.

2.4. Cell assembly and testing

A half-cell with the afore-prepared cathode and Li-metal foil as anode was assembled. A circular lithium-metal anode with a 1.2 cm diameter and 0.2–0.3 mm thick was deposited on stainless steel and then covered with a paper matrix containing the glass electrolyte (thickness 40 ≤ d ≤ 60 µm). Finally, the cathode coated with SN was added as well as a spacer and spring. We used half a drop of 1 M LiClO$_4$ in propylene carbonate (PC) and diethyl carbonate (DEC) 1:1 to facilitate the contact between the paper and the cathode SN-surface; no excess liquid was ever found in the cell; and when cells were opened after cycling, the paper was strongly attached to the SN surface of the cathode coat making it very hard to detach.

The cell has been tested electrochemically at room temperature in a battery testing analyzer (LAND, China CT2001A) at constant specific current density (23 mA·g$^{-1}$) and potential between 2.5 and 4.8 V.

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dib.2019.105087.
References

[1] M.H. Braga, C.M. Subramaniyam, A.J. Murchison, J.B. Goodenough, Nontraditional, Safe, High voltage rechargeable cells of long cycle life, J. Am. Chem. Soc. 140 (20) (2018) 6343–6352.

[2] M.H. Braga, J.E. Oliveira, T. Kai, A.J. Murchison, A.J. Bard, J.B. Goodenough, Extraordinary dielectric properties at heterojunctions of amorphous ferroelectrics, JACS 140 (51) (2018) 17968–17976.

[3] S. Das, S.J. Prathapa, P.V. Menezes, T.N. Guru Row, A.J. Bhattacharyya, Study of ion transport in lithium perchlorate-succinonitrile plastic crystalline electrolyte via ionic conductivity and in situ cryo-crystallography, J. Phys. Chem. B 113 (15) (2009) 5025–5031.