

Single-ion Monomers and Polymers: Towards high conductive and safer lithium battery electrolytes



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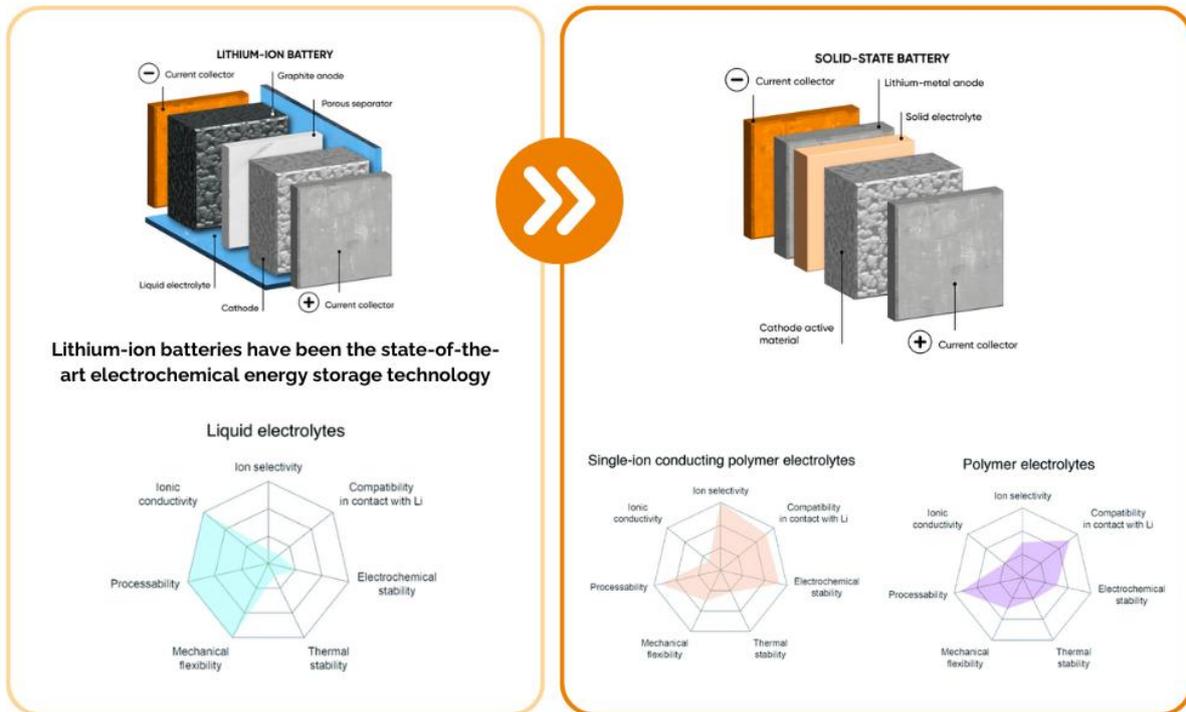
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Solid-state batteries are attracting significant interest for their potential to **reshape the energy storage landscape**. Traditional batteries, which rely on **liquid electrolytes** offer **cost** and **performance advantages** but face **significant safety concerns**, especially with **Li-metal anodes** and **high-potential cathodes**.

Solid-State Batteries : Toward Solid Electrolytes



Solid-state batteries use **solid electrolytes** that **eliminate** the use of **flammable components**. This innovation not only enhances safety by **reducing risks of leaks and fires**, but are also attracting major interest due to **their small volume change** during the charging/discharging process and ease of manufacturing. Solid state electrolytes can whether be **ceramic or polymer-based**. Ceramics excel in conductivity and thermal/electrochemical stability whereas Polymers are **cost-effective, flexible, and easier to shape**, with **reduced sensitivity to oxygen and water** compared to ceramics.



At the Batteries Event 2024 in Lyon, France, Cédric Loubat, SPECIFIC POLYMERS' CEO showcased the latest advancements and future directions of the company in the field of energy and lithium batteries. In this newsletter, you'll find a summary of the key information and announcements shared at the event.

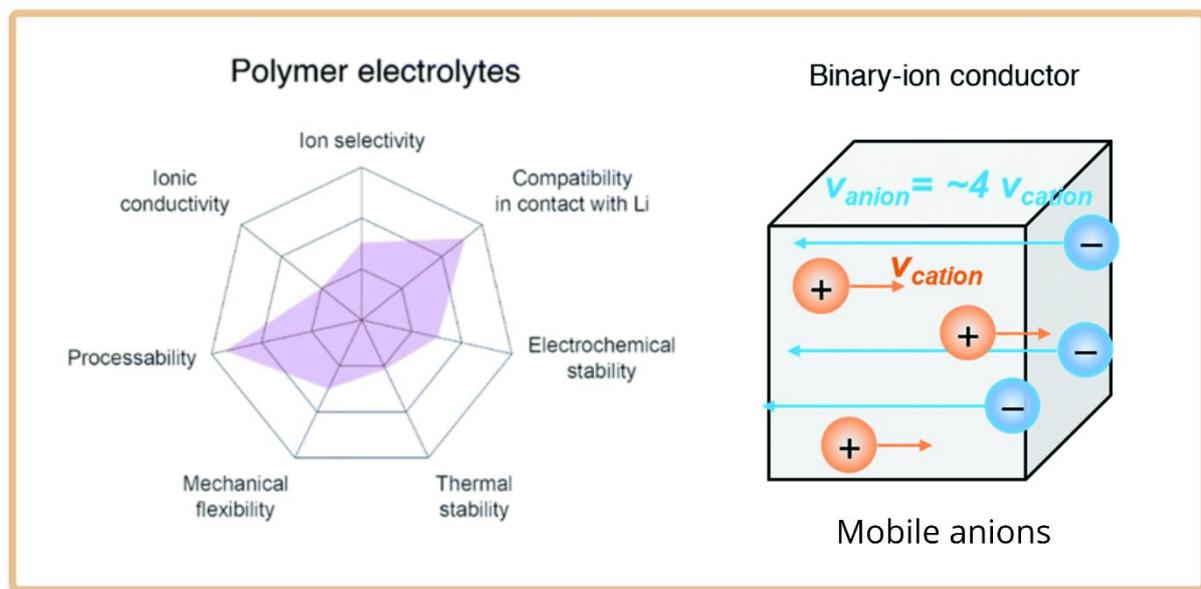
Based on the literature, **typical composition of polymer electrolyte formulations** for solid-state batteries (SSB) is **60-80% of PEO, 10-30% TFSI salts**, and **5-10% of additives**. The

development of these electrolytes marked a **significant first step** for all-solid-state batteries. However, this technology now struggles to keep up with the **increasing demands of today's applications**. In these binary-ions conductor systems, power delivery is constrained by the **concentration gradient of the lithium salt**, resulting in a **low lithium transference number**. Indeed, in such systems, **both cations and anions are mobile** within the **polymer electrolyte phase**. In **PEO matrices**, Li^+ cations **move much more slowly** than anions, which eventually **leads to polarization gradients** that ultimately **reduce electrolyte performance**.

Solid-state Batteries : Single-Ion Polymers and Single-Ion Conducting Polymers

To delve deeper, SPECIFIC POLYMERS researchers are focusing on both **Single-Ion Polymer (SIP)** and **Single-Ion Conducting Polymer (SICP)** Electrolytes. These electrolytes **immobilize the lithium counter ion** within the polymer material, offering **enhanced transport behavior** along with **solid-state nature, flexibility, and processability**. The advantages of these single-ion Conductors include **high ionic selectivity** for lithium, approaching unity, **high oxidation voltage (>4.0V)**, and **resistance to dendrite formation**, which allows for even **lithium plating and stripping** during the charging and discharging process.

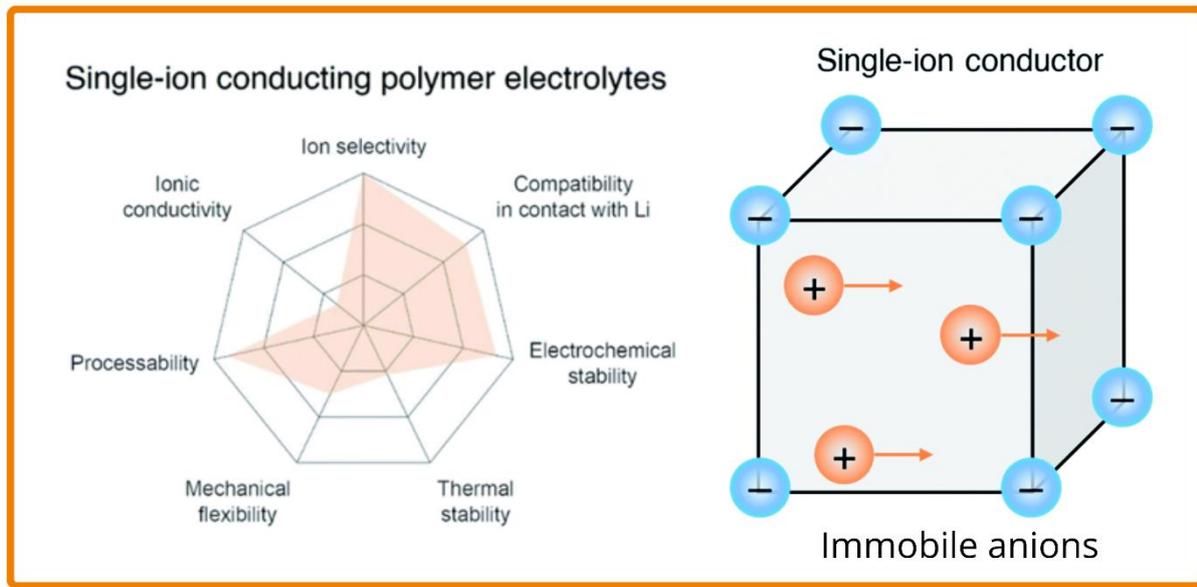
Polymer electrolyte



Power delivery of Solid Polymer Electrolyte materials is **limited by the concentration gradient of the lithium salt**, resulting in a low lithium transference number.

Dual-ion conductors : **Both cations and anions are mobile** in the polymer electrolyte phase. The mobility of both ions **induces a concentration polarization** and finally ends up **reducing electrolyte performance**.

Single-ion Conducting Polymer Electrolyte

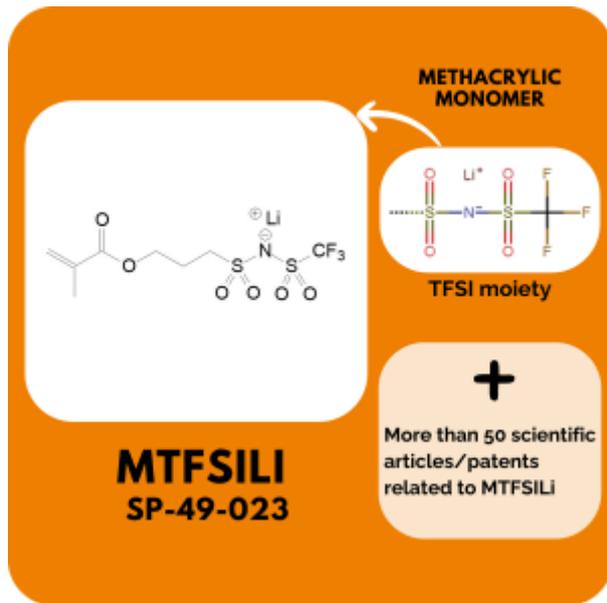


SIP and SICP electrolytes, consists of **immobilizing** the **counter ion** to the **polymeric material**.

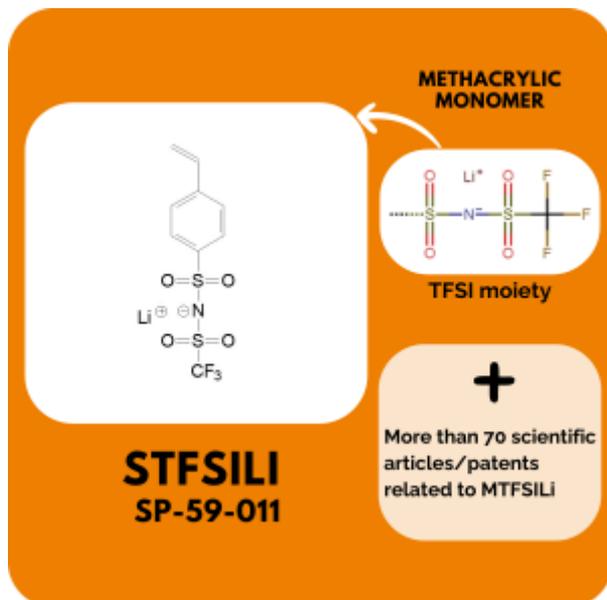
This improves lithium transport properties while leveraging their solid-state nature, **flexibility**, and **processability** and allow **high lithium selectivity**, **stability** at voltages exceeding 4.0V, and **resistance to dendrite growth**.

Solid-state Batteries : SIM – Single-Ion Monomers

As part of these activities, SP has been marketing **two ‘Single Ion Monomers’ (SIM)** since 2017: a **methacrylic monomer** named [MTFSiLi \(SP-49-023\)](#) and a **styrenic monomer** named [STFSiLi \(SP-59-011\)](#). These monomers support companies and research centers in developing **new technologies for Single-ion Polymers and Single-Ion Polymer Electrolytes**. The availability of these two monomers has enabled many researchers worldwide to **develop various types of polymer electrolytes** by using them in **polymerization or copolymerization** reactions with different co-monomers. From 2017 to 2023, the number of **scientific articles, publications, and patents** based on the use of these two monomers has seen **significant growth**, clearly demonstrating their **relevance** in this field.



[SP-49-023](#)

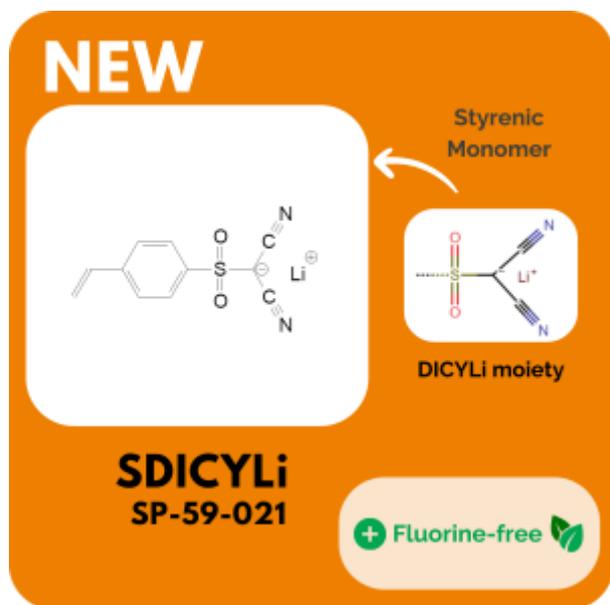


[SP-59-011](#)

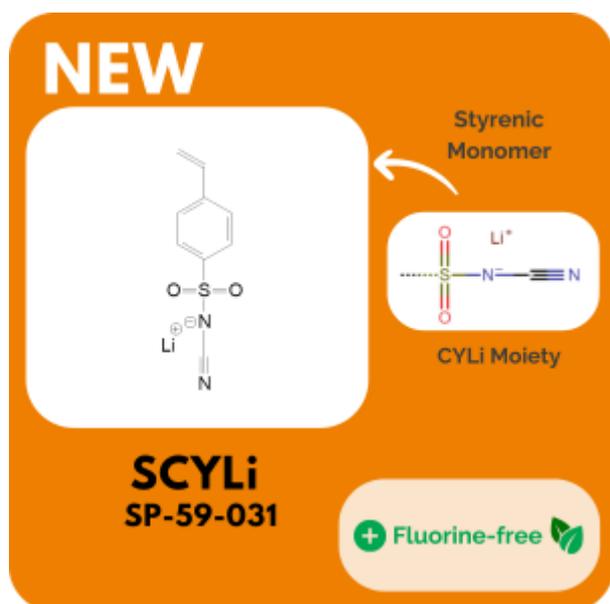
Solid-state Batteries : NEW Single-Ion Monomers

In 2024, we are proud to announce the **release and commercialization of two new monomers** of interest for this application field. In response to the need for **cost reduction** and to address regulations surrounding fluorinated compounds, especially PFAS, SPECIFIC POLYMERS scientists have developed **two new ‘Single Ion Monomers’ (SIM): SDICYLi (SP-59-021) and SCYLi (SP-59-031)**. We are currently able to **produce these two monomers** at

the **laboratory scale** (hundred of grams per batch) and, at this stage of our developments, we have not identified any obstacles to **scaling up their production**. Once again, we are confident that the commercialization of these new monomers will **enable significant advancements** of the **scientific community** in this strategic field.



[SP-59-021](#)



[SP-59-031](#)

At the same time, we will **continue our R&D efforts in this field**. Our goal and mission remain to **fill the gap between academic interest and industrial reality** and **push the commercialization of Single Ion Monomers, Polymers and Single-Ion Conducting Polymer** at the **industrial level**. Achieving this goal **involves numerous challenges**, such as **addressing process safety, regulations, supply chain issues, performance reproducibility**, and more. In recent years, we have made significant progress on these fronts and have been able to **increase our production capacity**. We are committed to continuing this effort because we are convinced that **Single-Ion Polymer (SIP) and Single-Ion Conducting Polymer (SICP) technologies** will be at the **heart of the energy sector's transformation by 2030**.

Feel free to contact us if you see **any potential for collaboration** with our teams in this field. Our expertise in organic and polymer chemistry, combined with our experience in battery electrolytes and industrial approach, enables us to **provide strong scientific support**. We would be very happy to discuss your projects and explore how we can assist you.

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[Contact us](#)