

Halide Solid Electrolytes for Li-ion Batteries

Patent Landscape Analysis

April 2024



TABLE OF CONTENTS

INTRODUCTION	5	FOCUS ON KEY IP PLAYERS	48	
<ul style="list-style-type: none"> • Context and objectives of the report • Scope of the report • Methodology for patent search, selection, and analysis • Halide Solid Electrolytes <ul style="list-style-type: none"> – <i>Chemical composition</i> – <i>Room temperature ionic conductivity of main halide solid electrolyte materials</i> – <i>Main properties, advantages and drawbacks</i> – <i>Challenges and envisioned solutions for main halide solid electrolyte materials</i> – <i>Main manufacturing methods</i> 		<ul style="list-style-type: none"> • Table showing material compositions and technical challenges mentioned in patent portfolios of patent assignees • IP profile of key players (IP portfolio overview and key patented technologies): <ul style="list-style-type: none"> – Panasonic/Sanyo – Samsung – Saint-Gobain – Guolian Automobile Power Battery Res. Inst. (GLABAT) – University of Western Ontario – SVOLT – EVE Energy – TDK – KETI (Korea Electronics Technology Institute) – Toyota – USTC (University of Science and Technology of China) – Liong New Energy Technology – Qingtao Energy Development – University of Maryland – BYD – Global Graphene – Baowu Steel Group – Hanyang University – BASF / University of Waterloo – Guoxuan High Tech Power Energy / Gotion – Yonsei University – BattFlex – Ningbo University – XPeng – FAW – GAC – Nichia – Aichi Steel 		<ul style="list-style-type: none"> – Fujifilm – Sumitomo/ Tanaka – Hyundai/Kia – Solvay – Sidus – General Motors – Corning – University of Dayton – Volkswagen – University of Liverpool
HIGHLIGHTS	18			
PATENT LANDSCAPE OVERVIEW	26			
<ul style="list-style-type: none"> • Time evolution of patent publications • Patent filings by country • Typology of patent assignees • Main IP players per country and typology • Startups and pure players • Main patent assignees • Most active IP players in 2022-2023 • Timeline of IP players • IP newcomers • Current legal status of patents • IP leadership of countries • IP leadership of patent assignees • Main players' patent legal status and geographical coverage • Geographical distribution of alive patents • Key IP players and their IP position • IP blocking potential of patent assignees • IP strength of patent assignees 				ANNEX 91 <ul style="list-style-type: none"> • Basic knowledge of patents • Terminology • Key IP players: definition and examples • Essentials on Solid-state Batteries <ul style="list-style-type: none"> – <i>Definitions</i> – <i>Impact of main bulk solid-state battery technical issues on its performances</i> – <i>Challenges and improvement solutions for bulk solid-state lithium battery</i> – <i>Overview of main technical issues for bulk solid-state lithium batteries</i> – <i>Categories of solid electrolytes</i> – <i>Properties of each solid electrolyte categories</i> – <i>Overview of main inorganic solid electrolyte materials</i> – <i>Ionic conductivities of main other inorganic solid electrolyte materials</i> – <i>Properties of main other inorganic solid electrolyte materials</i> • Bibliographic references
				KNOWMADE PRESENTATION 109

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INTRODUCTION

Context and objectives of the report

Solid-state Li-ion batteries have garnered significant attention in recent decades due to their notable advantages of safety and potential for high energy density. Solid electrolytes (SE) with rapid ionic transport and excellent stability are essential for the commercialization of this promising next-generation of Lithium batteries. Hence, there has been extensive exploration of inorganic solid electrolytes, including sulfide- and oxide-based electrolytes. Unfortunately, both have been unable to strike an optimal balance between conductivity and stability. Oxides suffer from high impedance of grain boundaries, while sulfides experience poor stability. However, **halide-based solid electrolytes** are increasingly being recognized as one of the most promising options for solid-state Li-ion batteries, owing to their decent room temperature ionic conductivity ($>10^{-3}$ S.cm⁻¹), good compatibility with oxide cathode materials, excellent chemical stability, and scalability.

The increasing interest in **halide solid electrolytes** has been observed while [monitoring patents on solid-state Li-ion batteries](#). As of September 2023, over 330 patent families have been published on halide solid electrolyte materials for Li-ion batteries. It is now crucial for companies operating in the solid-state battery industry to closely examine these emerging materials from technological, competitive, and intellectual property (IP) perspectives.

In this context, **Knowmade** is releasing a **new patent landscape report** that focuses on **halide solid electrolyte materials for Li-ion batteries**. In this report, Knowmade's analysts have selected and analyzed over **860 patents and patent applications** from more than **330 patent families** (inventions) filed by **110+ different entities**. This new IP report is complementary to our previous patent landscape reports and patent monitors on solid-state batteries.

In this **Halide Solid Electrolytes for Li-ion Batteries Patent Landscape** report, Knowmade's analysts provide a comprehensive overview of the competitive IP landscape and latest technological developments in this field.

The report covers **IP dynamics** and **key trends** in terms of patents applications, patent assignees, filing countries, and patented technologies. It also identifies the **IP leaders**, most **active patent applicants**, and **new entrants** in the IP landscape. The report also sheds light on **under-the-radar companies and new players** in this field. Additionally, it analyzes the **strength of IP portfolios** and the **technology/application focus** of key players. An overview of the current status and trends of **patented technologies** and their applications is also provided. Furthermore, the report examines the **strategic and technological directions** of both leading companies and newcomers in the field.

This 2024 edition of the report provides a detailed analysis of the **IP landscape** and **noteworthy patents** concerning **halide solid electrolyte materials**.

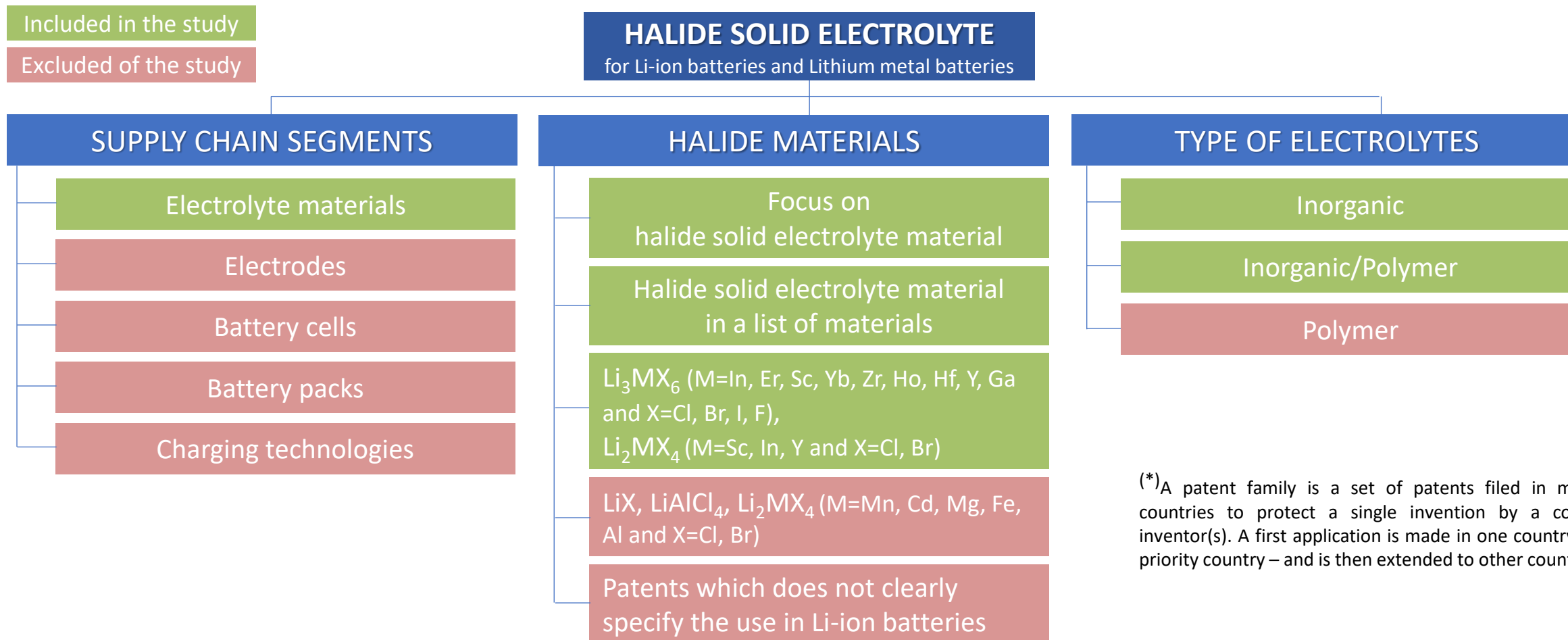
Throughout the year, Knowmade's analysts conduct **thorough investigations of the solid-state battery patent landscape** in order to gain a comprehensive understanding of the technological and IP developments and its impacts on the industry. This new report is one of our collection of products and services, including [Solid-State Li-ion Batteries IP report](#), [Solid Electrolytes for Li-ion Batteries IP report](#), [Silicon Anode for Li-ion Batteries IP report](#), [Solid-State Batteries Patent Monitor](#), and upcoming analyses on Recycling of Li-ion batteries, LFP, and Na-ion batteries.

INTRODUCTION

Scope of the report

SAMPLE

This report covers **halide solid electrolyte materials for Li-ion batteries (incl. Lithium metal batteries)**. Other solid-state battery technologies (Li-S, Li-Air, Na-ion, Mg-ion, etc.) are excluded. We have selected and analyzed more than **330 patent families*** related to **halide solid electrolytes**, comprising over 860 patent applications published worldwide as of September 2023.



(*)A patent family is a set of patents filed in multiple countries to protect a single invention by a common inventor(s). A first application is made in one country – the priority country – and is then extended to other countries.

INTRODUCTION

Methodology for patent search, selection, and analysis

- The data are extracted from the **FamPat worldwide patent database** (Questel-ORBIT) which provides 100+ million patent documents from 100 patent offices (USA, Japan, Europe, China, Korea, Taiwan, Hong Kong, Singapore, etc.).
- The search for patents related to **halide solid electrolytes for Li-on batteries** was completed in **September 2023**, hence patents published after this date are not available in this report.
- Both the **selection of relevant patents and their categorization into technical segments** are **manually** performed using **keywords and patent classes** (IPC, CPC), combined with **manual analysis** of each patent title, abstract, descriptions, illustrations and claims in conjunction with **expert review** of the subject-matter of the inventions.
- Some patents held by different entities are grouped considering the M&A history.
- The patents are grouped in **patent families**. A patent family is a set of patent applications filed in multiple countries to protect a single invention by a common inventor(s). A first patent application is filed in one country – the priority country – and is then extended to other countries.
- **Data analysis** is performed using the **Questel Orbit IP Business Intelligence analytics platform** combined with **Excel-based data processing** and will be supplemented by **expert analysis**.

We have selected and analyzed more than **860 patents and patent applications** grouped in more than **330 patent families** relevant to the scope of this report

Disclaimer: This report **does not provide** any insight **analyses or counsel regarding legal aspects** or the **validity** of any individual patent. Knowmade is a research firm that provides technical analysis and technical opinions. Knowmade is not a law firm. The research, technical analysis and/or work proposed or provided by Knowmade and contained herein is not a legal opinion and should not be construed as such.

INTRODUCTION

Found the right information in the report

SAMPLE

Report sections



Your concern



Information you get



PATENT LANDSCAPE OVERVIEW

- **Ranking of players** (enforceability, current activity, geo/tech coverage, prior-art contribution, etc.)
- **Patent filings dynamics per player**
- **IP collaborations** (co-filings, IPR transfers)
- **Patent litigation/oppositions**

SEGMENTS ANALYSIS

- **Patent filings dynamics per segment**
- **IP leaders per segment** (enforceability, current activity, blocking potential)
- **Key patents per segment**
- **Recent patenting activity per segment**

IP PROFILE OF KEY PLAYERS

- **Patent portfolio summary** (portfolio size, IP activity evolution, patents legal status, geo/tech coverage, strengths/weaknesses, etc.)
- **Key patents**
- **Recent patenting activity**

TECHNOLOGY

For R&D teams, engineers, scientists

Innovators

Technology trends
Technology mapping

Current R&D activities
Technology roadmap

IP

For IP teams, patent attorneys

Main patent owners
IP risks/opportunities

Blocking players
IP risks/opportunities in each segment (FTO, litigation, licensing)

Blocking patents
Geo/Tech coverage
Link between patents and products

MARKET

For executives, business developers

Ecosystem (competitors, newcomers, partners, clients)
Main trends
IP vs Market

Benchmarking
Markets of interest
Future developments

Future products
Potential partners
Potential targets

PLAYER

Zoom in a competitor / partner

IP position vs Market position
Player relationships (collaborations/dependencies)

IP position and level of investment in each segment
Key IP developments

R&D investment level
Key inventions
Current IP activities
Strengths / Weaknesses

HALIDE SOLID ELECTROLYTES

Chemical composition, ionic conductivity, advantages/drawbacks, challenges/solutions, manufacturing methods

SAMPLE

Halide Solid Electrolytes

Room temperature ionic conductivity of main halide solid electrolyte materials

Structure	Halide	Chemical formula	RT ionic conductivity (S.cm ⁻¹)	Compatibility for use in solid-state Li-ion batteries
LIMX4	Cl	LiMeX ₄ (Me=Mg)	~10 ⁻⁴	Bad
			~10 ⁻³	Medium
			~10 ⁻²	Good
LIMX6	Cl		~10 ⁻⁴	Bad
			~10 ⁻³	Medium
			~10 ⁻²	Good
			~10 ⁻¹	Good
	F + Br			
	F + Cl			
	I			

Compatibility for use in solid-state Li-ion batteries: Good (Green), Medium (Yellow), Bad (Red)

Halide Solid Electrolytes

Main manufacturing methods

- Cost-effective, green influences the ionic conductivity
- There are currently temperature dry solid state synthesis methods
- Mechano-chemical**: This method is low cost and allows for large scale production. The low crystallinity of the materials leads to high ionic conductivity.
- Co-melting/sintering**: This method is also used to obtain large crystals. It involves high temperatures and can lead to grain growth, which reduces ionic conductivity.
- Liquid-phase synthesis**: This method is used to synthesize nanoscale particles. An additive is used to stabilize the particles. There are still significant challenges with this method as halide SSEs are generally demanding since they are often highly hygroscopic, such as HCl and HBr, and require special handling to avoid irreversible hydrolysis. The thermal and electrochemical performances of fluoride-based solid electrolytes are generally better than those of chloride and bromide-based materials.

Halide Solid Electrolytes

Chemical composition

Chemical composition of halide solid electrolytes is generally Li_{1-x}MX₄ or Li_{1-x}MX₆, where M is a divalent metal (Mg, Ca, Sr, Ba) and X is a halogen (Cl, Br, I, F). The structure is typically layered, with lithium ions occupying interstitial sites between the halide layers.

Main Halide solid electrolyte materials with good ionic conductivities at Room Temperature

Halide Solid Electrolytes

Main properties, advantages and drawbacks

Main properties of Halide solid electrolytes	Halides (Cl, Br, I)		Fluorides (F)
	Soft	Hard	Soft
RT ionic conductivities (S.cm ⁻¹)	~10 ⁻⁴	~10 ⁻³	~10 ⁻²
Electrochemical stability window (V vs. Li ⁺ /Li ⁰)	~4.5	~5.5	~6.0
Thermal stability	~300°C	~400°C	~500°C
Chemical compatibility with Lithium	Good	Good	Good
Stability in dry air	Good	Good	Good

Halides	Main advantages and drawbacks of halides solid electrolytes	
	Advantages	Drawbacks
Common to Cl, Br, I and F	<ul style="list-style-type: none"> High-voltage stability window Enable high-capacity cathodes Stability Compatibility with Lithium metal 	<ul style="list-style-type: none"> Low ionic conductivity at room temperature Highly hygroscopic materials (e.g., HCl, HBr, HI) are difficult to handle Highly hygroscopic materials are difficult to handle Highly hygroscopic materials are difficult to handle
Specific to Fluorides (F)	<ul style="list-style-type: none"> High ionic conductivity at room temperature Highly stable in air 	<ul style="list-style-type: none"> Low electrochemical stability window Highly hygroscopic materials are difficult to handle Highly hygroscopic materials are difficult to handle

Main halide solid electrolyte materials

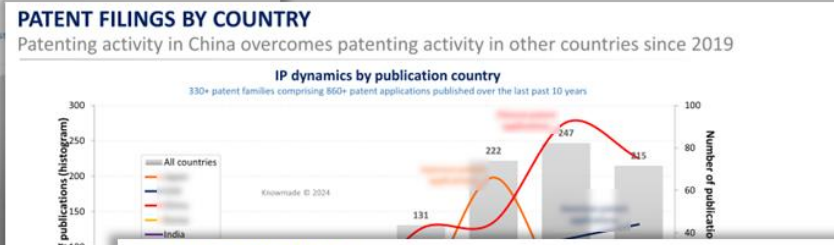
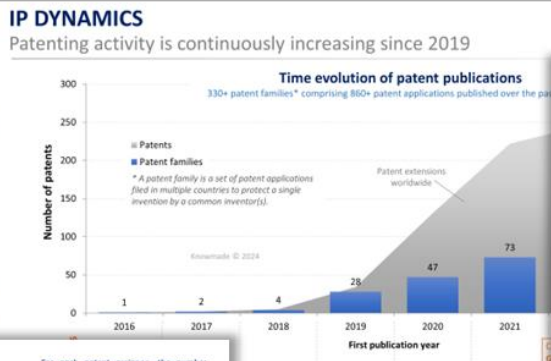
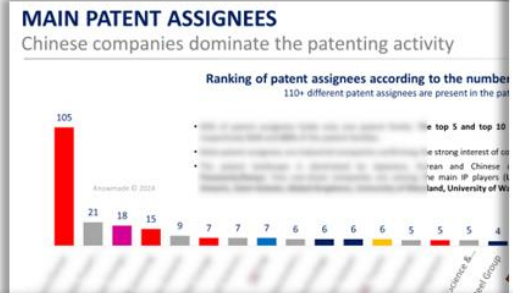
Improvement solutions

- Use of fluoride-based materials as central element
- Use of mixed halides (e.g., Cl, Br, I, F)
- Use of layered structures
- Use of nanoscale particles
- Use of high-temperature synthesis
- Use of large-scale production

PATENT LANDSCAPE OVERVIEW

General trends, main patent assignees and newcomers

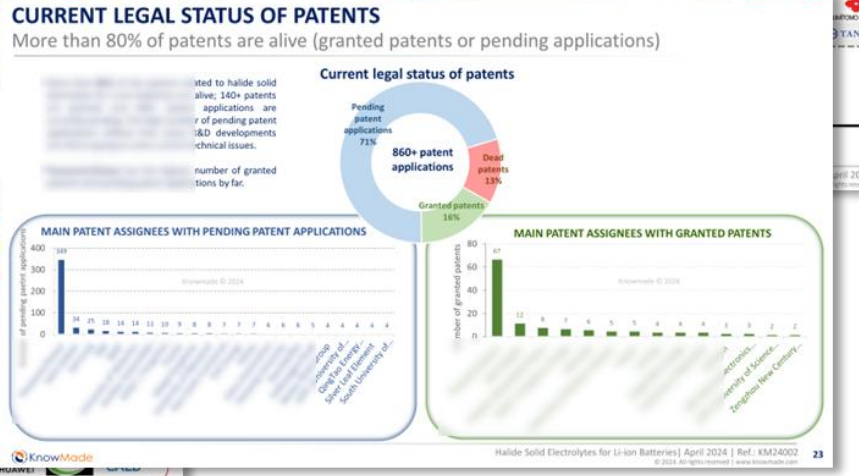
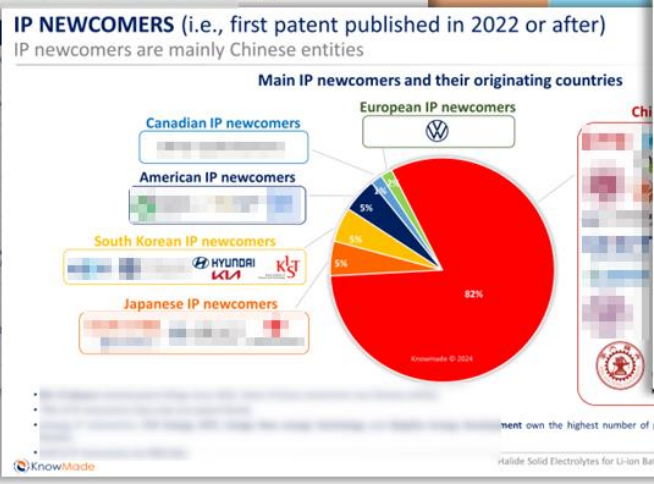
SAMPLE



START-UPS AND PURE PLAYERS

Start-ups and pure players mainly come from China

Patent assignees*	Company type	Headquarters
SVOLT / Fengshao Energy Technology		
Liongo New Energy Technology		



PATENT LANDSCAPE OVERVIEW

IP leaders, geographical coverage of patents, blocking potential of key players

SAMPLE

GEOGRAPHICAL DISTRIBUTION OF ALIVE PATENTS

IP portfolio geographic coverage of leading companies

Assignee	Headquarters	Number of patent families	Number of granted patents	Distribution of granted patents					
				USA	Europe	Japan	China	Korea	Other
Japan		105	47	15	0	13	22	7	12
China		21	8						
China		38	7						
Korea		35	6	3	1	1	1		
Canada		9	5						
China		7							
China		7	2						
Japan		7	1						
Korea		6	3						
China		6	4						
France		6	32	6	3				
Japan		6	5	4	2				
China		5	1						
China		5	1						
China		5	1						
China		4							

IP LEADERSHIP OF PATENT ASSIGNEES

IP leadership of patent assignees

The more the company combines a high number of granted patents with a high number of pending patent applications, the greater its IP leadership. The bubble size represents the number of patent families selected for the study.

LEGAL STATUS AND GEOGRAPHICAL COVERAGE OF PATENTS

Most of leading companies, their patents in foreign countries

Geographical coverage of patent portfolio	Legal status of patents		
	Mainly pending IP players which start or increase their patenting activity recently	Mainly granted Established IP players with no or limited recent patenting activity	Notable number of granted and pending Established IP players reinforcing their patent portfolio
Priority patents extended in one or several other countries			
Focused on China			
Focused on other domestic country			

KEY IP PLAYERS

have the stronger IP position

Key blocking IP players no more active since 2022
These IP players have a high capability to limit the FTO of other companies and still strengthen their patent portfolio, thanks to their high number of granted patents or highly cited granted patents, but they have not filed new patent applications since 2022.

Key blocking IP leaders
These players have a high capability to limit the FTO of other companies and still strengthen their patent portfolio, thanks to a high number of granted patents or highly cited granted patents, with a high number of pending patent applications and/or patent extensions.

IP leaders with low FTO blocking potential
These players have a low capability to limit the FTO of other companies, but their IP position could be improved.

IP STRENGTH OF PLAYERS

Other Chinese IP players

Assignee	Size
BYD	
USTC	
South University of Science & Technology of China	
Liangxi New Energy Technology	
QingTao Energy Development	
Rare Earth Functional Materials Innovation Center	
EVE Energy	
Baowu Steel Group	

IP STRENGTH OF PLAYERS

Key IP players have different capabilities to limit the IP activity of others

Patent assignee	Size	IP Position			Patenting activity
		Lead	IPB	FTO-SP	
Battiflex		SA	SA	SA	
Ningbo University		SA	SA	SA	

IP BLOCKING POTENTIAL OF PLAYERS

Despite their significant patenting

Prior Art Blocking Potential
Bubble size represents the number of patent families selected for the study.

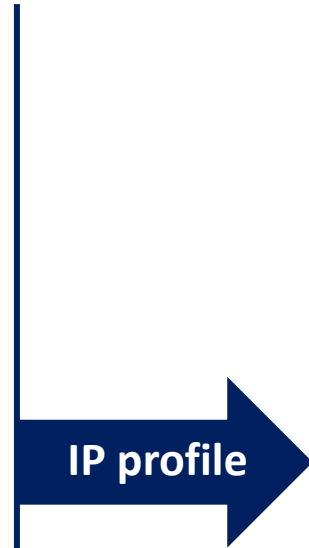
FTO blocking potential
Bubble size represents the number of patent families with granted patents selected for the study.

IP PROFILE OF KEY PLAYERS

IP portfolio summary, IP strategy, key patents and recent IP activity

SAMPLE

A focus on the **key IP players** and **newcomers** is provided in a dedicated section. For each player, the patent portfolio related to **halide solid electrolytes** is analyzed to provide an overview of its **level of IP activity**, **geographical coverage**, **strengths**, **potential for reinforcement**, and **key patented technologies**.



Material chemical formula	Ionic conductivity [mS/cm]	Representative number of patent
$\text{Li}_x\text{YBr}_{1-x}\text{Cl}_x$		
$\text{Li}_x\text{YBr}_{1-x}\text{Cl}_x$		
$\text{Li}_x\text{YBr}_{1-x}\text{Cl}_x$		
$\text{Li}_x\text{YBr}_{1-x}\text{Cl}_x$		
$\text{Li}_x\text{YBr}_{1-x}\text{Cl}_x$		
$\text{Li}_x\text{YBr}_{1-x}\text{Cl}_x$		
$\text{Li}_x\text{YBr}_{1-x}\text{Cl}_x$		
$\text{Li}_x\text{YBr}_{1-x}\text{Cl}_x$		
$\text{Li}_x\text{YBr}_{1-x}\text{Cl}_x$		
$\text{Li}_x\text{YBr}_{1-x}\text{Cl}_x$		

ORDER FORM

Halide Solid Electrolytes for Li-ion Batteries

Patent Landscape Analysis – April 2024

Ref.:KM24002



SHIP TO

Name (Mr/Ms/Dr/Pr):

Job Title:

Company:

Address:

City:

State:

Postcode/Zip:

Country:

VAT ID Number for EU members:

Tel:

Email:

Date:

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KnowMade S.A.R.L.
2405 route des Dolines, Le Drakkar,
06560 Valbonne Sophia Antipolis
FRANCE

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Bank: Banque Populaire Méditerranée, CAP 3000 Quartier du lac, 06700 St Laurent du Var, France
IBAN: FR76 1460 7003 6360 6214 5695 139
BIC/SWIFT: CCBPFRPPMAR

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- within a reasonable time for Products ordered prior to their effective release. In this case, the Seller shall use its best endeavours to inform the Buyer of an indicative release date and the evolution of the work in progress.

2.2 Some weeks prior to the release date the Seller can propose a pre-release discount to the Buyer.

The Seller shall by no means be responsible for any delay in respect of article 2.2 above, and including in cases where a new event or access to new contradictory information would require for the analyst extra time to compute or compare the data in order to enable the Seller to deliver a high quality Products.

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produce sufficient evidence of such defects.

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3.1 Prices are given in the orders corresponding to each Product sold on a unit basis or corresponding to annual subscriptions. They are expressed to be inclusive of all taxes. The prices may be reevaluated from time to time. The effective price is deemed to be the one applicable at the time of the order.

3.2 Payments due by the Buyer shall be sent by cheque payable to Knowmade, PayPal or by electronic transfer to the following account:

Banque Populaire Méditerranée, CAP 3000 Quartier du lac, 06700 St Laurent du Var, France

BIC or SWIFT code: CCBPFRPPMAR

IBAN: : FR76 1460 7003 6360 6214 5695 139

To ensure the payments, the Seller reserves the right to request down payments from the Buyer. In this case, the need of down payments will be mentioned on the order.

3.3 Payment is due by the Buyer to the Seller within 30 days from invoice date, except in the case of a particular written agreement. If the Buyer fails to pay within this time and fails to contact the Seller, the latter shall be entitled to invoice interest in arrears based on the annual rate Refi of the «BCE» + 7 points, in accordance with article L. 441-6 of the French Commercial Code. Our publications (report, database, tool...) are delivered only after reception of the payment.

3.4 In the event of termination of the contract, or of misconduct, during the contract, the Seller will have the right to invoice at the stage in progress, and to take legal action for damages.

4. LIABILITIES

4.1 The Buyer or any other individual or legal person acting on its behalf, being a business user buying the Products for its business activities, shall be solely responsible for choosing the Products and for the use and interpretations he makes of the documents it purchases, of the results he obtains, and of the advice and acts it deduces thereof.

4.2 The Seller shall only be liable for (i) direct and (ii) foreseeable pecuniary loss, caused by the Products or arising from a material breach of this agreement

4.3 In no event shall the Seller be liable for:

a) damages of any kind, including without limitation, incidental or consequential damages (including, but not limited to, damages for loss of profits, business interruption and loss of programs or information) arising out of the use of or inability to use the Seller’s website or the Products, or any information provided on the website, or in the Products;

b) any claim attributable to errors, omissions or other inaccuracies in the Product or interpretations thereof.

4.4 All the information contained in the Products has been obtained from sources believed to be reliable. The Seller does not warrant the accuracy, completeness adequacy or reliability of such information, which cannot be guaranteed to be free from errors.

4.5 All the Products that the Seller sells may, upon prior notice to the Buyer from time to time be modified by or substituted with similar Products meeting the needs of the Buyer. This modification shall not lead to the liability of the Seller, provided that the Seller ensures the substituted Product is similar to the Product initially ordered.

4.6 In the case where, after inspection, it is acknowledged that the Products contain defects, the Seller undertakes to replace the defective products as far as the supplies allow and without indemnities or compensation of any kind for labor costs, delays, loss caused or any other reason. The replacement is guaranteed for a maximum of two months starting from the delivery date. Any replacement is excluded for any event as set out in article 5 below.

4.7 The deadlines that the Seller is asked to state for the mailing of the Products are given for information only and are not guaranteed. If such deadlines are not met, it shall not lead to any damages or cancellation of the orders, except for non-acceptable delays exceeding [4] months from the stated deadline, without information from the Seller. In such case only, the Buyer shall be entitled to ask for a reimbursement of its first down payment to the exclusion of any further damages.

4.8 The Seller does not make any warranties, express or implied, including, without limitation, those of saleability and fitness for a particular purpose, with respect to the Products. Although the Seller shall take

reasonable steps to screen Products for infection of viruses, worms, Trojan horses or other codes containing contaminating or destructive properties before making the Products available, the Seller cannot guarantee that any Product will be free from infection.

5. FORCE MAJEURE

The Seller shall not be liable for any delay in performance directly or indirectly caused by or resulting from acts of nature, fire, flood, accident, riot, war, government intervention, embargoes, strikes, labor difficulties, equipment failure, late deliveries by suppliers or other difficulties which are beyond the control, and not the fault of the Seller.

6. PROTECTION OF THE SELLER’S IPR

6.1 All the IPR attached to the Products are and remain the property of the Seller and are protected under French and international copyright law and conventions.

6.2 The Buyer agreed not to disclose, copy, reproduce, redistribute, resell or publish the Product, or any part of it to any other party other than employees of its company. The Buyer shall have the right to use the Products solely for its own internal information purposes. In particular, the Buyer shall therefore not use the Product for purposes such as:

- Information storage and retrieval systems;

- Recordings and re-transmittals over any network (including any local area network);

- use in any timesharing, service bureau, bulletin board or similar arrangement or public display;

- Posting any Product to any other online service (including bulletin boards or the Internet);

- Licensing, leasing, selling, offering for sale or assigning the Product.

6.3 The Buyer shall be solely responsible towards the Seller of all infringements of this obligation, whether this infringement comes from its employees or any person to whom the Buyer has sent the Products and shall personally take care of any related proceedings, and the Buyer shall bear related financial consequences in their entirety.

6.4 The Buyer shall define within its company point of contact for the needs of the contract. This person will be the recipient of each new report in PDF format. This person shall also be responsible for respect of the copyrights and will guaranty that the Products are not disseminated out of the company.

7. TERMINATION

7.1 If the Buyer cancels the order in whole or in part or postpones the date of mailing, the Buyer shall indemnify the Seller for the entire costs that have been incurred as at the date of notification by the Buyer of such delay or cancellation. This may also apply for any other direct or indirect consequential loss that may be borne by the Seller, following this decision.

7.2 In the event of breach by one Party under these conditions or the order, the non-breaching Party may send a notification to the other by recorded delivery letter upon which, after a period of thirty (30) days without solving the problem, the non-breaching Party shall be entitled to terminate all the pending orders, without being liable for any compensation.

8. MISCELLANEOUS

All the provisions of these Terms and Conditions are for the benefit of the Seller itself, but also for its licensors, employees and agents. Each of them is entitled to assert and enforce those provisions against the Buyer.

Any notices under these Terms and Conditions shall be given in writing. They shall be effective upon receipt by the other Party.

The Seller may, from time to time, update these Terms and Conditions and the Buyer, is deemed to have accepted the latest version of these terms and conditions, provided they have been communicated to him in due time.

9. GOVERNING LAW AND JURISDICTION

9.1 Any dispute arising out or linked to these Terms and Conditions or to any contract (orders) entered into in application of these Terms and Conditions shall be settled by the French Commercial Courts of Grasse, which shall have exclusive jurisdiction upon such issues.

9.2 French law shall govern the relation between the Buyer and the Seller, in accordance with these Terms and Conditions.

KNOWMADE

Patent and Technology Intelligence

KNOWMADE PURPOSE

Turning **patent information** and **scientific literature** into actionable insights, providing high added value reports for **decision-makers** working in **R&D, Intellectual Property, Innovation Strategy, and Marketing**

Competitive landscape | Technology trends | Opportunities / Risks | R&D and IP strategy



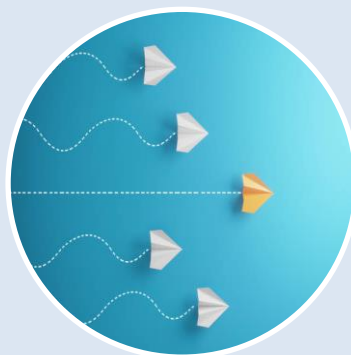
WHAT INFORMATION CAN YOU GET ?



MARKET

*For executives,
business developers*

- Identify competitors
- Compare IP with market position
- Evaluate the level of investment
- Future products & target markets



TECHNOLOGY

*For R&D teams,
engineers, scientists*

- R&D activities
- Technological roadmap
- Position on the supply chain



INTELLECTUAL PROPERTY

*For IP teams,
patent attorneys*

- Risks and opportunities (FTO, litigations, licensing)
- Key patents
- Link between patents and products

KNOWMADE OFFER

CUSTOM SERVICES

(Tailor-made analysis)

To meet your needs and budget/lead time constraints

- Specific and dedicated report.
- Prior-art search, freedom-to-operate, patent landscape, patent valuation, technology scouting, monitoring service, etc.

Format

- PDF file with analyses.
- Excel file with data.
- Access to the analyst.

REPORTS

(multi-client product)

To understand the competitive landscape and explore the emerging ecosystems and new technologies

- Stand alone report
- Patent landscape.
- Overview on IP dynamics, trends and players.
- Competitor, technology and strategy analysis.
- Benchmark of patent portfolios.
- Key IP players & key patents.

Format

- PDF file with analyses.
- Excel file with patent data.

MONITORS

(multi-client product)

To track the latest R&D developments and IP activities, and to be sensitive to weak signals

- Annual subscription
- Patent monitoring service.
- Quarterly updated patent data and technology trends.
- Current R&D and IP activities.
- Early detect weak signals, opportunities and risks.
- Open discussion with analyst.

Format

- PDF file with analyses.
- Excel file with patent data.
- Direct access to the analyst.

INSIGHTS

(free article & webinar)

To get unique information about industry and technology

- Analyst point of view about industry news (product release, M&A, start-up, fund-raising, etc.) from a patent perspective.

Format

- Knowmade website

MAIN FIELDS OF EXPERTISE

SEMICONDUCTORS

- Materials & Substrates
- Power electronics
- RF & Wireless datacom
- MEMS, Sensing & Imaging
- Photonics, Lighting & Display
- Memory
- Packaging

ENERGY

- Batteries
- Fuel-cells
- Solar PV
- Power management

HEALTHCARE

- Therapeutic tools
- Diagnostics and Theragnostics
- Medical devices and imaging
- Drug discovery and delivery

AGRI-FOOD

- Food processing & formulation
- Vegan food
- Next-gen packaging
- Agriculture 4.0





Energy storage devices

- Batteries
- Fuel cells
- Supercapacitors
- Primary & Secondary devices
- Thin film & Microdevices
- Cylindrical, prismatic, pouch



Whole supply chain

- Active Materials
- Battery electrodes, electrolytes, separators
- Fuel cell electrodes, membranes, catalysts, gas diffusion layer, bipolar plates, electrolytes
- Battery cells / Fuel cells
- Battery packs / Fuel cell stacks
- Manufacturing & Recycling



Key technologies

Li-ion batteries

- LTO, Li-metal, silicon anodes
- NMC, NCA, LNMO, LFP cathodes
- Solid electrolytes

Post Li-ion batteries

- Na-ion
- Li-S
- Mg-ion
- Al-ion
- Ca-ion
- Zn-ion
- F-ion
- Li-air

Fuel cells

- PEMFC
- SOFC
- MCFC
- PAFC
- AFC



Energy

from materials and cells to modules and systems

All applications

- Automotive (BEV, FCEV)
- Consumer electronics
- Stationary energy storage



Power Management & Control

- Power electronics
- BMS
- Thermal management





Solid-state Li-ion batteries

PATENT LANDSCAPE REPORT

- Solid-State Li-ion Batteries with Inorganic Solid Electrolytes
- Solid Electrolytes for Li-ion Solid-State Batteries
- Halides Solid Electrolytes

PATENT MONITOR

- Solid-state Li-ion Batteries



Active materials and their use in Li batteries

PATENT LANDSCAPE REPORT

- Silicon Anode for Li-ion Batteries
- LFP Li-ion Batteries *(in development)*
- NMC Li-ion Batteries

PATENT MONITOR

- Silicon Anode for Li-ion Batteries *(in development)*



Post Li-ion Batteries

PATENT LANDSCAPE REPORT

- Na-ion Batteries *(in development)*



Fuel Cells

PATENT LANDSCAPE REPORT

- Hydrogen Fuel Cells



Recycling

PATENT LANDSCAPE REPORT

- Recycling of Li-ion Batteries *(in development)*

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[IP reports](#)

[IP monitors](#)

[Insights](#)





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