

November 1, 2022

 OSAKA SODA CO., LTD.

2022 日韓IoTビジネスフロンティア交流・商談会

## Special Polymer for Semi-Solid Polymer Battery (Gelling Agent for electrolyte)

*Innovation Center  
Development & Commercialization Div.  
OSAKA SODA Co., Ltd.*

 OSAKA SODA

 DAISO CHEMICAL CO., LTD.

 Something Better with Chemicals

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 OSAKA SODA

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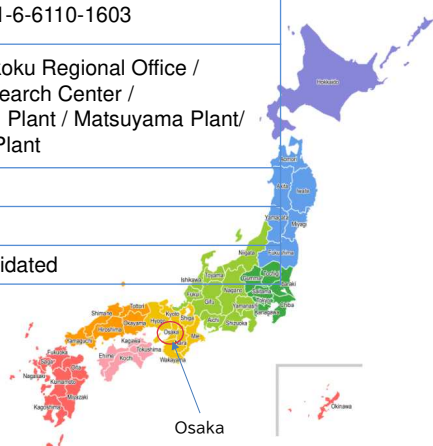
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## 1. Corporate Profile (As of March, 2022)

Company Name	<b>OSAKA SODA CO., LTD.</b>
Representative	Kenshi Terada President & CEO
Headquarters	12-18, Awaza 1-chome, Nishi-ku, Osaka City, Osaka, Japan 550-0011 Tel:+81-6-6110-1560 Fax:+81-6-6110-1603
Offices	Tokyo Branch / Chugoku-Shikoku Regional Office / Kyushu Regional Office / Research Center / Kitakyushu Plant / Amagasaki Plant / Matsuyama Plant/ Mizushima Plant / Okayama Plant
Establishment	October 26, 1915
Capital	¥ 15,871 million
Employees	Consolidated 991 Non-consolidated



head office



## Business Fields

### Basic Chemical Products

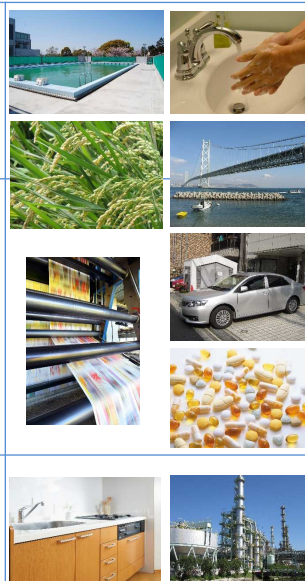
Caustic Soda, Hydrochloric Acid, Liquid Chlorine, Chlorine Gas, Sodium Hypochlorite, Sodium Chlorite, Sodium Chlorate, Caustic Potash, Hydrogen Gas, Epichlorohydrin, Allyl Chloride, Paint Materials, Adhesive Materials etc.

### Functional Chemical Products

Allyl Derivatives, Epichlorohydrin Rubber 'EPICHLOMER™', Acrylic Rubber 'RACRESTER™', Diallyl Phthalates 'DAISO DAP™', Non-Phthalate allyl resin 'RADPAR™', Polysulfide System Silane Coupling Agent 'CABRUS', Silica gel for HPLC 'DAISOGEL™', HPLC Column 'CAPCELL PAK™', Bulk Pharmaceuticals and Intermediates, Optically Active Substance, Lens Materials, Photosensitive Resin, Color Resist, Electrodes 'NEOLORD™' Glass Fiber, Material Recycle etc.

### Housing Facilities and others

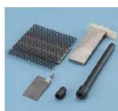
DAP Decorative Board, Housing Facilities, Health Food, Chemicals Plant, Transportation and storage of chemical products, Environmental preservation facilities etc.



## Group Companies in Japan



**DAISO CHEMICAL CO., LTD.**  
[Sale of Chemical Products]  
12-18, Awaza 1-chome, Nishi-ku,  
Osaka 550-0011, Japan



**DAISO ENGINEERING CO., LTD.**  
[Manufacture and Sale of Electrodes, Design and Processing of Chemical Equipment]  
12-18, Awaza 1-chome, Nishi-ku,  
Osaka 550-0011, Japan



**SANYO FINE CO., LTD.**  
[Manufacture and Sale of APIs and Intermediates]  
12-18, Awaza 1-chome, Nishi-ku,  
Osaka 550-0011, Japan



**JMR CO., LTD.**  
[Resource Recycling]  
9-2, Otakasu-cho, Amagasaki,  
Hyogo 660-0842, Japan



**DS LOGISTICS CO., LTD.**  
[Shipping and Handling for Chemical Products]  
11, Otakasu-cho, Amagasaki,  
Hyogo 660-0842, Japan



**SANYO FINE IRICA TECHNOLOGY CO., LTD.**  
[Manufacture of Columns, Devices, and other Analysis Equipment]  
12, Nishikawabecho, Higashikujo,  
Minami-ku, Kyoto 601-8037, Japan



**DS WELLFOODS CO., LTD.**  
[Manufacture, Processing and Sale of Health Food Materials]  
12-18, Awaza 1-chome, Nishi-ku,  
Osaka 550-0011, Japan



**DAISO INSURANCE CO. LTD.**  
[Providing nonlife and life insurance products & services]  
12-18, Awaza 1-chome, Nishi-ku,  
Osaka 550-0011, Japan



**NITTO KAKO CO., LTD.**  
[Manufacture and Sale of Industrial Rubbers and Resin Products]  
6-1-3, Ichinomiya, Samukawa-machi,  
Kouza-gun, Kanagawa 253-0111,  
Japan



**INB Planning Co., Ltd.**  
[Manufacture and Sale of Rubber Compounds]  
1-100 Takaka-cho, Obu,  
Aichi 474-0042, Japan

## Overseas Group Companies



**SANYO FINE TRADING CO., LTD.**  
[Sale of Columns, Devices, and other Analysis Equipment]  
Room 02, 20th Floor, Jinghui Building,  
NO.118 Jianguo Road Yi, Chaoyang  
District, Beijing, 100022, China



**DAISO Fine Chem USA, Inc.**  
[Sale of Pharmaceutical Purification Materials]  
3848 Carson Street,  
Suite 105 Torrance, CA 90503, USA



**DAISO CHEMICAL (Shanghai) CO., LTD.**  
[Importation and Exportation of Functional Chemicals, Electronic Materials, etc.]  
Room No.901, Tower1, NO.523,  
Loushuan Road, Changning District,  
Shanghai, P.R.C. 200051, China



**TAIWAN DAISO CHEMICAL CO., LTD.**  
[Importation and Exportation of Functional Chemicals, Electronic Materials, etc.]  
3F-1, No.112, Sec.2, Zhongshan N.Rd.,  
Zhongshan Dis., Taipei, Taiwan,  
R.O.C. 10449







**DAISO Fine Chem GmbH**  
[Sale of Pharmaceutical Purification Materials and Functional Chemicals]  
Immermannstrasse 13, 40210,  
Duesseldorf, Germany



**DAISO CHEMICAL (THAILAND) CO., LTD.**  
[Importation and Exportation of Functional Chemicals, Electronic Materials, etc.]  
54 Harindhorn Tower, 9th floor, Unit 9F,  
North Sathorn Rd, Silom, Bangrak,  
Bangkok 10500, Thailand

## 100 years of manufacturing history

Expanding from basic chemicals to functional chemicals and further to pharmaceutical-related fields

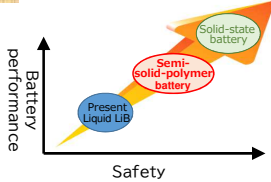
<b>Founding period (1915-)</b>	<b>Started business of basic chemicals (inorganic chemistry)</b> Electrolysis of salt by original technology Succeeded in industrialization of caustic soda	<b>Main products</b> Caustic soda, liquefied chlorine, hydrochloric acid, hydrogen gas, caustic potash, sodium hypochlorite, etc.	
<b>1960s-</b>	<b>Started business of functional chemicals (organic chemistry) Entered the petrochemical business</b> Select chlorination of propylene	<b>Main products</b> Epichlorohydrin, Allyl Chloride, DAISO DAP™, DAP Decorative Board, Agricultural chemicals, etc.	
<b>1980s-</b>	<b>Expansion of functional chemicals</b> Succeeded in developing high-performance chemical products	<b>Main products</b> Allyl ethers, Epichlorohydrin Rubber, Electrodes, optically active materials, refined pharmaceutical materials, pharmaceutical intermediates, etc.	
<b>2000s~</b>	<b>Expansion of business areas for functional chemicals</b> Expanding to pharmaceutical-related fields	<b>Main products</b> Drug substance, diagnostic agent, acrylic rubber, Modifier for energy-saving tires, Non-phthalate type allyl resin, column, Analytical instruments, functional food materials, Resource recycling, etc.	

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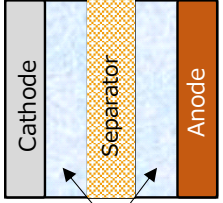
## 2. Evolution of LiB and Semi-Solid-Polymer Battery

### What is Semi-Solid-Polymer (SSP) Battery?

“The electrolyte gelled(semi-solid)” LiB  
 It can be improved safety and performance, keeping the current liquid-based LiB process.

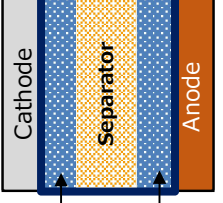


**Present Liquid LiB**



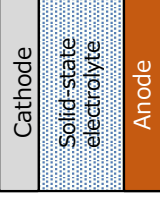
Liquid electrolyte

**SSP battery**



Polymer Layer (GEL) absorbing electrolyte

**Solid-state battery**



Solid-state electrolyte

High ← Risk of liquid leakage and ignition → Low

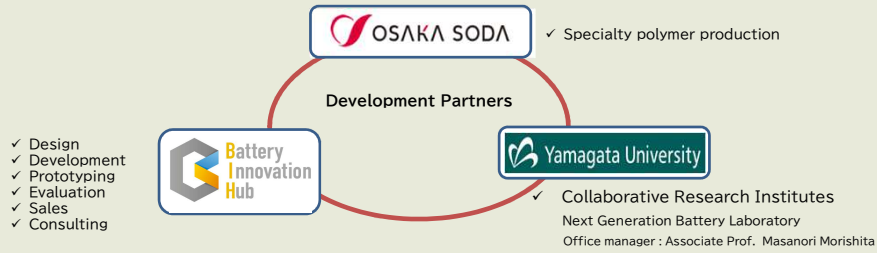
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### 3. Background of the development of SSP battery

#### ■ SSP battery using our special polymer

Point

- ✓ Excellent battery safety
- ✓ Excellent battery performance



#### Safety performance (Nail penetration test)



### 4. Key Technology of Special Polymer for battery

Expansion of special rubber technology for automobiles into battery applications

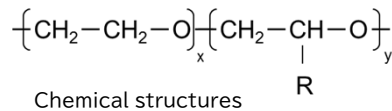


Polyether rubber  
EPICHLONER™



battery-specific design

Special Polymer for battery



- < Features > High electrolyte retention      High ion conductivity
- < Effect > Reduced battery resistance      Improved battery performance

## Basic Properties of special polymer

### 1. Good ionic conductivity

- Lower crystallinity and glass transition temperature ( $T_g < -70^\circ\text{C}$ ) than general-purpose polyethers, and high solubility of Li salts

### 2. Wide potential window 0 to 4.3 V vs. Li<sup>+</sup>/Li

### 3. Forms stable interface with metallic Li

### 4. Good mechanical properties

- High molecular weight ( $M_w > 106$ )
- Viscoelasticity can be imparted by cross-linking with heat or UV light irradiation

### 5. Good processing properties / thin films and gels can be easily prepared

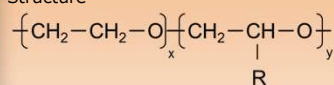
- Soluble in water, alcohols, toluene and other common solvents
- Can be cross-linked by heat or UV light
- Can be applied to substrates such as separators and electrodes

## Effects of applying the gel to batteries

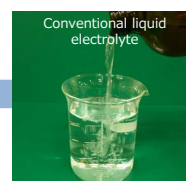
Gelator for LIB electrolyte using our special synthetic rubber "Epichromer™" (\*)  
 technology (\*) World's top share in epichlorohydrin rubber, which is indispensable for automotive parts

### Gelator for electrolyte (special polyether)

Structure



High molecular weight, high ionic conductivity, high liquid retention, and high solubility based on original technology



### Characteristics of Gel Electrolyte and Effects on Batteries

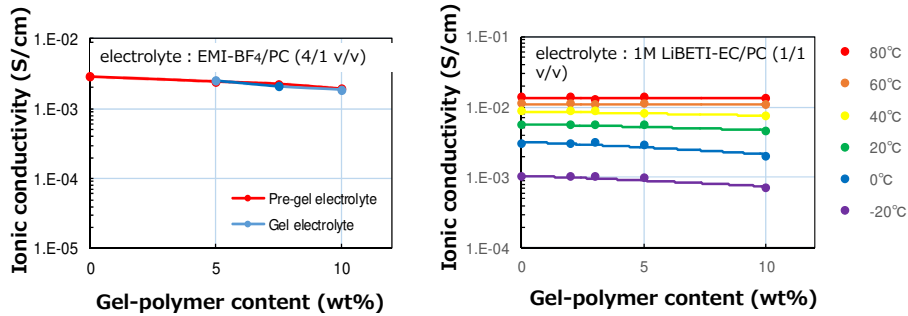
- ✓ Suppresses thermal runaway and gas generation in the event of an accident  
 → Improved battery safety
- ✓ Improvement of liquid retention and suppression of gas generation  
 → Increased battery life (improved charge-discharge cycle characteristics)
- ✓ Higher flexibility, thinner film, and larger size  
 → Increased flexibility in battery design



Gels electrolyte with high liquid retention!

## Ionic conductivity of gel electrolyte

Ionic conductivity of gel electrolytes prepared by adding up to 10 wt% gelling agent to the electrolyte



➤ There is almost no loss of ionic conductivity due to gelation

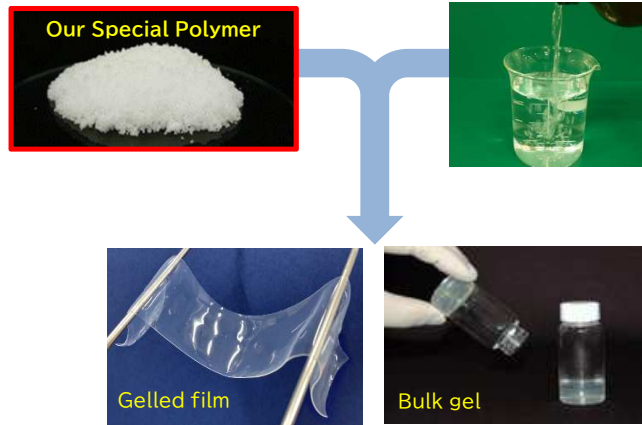
## 5. Features of SSP battery

Battery performance improved by SSP batteries

1. Suppress Liquid leaking
2. Suppression of gas generation
3. Lengthen the life of batteries
4. Reduce the risk of ignition
5. Reduce a time of charging
6. Suppress the self-discharge

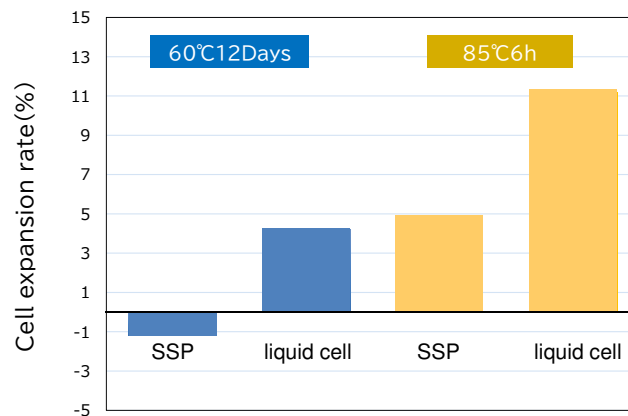
## 5-1. Suppress Liquid leaking

Suppress Liquid leaking



- High electrolyte retention
- High processing characteristics

## 5-2. Suppression of gas generation



Reduces swelling due to gassing during high temperature storage and cyclic charging/discharging and improves battery life

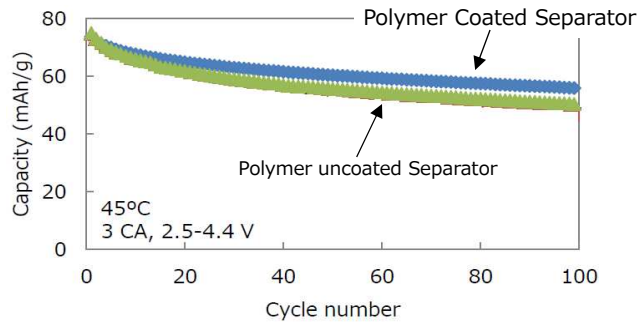
Provided by battery manufacturer



### 5-3. Cycle Characteristics of SSP Battery①

Improve the cycle life

Charge/discharge cycle characteristics



LMO/Graphite 2032 coin cell  
Electrode size : Anode 13mmφ, Cathode 14 mmφ  
Cycle condition: 2.5V-4.4V, 3CA, 45°C

\* Joint Research with Yamagata University

### 5-4. Nailing Test of SSP Battery

Improved safety

Battery for iPhone cases made in China



SSP Battery prototype cell



Video: Provided by Yamagata University

## 6. Comparison of conventional and PPS batteries

	Conventional Liquid-battery	SSP-battery (Present point)
Use	For Small-sized consumer	For Small-sized consumer
Shape	Cylinder Laminate	Cylinder Laminate
Cathode materials	Ni,Co,Mn layered base Fe olivine base	Ni,Co,Mn layered base
Electrolyte	Liquid	Gel(Semi-solid)
Safety	Risk of liquid leakage and ignition	No liquid leakage No ignition

SSP batteries can cover current liquid LiB applications, shapes, and materials, and can improve safety by preventing liquid leakage and smoke emissions.

## 7. Application to a Smartphone case (Prototype)




Battery Case for Smartphones with Semi-Solid Polymer Batteries  
Scheduled to be released in 2023 by BIH co.,ltd.



### Development in the future

- Yamagata Univ. and BIH take the lead in OEM production of SSP- batteries
- Manufacture of batteries using our special polymers for smartphone cases
- Plans to mass-produce SSP batteries by 2023

 **Thank you for your attention**

Contact: Takashi MATSUO (e-mail: [tmatsuo@osaka-soda.co.jp](mailto:tmatsuo@osaka-soda.co.jp))  
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Innovation center  
Development & Commercialization Div.