UNIPORE™

INTRODUCING A NEW METHOD FOR PRODUCING SAFER AND MORE EFFICIENT SECONDARY BATTERY SEPARATORS

PRESENTED BY EDGEX.,LTD

CONTENTS

COMPANY INTRODUCTION

EdgeX is the subsidiary of the KONEC Co., Ltd group.

EdgeX is a spin-off startup company set out to bring new products and service technologies to the market.

18 products and innovations registered at the Korean Intellectual Property Office

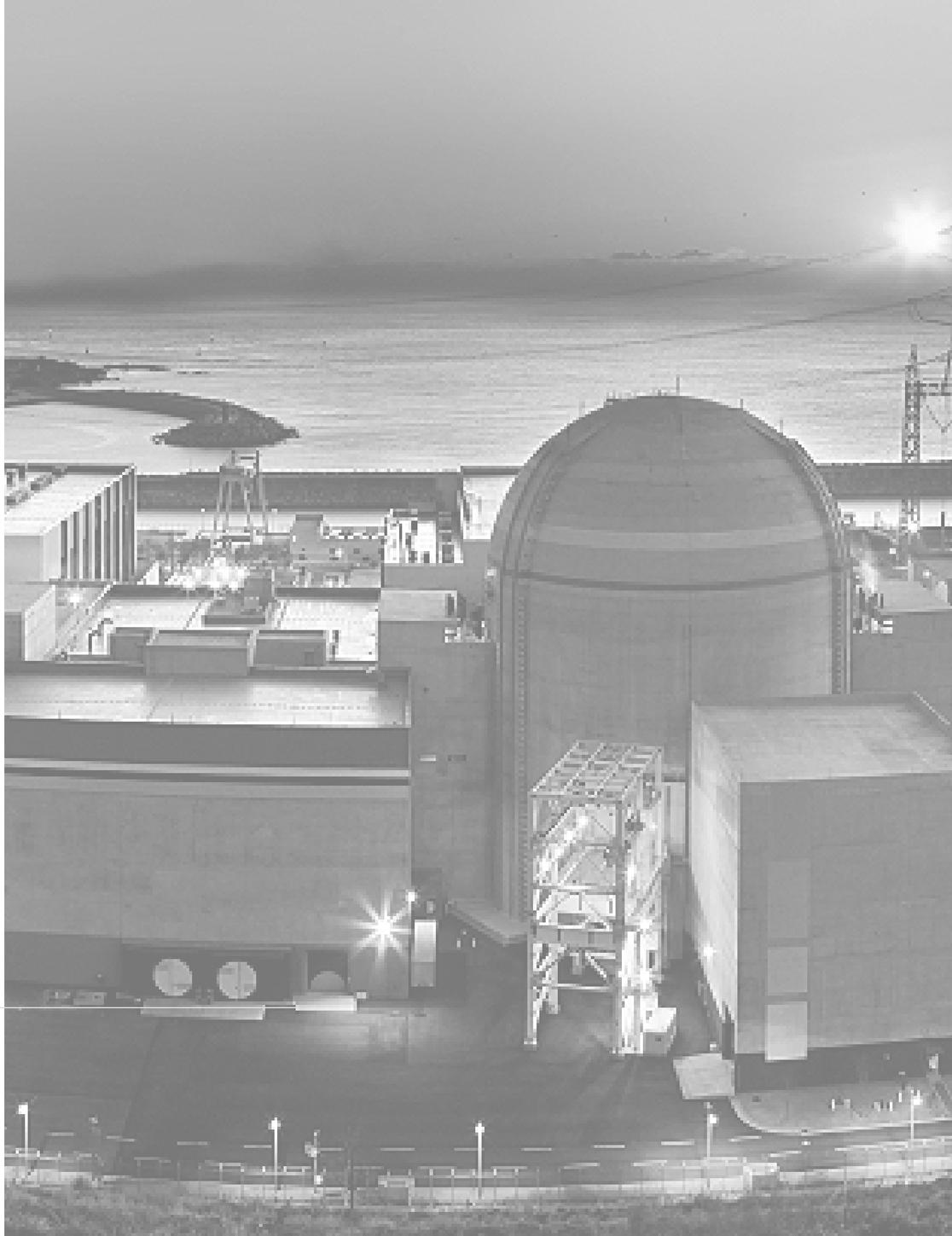
ABOUT KONEC

Korea Nuclear Engineering Management Corporation (KONEC) focuses on the management of nuclear and radioactive waste, and provides engineering services.

Tel: +82-2-539-7196

E-mail: konec2@naver.com

Address: #1712(SK V1 Tower) 25, Yeonmujang 5 ga-gil,Seongdong-gu, Seoul, Korea.



INTRODUCING UNIPORE™

*Patents Pending

UNIPORE™ technology produces separator membranes with homogeneous pores and distribution enabling mechanical strength and stability while increasing porosity and wettability to increased Li-ion transport.

UNIFORM

Uniform pore size, shape, and distribution, ensuring homogeneous lithium-ion transport

POROSITY

Increased porosity, over 50% of the separator membrane's surface.

STRUCTURE

Optimal pore structure improves air permeability, wettability, and lithium-ion conductivity while suppressing dendritic growth.

STABLE

Stable and controlled mechanical structure, ensures homogenous structure, resulting in a significant reduction in defect waste.

MATERIALS

The material is not restricted to PE & PP materials, but any of the polyamide series can also, be used alone or in combination, enhancing wettability, durability, and thermal stability.

MANUFACTURING

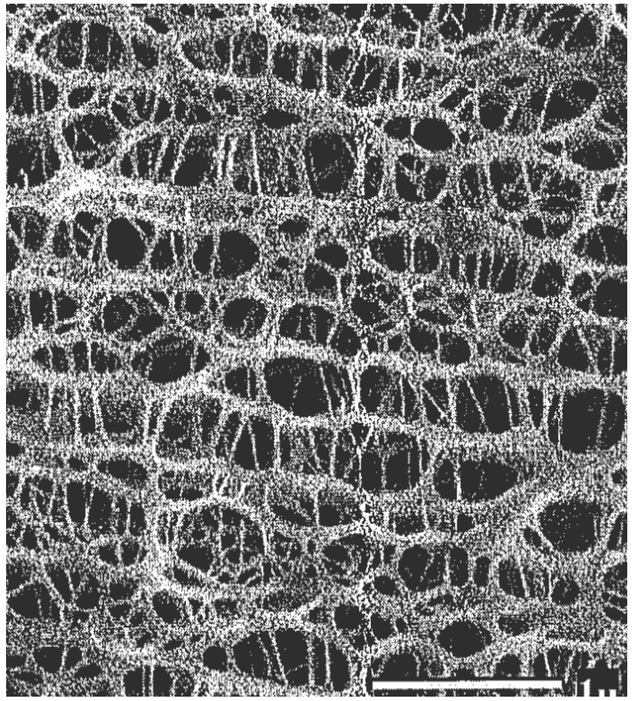
Manufacturing optimization provides cost-competitiveness, with no need for additives or stretching.

LIMITATIONS OF EXISTING PRODUCTS

TRADE-OFF BETWEEN EFFICIENCY AND SAFETY

Currently, the challenge with designing secondary battery separators is the trade-off between mechanical robustness and porosity/transport properties.

The pore-area is relatively small, 40% or less of the membrane surface area.	Reduces air permeability and ionic conductivity, affecting overall cell performance.
The inconsistent pore size and distribution can make separators subject to compressive stresses, which can deform the separator by several micrometres.	Limits the discharge rate, causes thermal damage to the separator, loss of structural integrity and increasing the risk of a short circuit.
Standard separator structure reduces the ionic conductivities of the electrolyte in the pore space to approximately 5–20% compared to the value of bulk liquid electrolyte.	Alone the geometric structure of the separator reduces ion transport to 16% of what it would be in a vat of electrolyte, unimpeded by the structure.



* The image shows the separator surface of the biaxially stretched wet method.

IMPACT ON SEPARATOR PRODUCTION

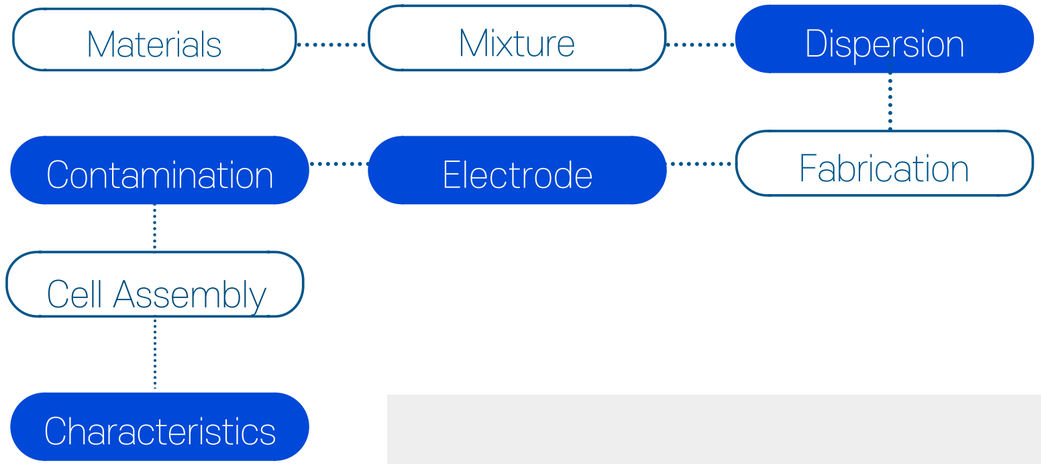
The separators account for up to 26% of the total secondary battery's production cost.

Thin NMP case	Breakdown	$/Ah	$/kWh
Cu foil	5.6%	0.0491	14.02
Anode	8.1%	0.0704	20.12
Separator	26.0%	0.2268	64.80
Cathode	32.7%	0.2855	81.58
Al Foil	0.5%	0.0048	1.37
Pouch material	2.2%	0.0191	5.46
Tab materials	0.5%	0.0045	1.28
Solvent	1.9%	0.0166	4.73
Solvent drying	6.9%	0.0606	17.30
Solvent recovery	5.7%	0.0493	14.09
Electrolyte	9.9%	0.0861	24.61
Total	100.0%	0.8728	249.36

*Costs are for cell construction only and do not include SEI formation step and pack assembly costs.

The manufacturing process of the cells is managed, the quality checked after the mixture stage for dispersion and after fabricating the membrane electrodes, and contamination is checked. Finally, after assembling the cell its overall characteristics and performance is judged.

QUALITY CHECKS:



Approximately 20 % of separator membranes are discarded due to product deficiencies, caused by the current manufacturing process.

OUR TECHNOLOGY INNOVATION

OUR "POROUS MICROSPHERE MANUFACTURING METHOD", PRODUCES A STABLE, HOMOGENEOUS SEPARATOR STRUCTURE, OFFERING CONTROL OVER PORE SIZE, SHAPE AND DISTRIBUTION, OPTIMIZING EFFICIENCY WITHOUT RISKING SAFETY.

01 CONTROL

Uniform pore size and morphology, enabling higher porosity and efficiency.

02 SAFETY

Homogeneous transport ensuring enhanced thermal stability and durability.

03 LITHIUM-ION TRANSPORT

Uniform pore size and dispersion maximizing air permeability and ionic conductivity.

04 COST COMPETITIVENESS

Cost-efficient production minimizing defective products, controlled and uniform separator structure.

UNIPORE™ SEPARATOR MANUFACTURING PROCESS

"POROUS MICROSPHERE METHOD"

CURRENT METHODS	UNIPORE SEPARATOR
Complex processes including additives and stretching.	The simple process does not require reforming or texturing the film with no additives or strecthing.
Up to 20% of the manufactured separator membranes, need to be discarded to inconsistency in the size of the pores and membrane structure.	The size of the pores can be controlled and optimized, providing a homonegious structure.
Both PP and/or PE are used to manufacture the the porous structure of the membrane, but sacrificing thermal stability, wettability and ionic conductivity	The best materials can be chosen based on ionic transport properties and thermal stability, for instance, any materials from the polyamide series can be used.

STEP1.
Steel microspheres are mixed with liquid polymer. The diameter of the spheres is set according to need.

STEP2.
A thin film is produced, wherein the spheres are positioned within its thickness having a portion of the spheres protrude.

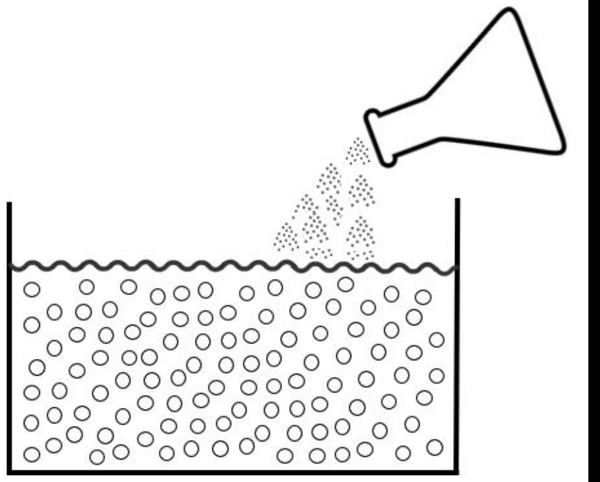
STEP3.
The removal of the spheres is performed by creating a magnetic field on one or both sides of the thin film.

STEP4.
Finally, the film is cured through infrared rays, ultraviolet rays, and hot air, smoothing the edge of the pores on the surface.

*For more details please refer to the process flowchart

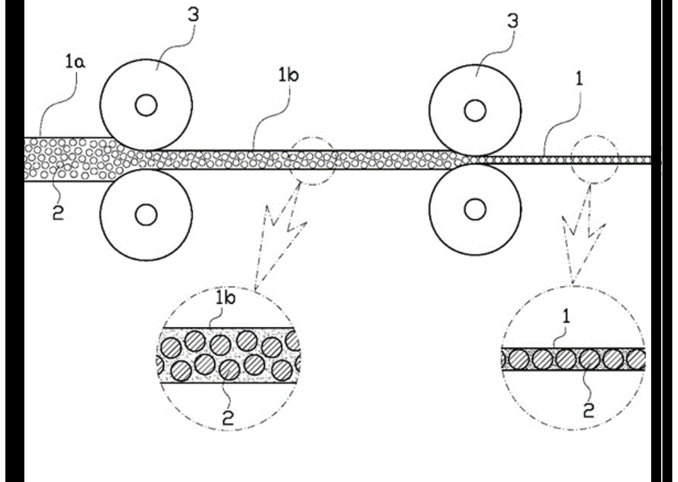
PROCESS FLOW CHART

01



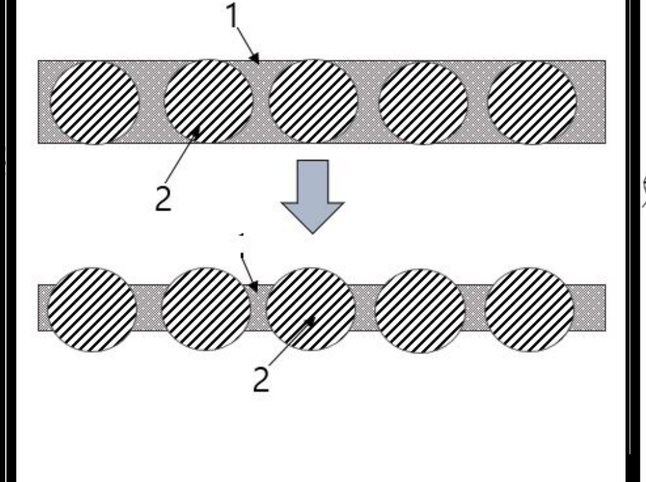
A number of steel microspheres is firstly mixed with liquid polymer. The diameter of the spheres is set according to the appropriate thickness of the pores needed.

02



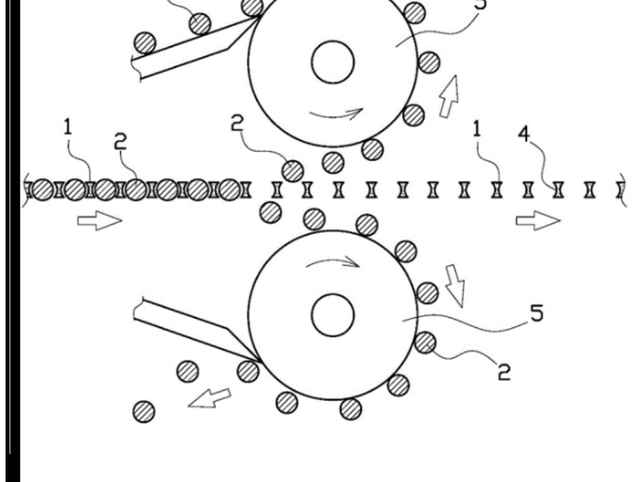
The mixture is used to produce a thin film, wherein the spheres are positioned within the thickness of the thin film or in a single line.

03



The steel microspheres are positioned to slightly protrude from the film surface.

04

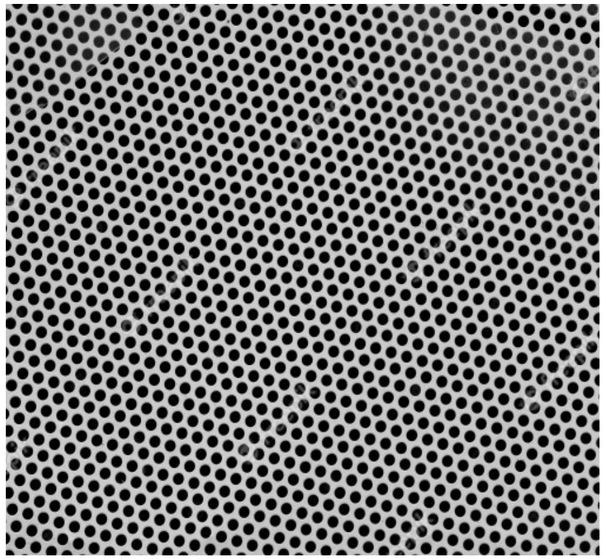


The removal of the spheres is performed by creating a magnetic field on both sides of the thin, porous film so that the spheres can be easily extracted from the film.

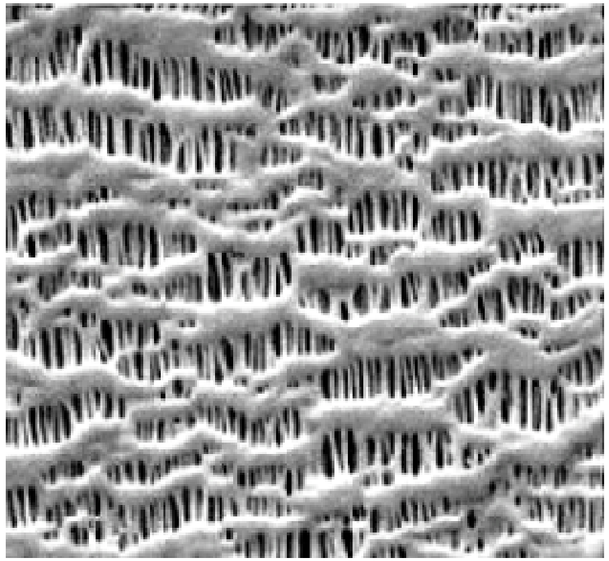
SURFACE COMPARISON

Both the separator structure and the interaction between pore-space surface and liquid electrolyte impact Lithium-ion transport and contribute to cell overpotentials.

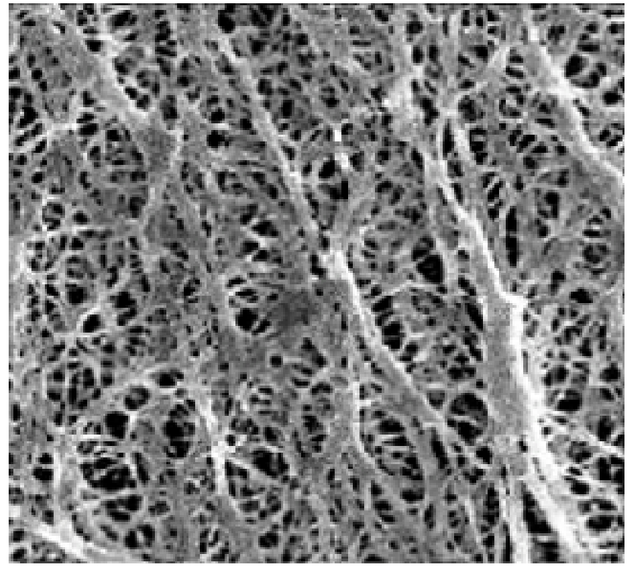
The geometric structure of the separator reduces Lithium-ion transport to 16% of what it would be based on vat of electrolyte capability, unimpeded by the structure.



IDENTICAL PORE
MICROSPHERE METHOD



BIAXIALLY STRETCHED
DRY METHOD



BIAXIALLY STRETCHED
WET METHOD

KEY BENEFITS

UNIPORE™ technology produces separator membranes with homogeneous pores and distribution improving mechanical strength and stability, while increasing porosity and wettability to increase Li-ion transport.

01	Control over the pore size	Uniform pore size and distribution, enabling homogeneous Li-ion transportand stable structure d separators, that will be constant in every manufactured unit.
02	Increased porosity	Increased porosity of over 50%, increasing the lithium-ionic transport, and wettability without reducing mechanicalstrength.
03	Improved Li-ion transport	The uniformity of the pore structure improves lithium transport properties.
04	Increased safety	Using polyamide series, and the stable mechanical separator structure improves the thermal stability and reduces risks of swelling, shutdown, and short circuit.

KEY BENEFITS

05 **Increased permeability**

The hollow shape of the pore increases the permeability of the lithium-ions as a result of the decrease in the contact area of the hydrophobic separator (PE) .

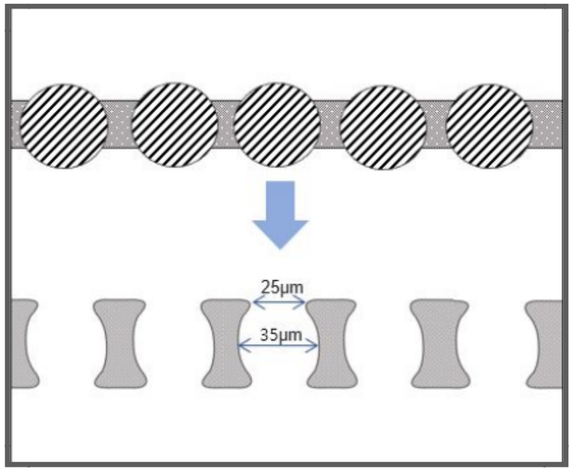
06 **Less coating required**

Alteration of robust material of separator enables less coating.

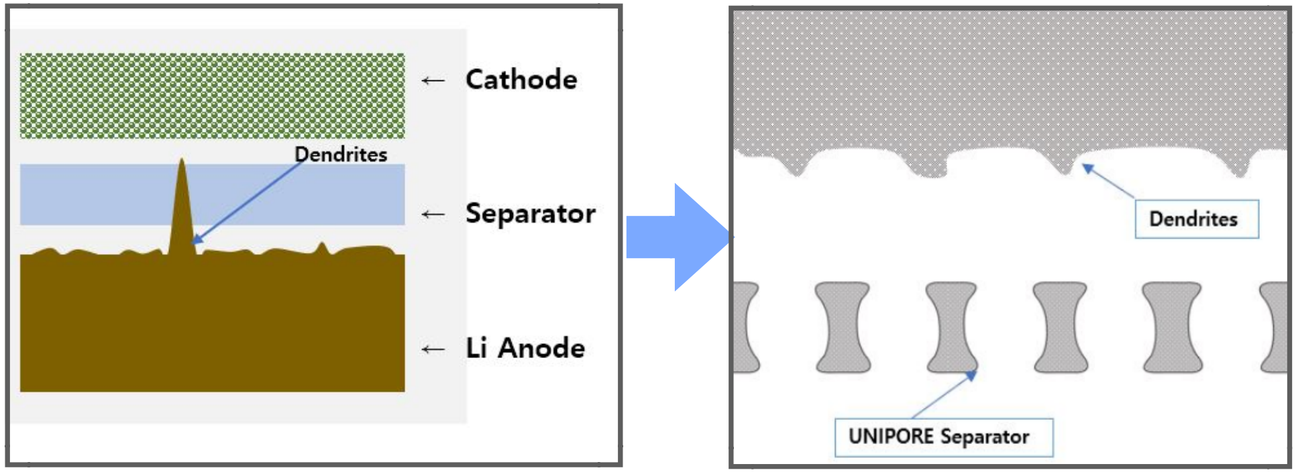
07 **Reduction of dendrite**

Eliminating the non-uniformity of the surface, with the homogenous shape of spheres, produces battery separator with low dendrite and improves their safety and strengthen their capacity.

5. INCREASED PERMEABILITY



7. REDUCTION OF DENDRITE



WHAT WE OFFER

COST

Cost competitive materials and process

CONTROL

Porosity can be optimized, homogenious structure

EFFICIENCY

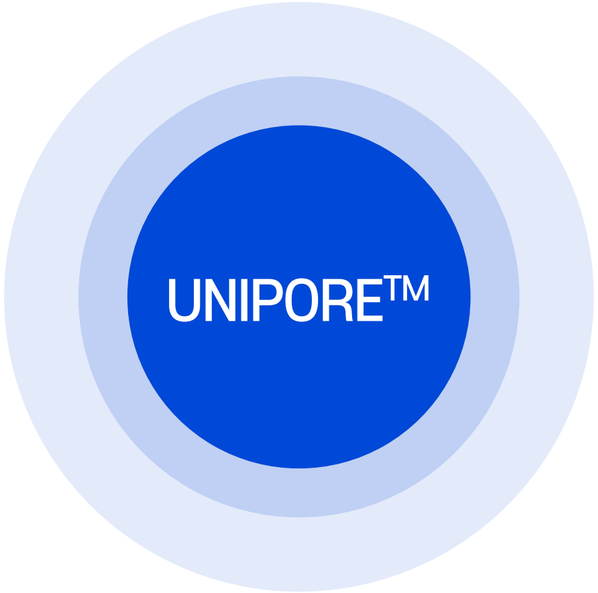
Maximized lithium-ion transport

SAFETY

Steady separator structure, thermal stables materials

SUSTAINABILITY

Considerable decrease in waste of defects



Uniform pore structure, increasing stability, permeability, transference and wettability.

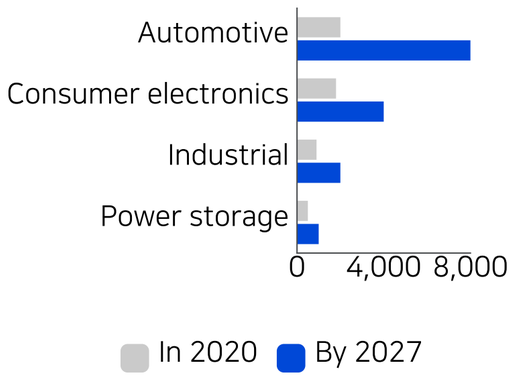
THE GLOBAL SEPARATOR MARKET

Global Battery Separators Market size reached USD 6.6 billion in 2020 and will showcase a growth rate of around 16.1% CAGR from 2021 to 2027.

2027 USD 12.42 billion

Asia CAGR	16.2%
LATAM CAGR	16.2%
Europe CAGR	20%

Global separator market by end-user (Million Square Meters)



https://www.marketsandmarkets.com

KEY MARKET PLAYERS:

THE FUTURE PROSPECTS

Our Identical Pore Separator (IPS) technology provides a safe and stable foundation on which secondary batteries can efficiently live up to their potential of becoming the future primary energy solution.

Separators comprise over 20% of the total battery cell cost, therefore decreasing the separator manufacturing cost will have a significant impact.

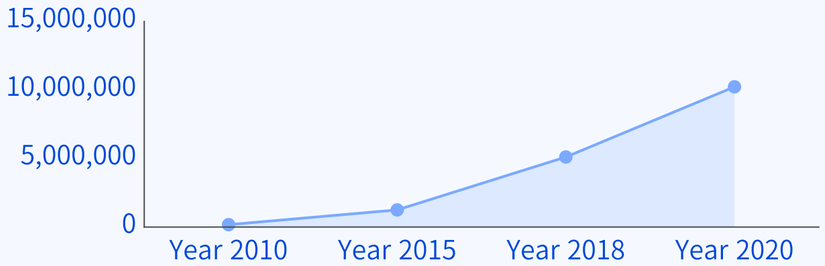
Battery separators are one of the most fast-growing industries receiving much attention and funding globally, driving towards a more sustainable future.

Lithium-ion battery development

Advancements in battery technology have dramatically increased the demand for improvement in separator design.

Existing separators, either in commercial usage or under the development stage, have yet to meet the high stability and lifespan performance standards necessary to prevent deterioration in the battery technologies' efficiency and reliability.

Electronic car stocks



In recent years, electric vehicles (EVs) have become the biggest consumers of lithium-ion batteries, owing to the sales growth of of EVs.

THANK YOU