

# CellForce<sup>®</sup> HT

**A low ER separator with the top of the line  
high temperature oxidation resistance**

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Microporous LLC,  
Piney Flats, Tennessee 37686 USA



**19th Asian Battery**  
Conference & Exhibition

# Our History

Over our 80+ year history, Microporous has firmly established a reputation for quality and innovation, offering the broadest line of high-performance battery separators to a global customer base.

American Rubber Company creates and patents the first rubber battery separator, Ace-Sil®



1934



American Rubber Co. is acquired by Amerace Corp.

Piney Flats facility becomes operational



1953



Amerace develops and patents Flex-Sil®

Microporous creates and patents the CellForce® separator



1978



Microporous installs its first PE and CellForce separator manufacturing line in Piney Flats

Microporous begins construction of a separator production facility in Feistritz, Austria



1999

2000



FTC mandates the divestiture of Microporous. New management team brought on board and operating as a fully independent company

2007

Feistritz installs third line to produce CellForce® and DuroForce™



2013



Piney Flats, TN. Expansion, groundbreaking ceremony.

2016

CellForce ULR becomes the newest separator in the Microporous family of products



2018

2019



Global partnership for manufacturing, distributing and developing Next-Gen AGM separator

Now

# MP's Product Portfolio

## Automotive



### CellForce® ULR™

Ultra Low Resistance  
PE-Rubber separator for  
EFB & SLI applications



### DuroForce® Ultra™

Low ER, puncture resistant  
PE separator for SLI  
application



### DuroForce® XE™

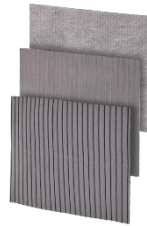
Extra Elongation, Low ER,  
puncture resistant PE  
separator for SLI application



### GlassForce® GF, PP Series

Absorbent Glass Mat (AGM)  
separators and pasting papers  
for VRLA automotive  
applications

## Motive Power



### Flex-Sil®

Ultra Low water loss rubber  
separator for Motive Power  
deep-cycle applications



### CellForce®

Low water loss PE-Rubber  
separator for Motive  
Power applications



### DuroForce® CL™

Durable, low ER, oxidation  
resistant PE separator for  
Motive Power applications



### GlassForce® IG, PP Series

Absorbent Glass Mat (AGM)  
separators and pasting papers  
for VRLA Motive Power  
applications

## Stationary



### Ace-Sil®

Ultra long life rubber  
separator for stationary  
applications



### CellForce®

Low water loss PE-Rubber  
separator for Stationary  
applications



### DuroForce® CL™

Durable, low ER, puncture  
resistant PE separator for  
Stationary applications



### GlassForce® FB, PP Series

Absorbent Glass Mat (AGM)  
separators and pasting papers  
for VRLA Stationary  
applications

# Products Map

| Automotive         |              |                   |                 |                  |
|--------------------|--------------|-------------------|-----------------|------------------|
| Applications       | Battery Type | Legacy Products   | New Products    | Future Products  |
| <i>SLI</i>         | SFB          | DuroForce® Ultra™ | CellForce® ULR™ |                  |
| <i>Start/Stop</i>  | EFB          |                   | CellForce® ULR™ |                  |
|                    |              |                   |                 | DuroForce® OE    |
|                    |              |                   |                 | DCA™ Booster Mat |
|                    | AGM          |                   | GlassForce™     |                  |
|                    |              |                   |                 | MaxiWik™         |
| Motive Power       |              |                   |                 |                  |
| Applications       | Battery Type | Legacy Products   | New Products    | Future Products  |
| <i>Forklifts</i>   | SFB          | DuroForce® CL™    |                 | CellForce® XAS   |
|                    | AGM          |                   | GlassForce™     | DCA™ Booster Mat |
| <i>LSEV</i>        | SFB          | Flex-Sil®         |                 | CellForce® XAS   |
|                    | AGM          | CellForce®        | GlassForce™     |                  |
| Stationary         |              |                   |                 |                  |
| Applications       | Battery type | Legacy Products   | New Products    | Future Products  |
| <i>Telecom/UPS</i> | SFB          | Ace-Sil®          |                 |                  |
|                    |              | DuroForce® CL™    |                 |                  |
|                    |              | CellForce®        |                 |                  |
|                    | AGM          |                   | GlassForce™     |                  |
| <i>ESS</i>         | AGM          |                   | GlassForce™     |                  |

## Separators

Legacy Products

CellForce® ULR™

GlassForce™

DuroForce® OE

CellForce® XAS™

## Laminates

DCA™ Booster Mat

MaxiWik™

## Pasting Papers

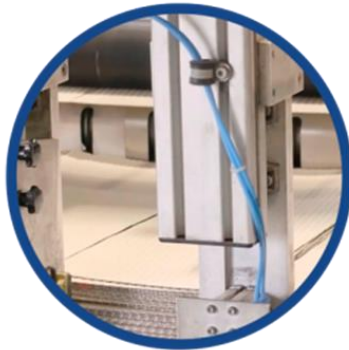
GlassForce™

# How Can We Partner with You?

With the most diverse separator portfolio in the deep-cycle market, Microporous supplies rubber, polyethylene (PE), and hybrid separators to serve all lead-acid battery markets, from automotive to nuclear.

## Easy To Work With

- Best in class service
- Customized solutions
- Customer intimacy



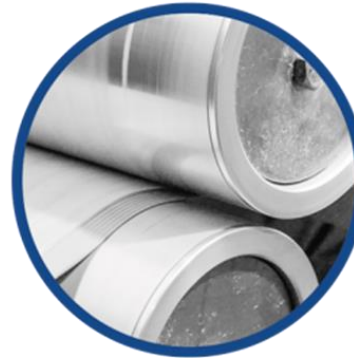
## Production Capabilities

- Five state-of-the-art PE lines
- Separator Capacities over 130MM SqM
- Custom solutions for all customers
- Roll Stock-universal or panel, Cut Piece, with or w/o Glass mat



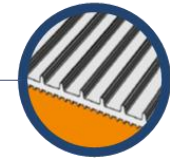
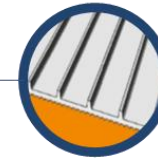
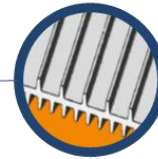
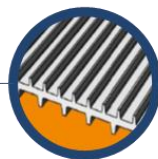
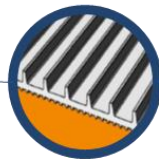
## Tool Capabilities

- 150µm BW to 700µm BW
- Widest range of overall thickness
- Available in a variety of rib pitches
- Positive rib profiles to suit all demands
- Mini/negative rib available



## Separator Profiles

- A wide range
- Advanced possibilities
- Custom solutions
- Automotive/SLI/EFB
- Industrial Sleeve/Universal
- Min-rib/Micro-rib/S-Mini



## **Product Description:**

A UHMWPE-based separator with Ultra Low Resistance for Fast Charging

## **Innovation:**

- Optimized formula for ultra low electrical resistance (ER)
- Minimizes ER to enhance charge acceptance and high rate performance in demanding applications
- Modifies the surface chemistry of the CellForce® systematically to improve the hydrophilicity of the PE separators

## **Targeted market segments:**

- Flooded for SLI aftermarket
- Can be manufactured with Industrial backwebs

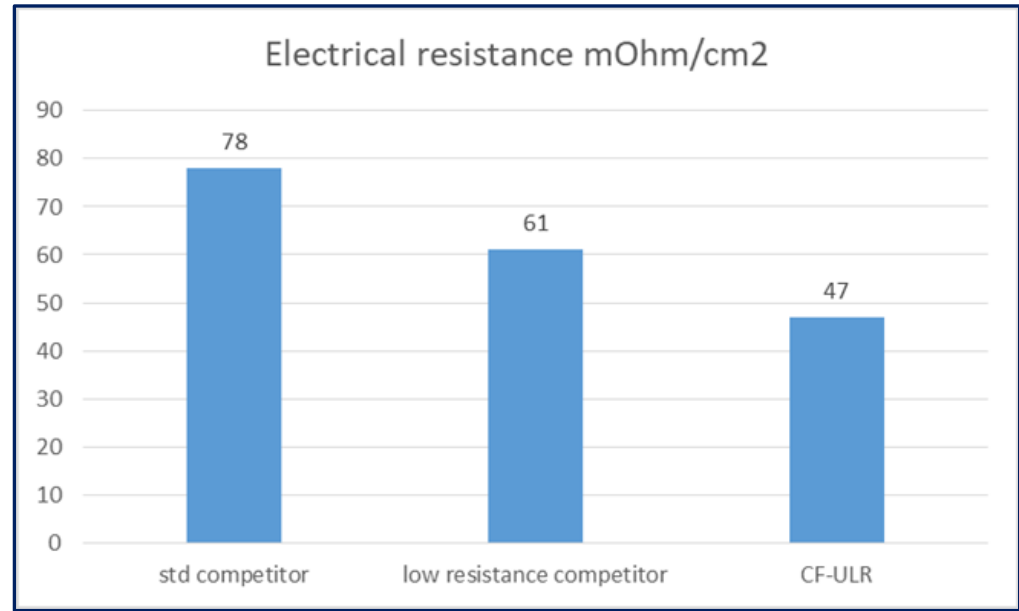
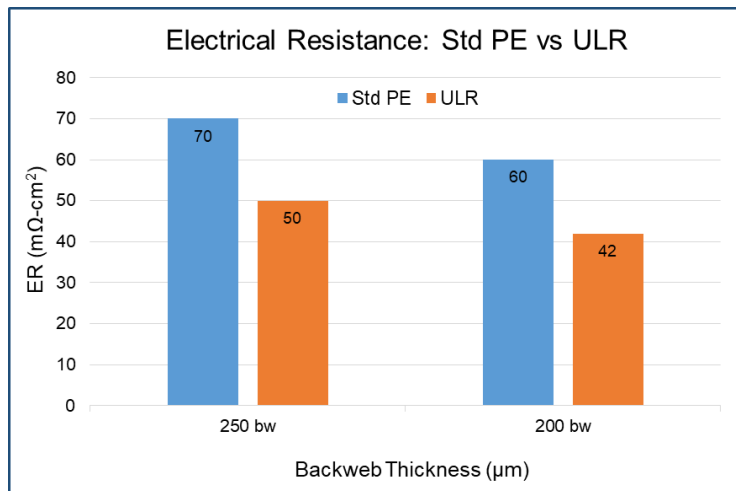
## **Product availability**

4Q20



## Performance targets:

- 30% Reduction in ER compared to Standard PE separators
- ER:  $\leq 50 \text{ m}\Omega\text{-cm}^2$  (250 BW),  $\leq 40 \text{ m}\Omega\text{-cm}^2$  (200 BW)
- Retention of CMD Elongation after Perox 40 hrs:  $> 60\%$



## **Product Description:**

High-temperature oxidation resistant separator for the Automotive OE market (EFB)

## **Innovation:**

- Re-design separator's physical/chemical characteristics based on fundamental understanding of the structure-property-relationship of mixed-matrix composites
- Sophisticated blending of the separator's key ingredients to maximize synergistic improvement of oxidation resistance with low ER

## **Targeted market segments:**

Automotive OE EFB market

## **Product availability**

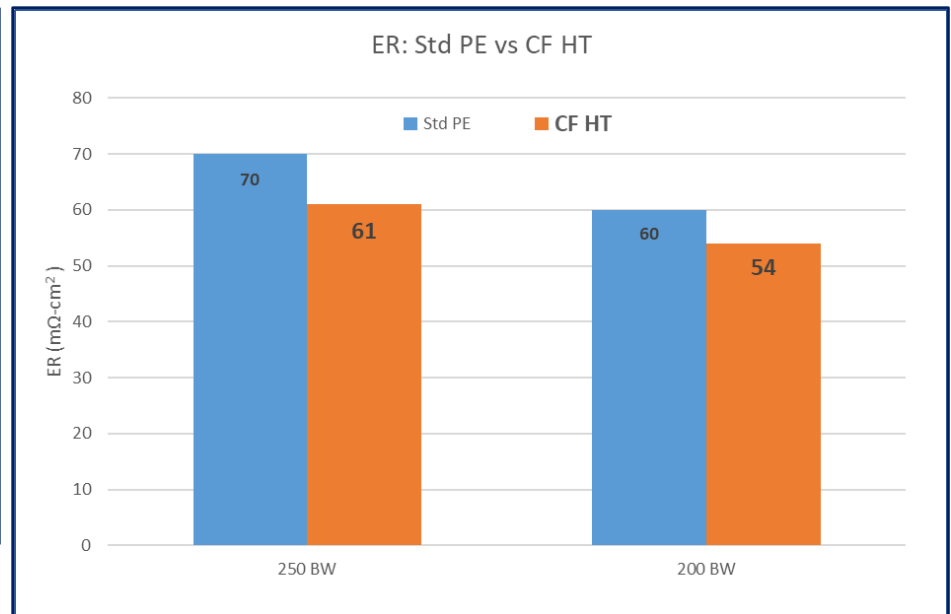
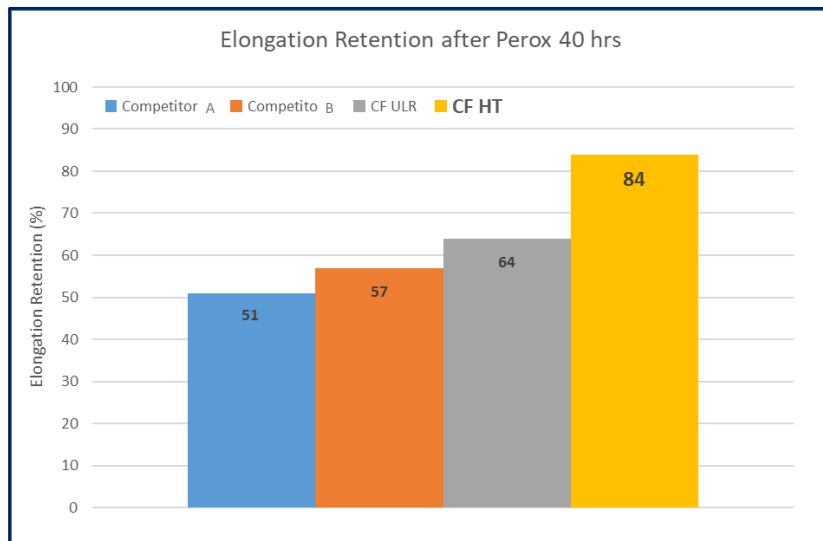
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## Performance targets:

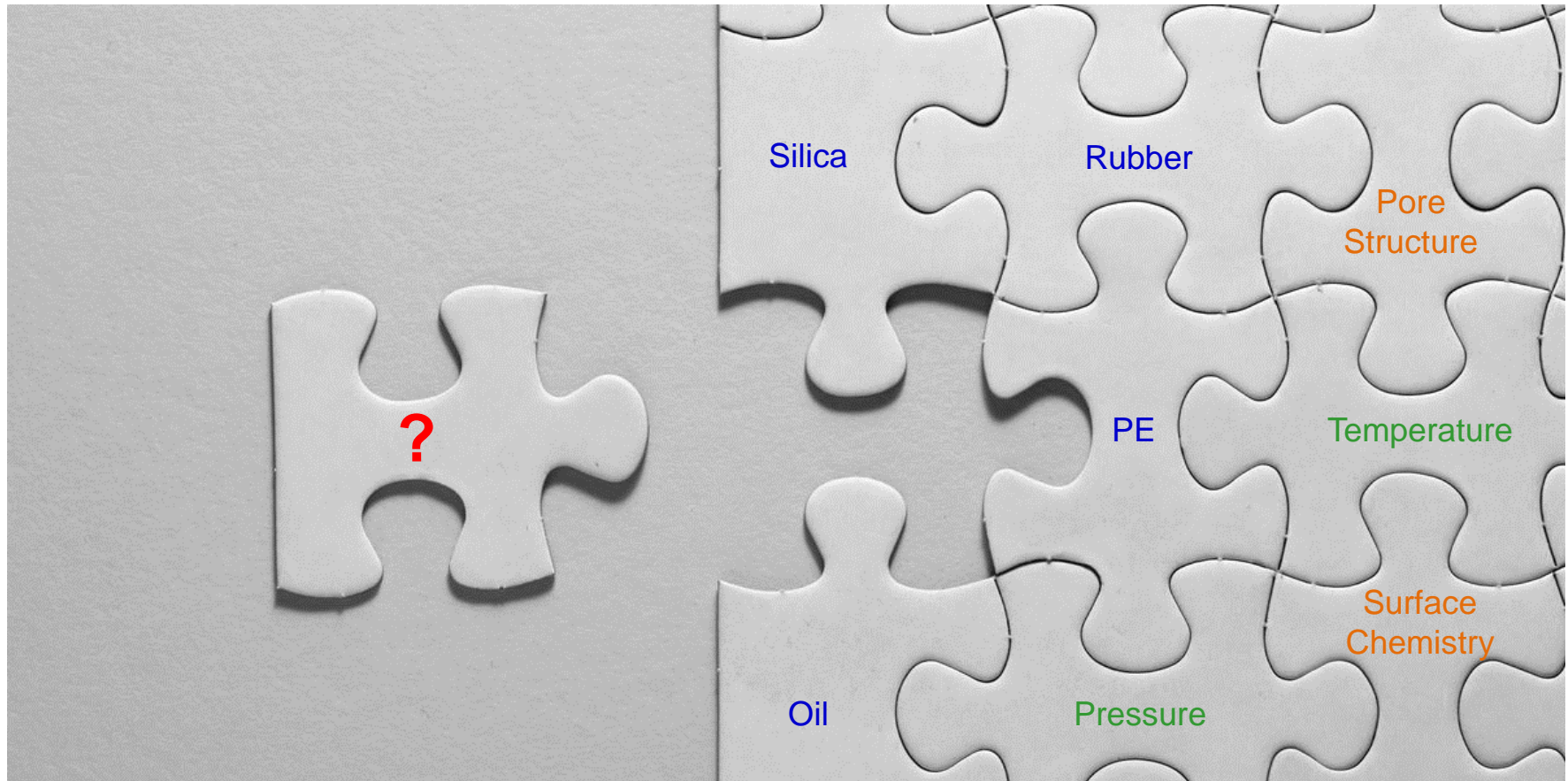
- High temperature oxidation resistance: Kill Test (5 A, 75 °C) > 150 hrs
- ER:  $\leq 65 \text{ m}\Omega\text{-cm}^2$  (250 BW),  $\leq 55 \text{ m}\Omega\text{-cm}^2$  (200 BW)
- Retention of CMD elongation after Perox 40 hrs: > 80%



# An Unsolved Problem in Separator Industry

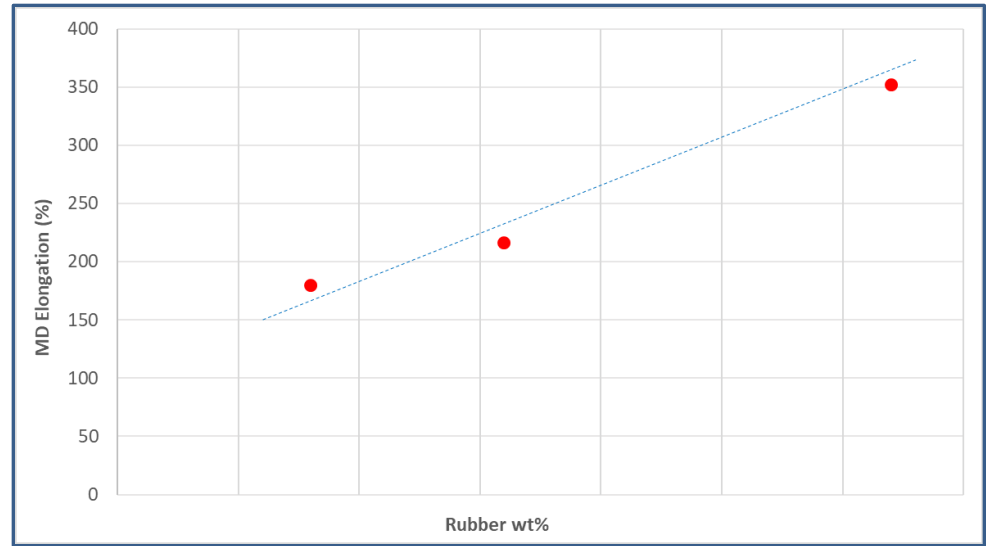
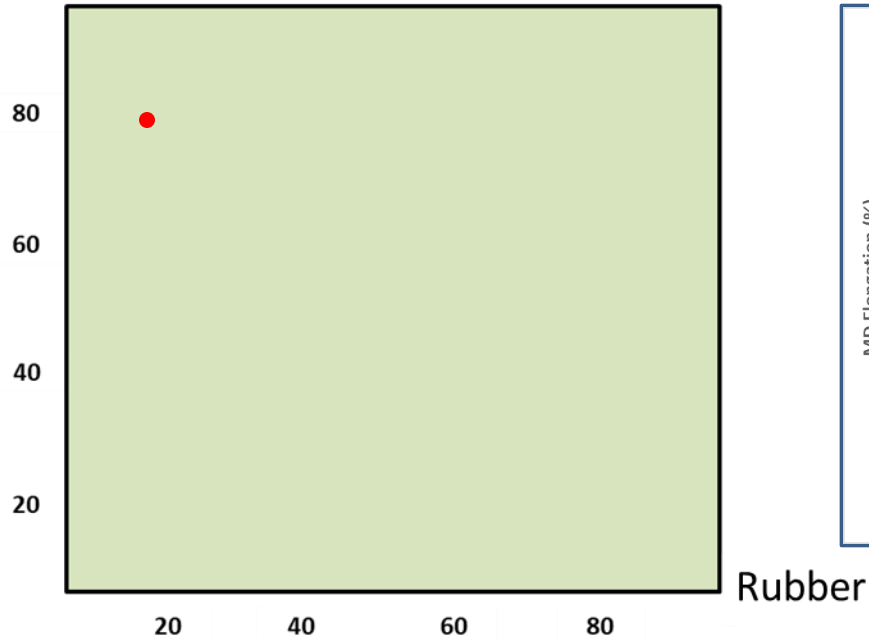
How to improve high temperature oxidation resistance without raising ER?

→ We started from a basic question, “why it has been unsolved so long?”



# Conventional: Single-Variable Analysis

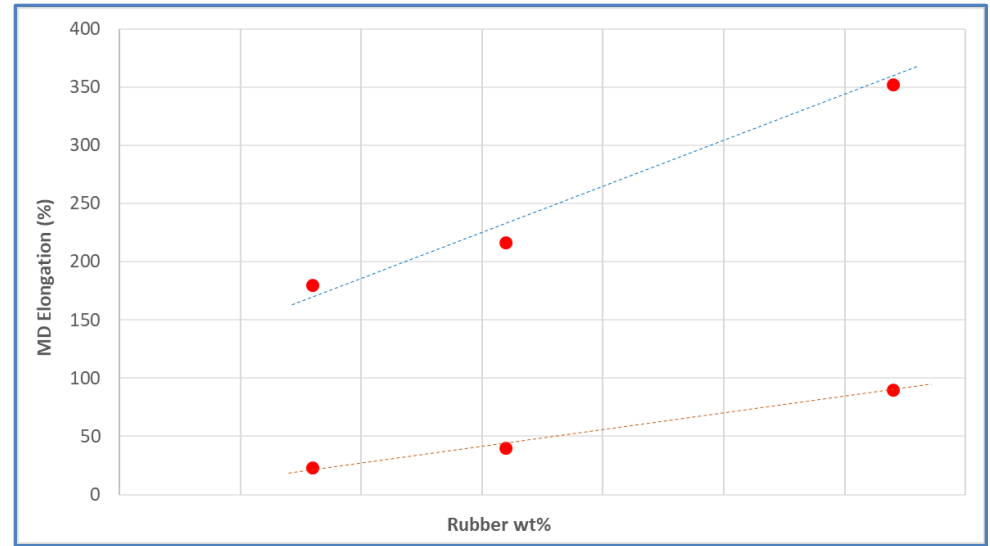
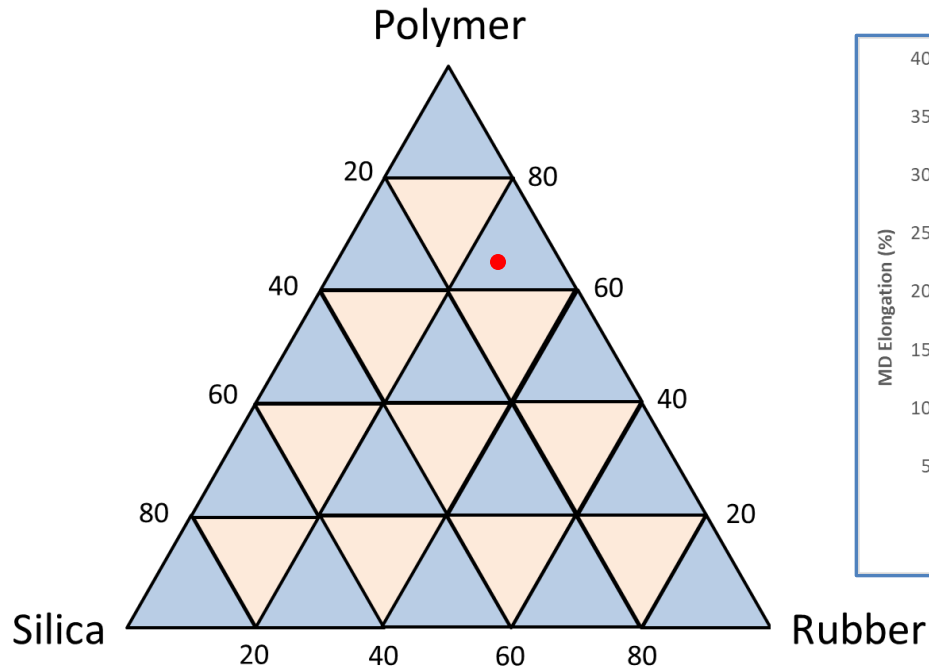
Polymer



## ● Simple approach

- Treat separators such as a binary composite
  - one-to-one correspondence analysis, straightforward, easy to understand
  - However, possibly too simplified to solve the open questions of separator industries

# Our R&D Direction: Multi-Variable Analysis



## ● Complex approach

- Treat separators such as a ternary/quaternary composite
  - solving multi-variable questions, complicated, hard to model/predict
  - However, possibly enable a wide spectrum of property changes that has been untouched

# Design Perspective: How to improve a property?

## ● Conventional design philosophy

$$SP = f(x) \text{ or } SP = f(y)$$

*SP*: separator properties (elongation, ER, etc.)

*x*: content of a constituent (e.g., wt% of rubber)

*y*: a specific process parameter (e.g., T)

## ● Our methodology

$$P = f(x_1, x_2, \dots, x_n, y_1, y_2, \dots, y_n)$$

$$C = f(x_1, x_2, \dots, x_n, y_1, y_2, \dots, y_n)$$

$$SP = f(C, P)$$

$x_1, x_2, \dots, x_n$ : content of each component

$y_1, y_2, \dots, y_n$ : process parameters

*P*: physical structure of a separator  
(e.g., pore characteristics)

*C*: chemical structure of a separator  
(e.g., surface chemistry)

# Example: Things to consider

- What should be considered to improve a single property of separator?
- Example: if we set MD elongation as SP

- Conventional approach

$$SP = f(x) \text{ or } SP = f(y)$$

$x$ : wt% of rubber

$y$ : calendaring temperature

- Our approach

$$P = f(x_1, x_2, \dots, x_n, y_1, y_2, \dots, y_n)$$

$$C = f(x_1, x_2, \dots, x_n, y_1, y_2, \dots, y_n)$$

$$SP = f(C, P)$$

$x_1$ : wt% of rubber

$x_2$ : wt% of silica

$x_3$ : wt% of oil

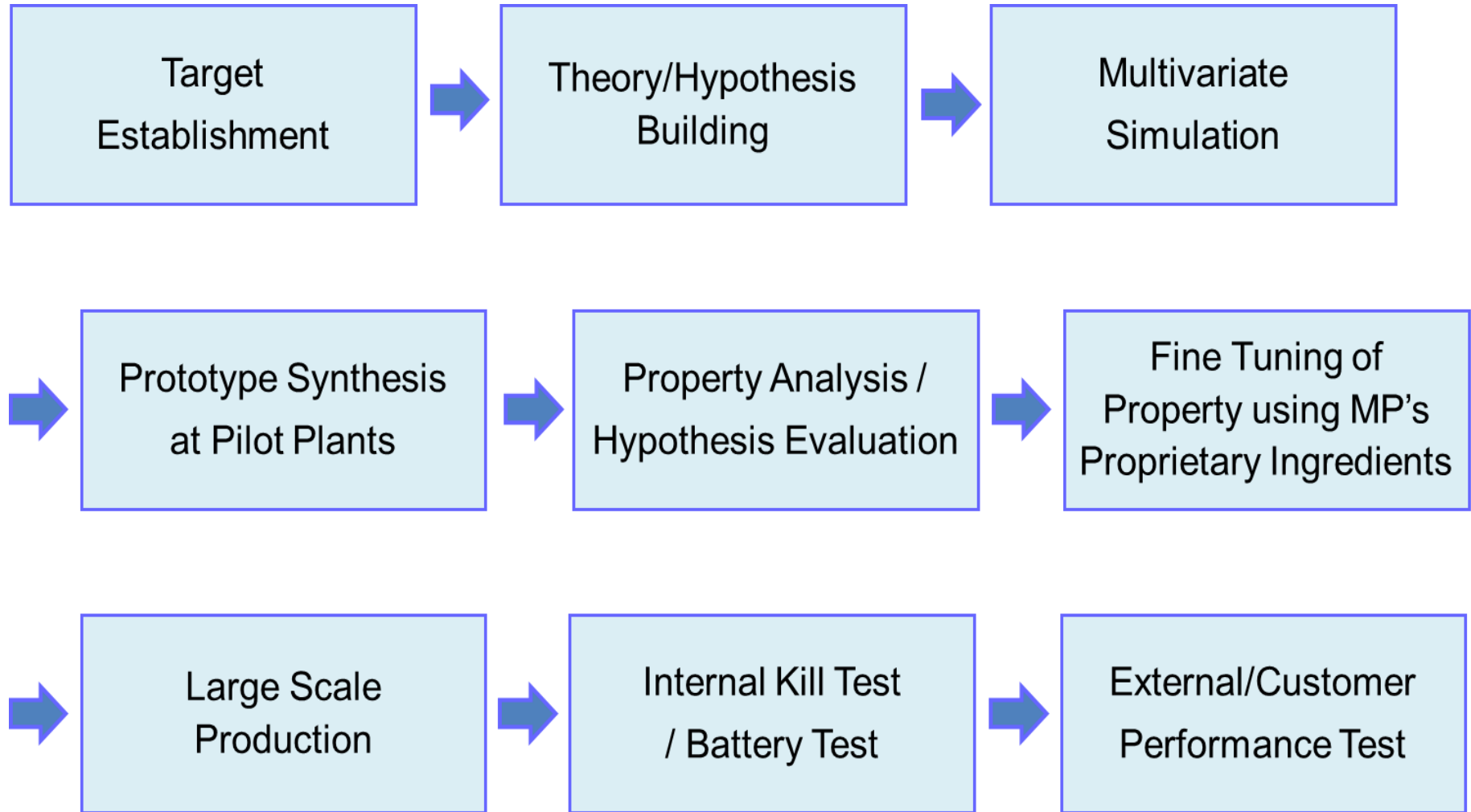
$y_1$ : calendaring temperature

$y_1$ : calendaring tension

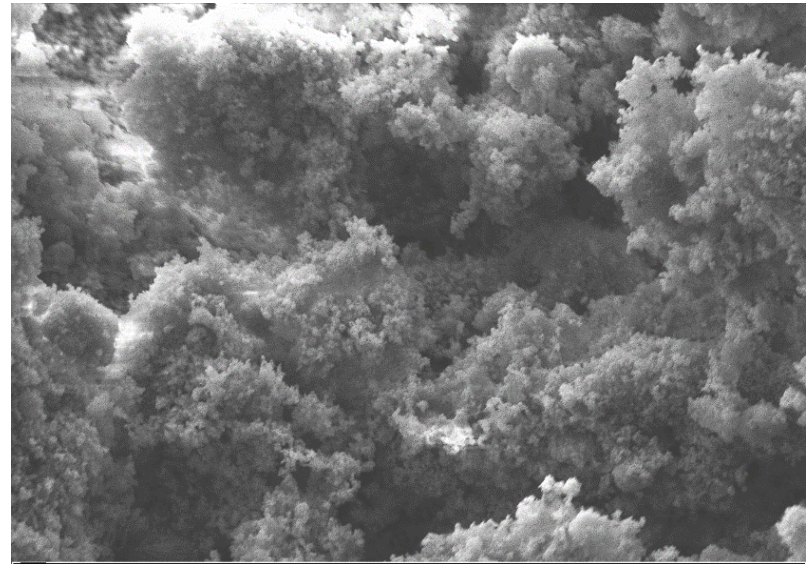
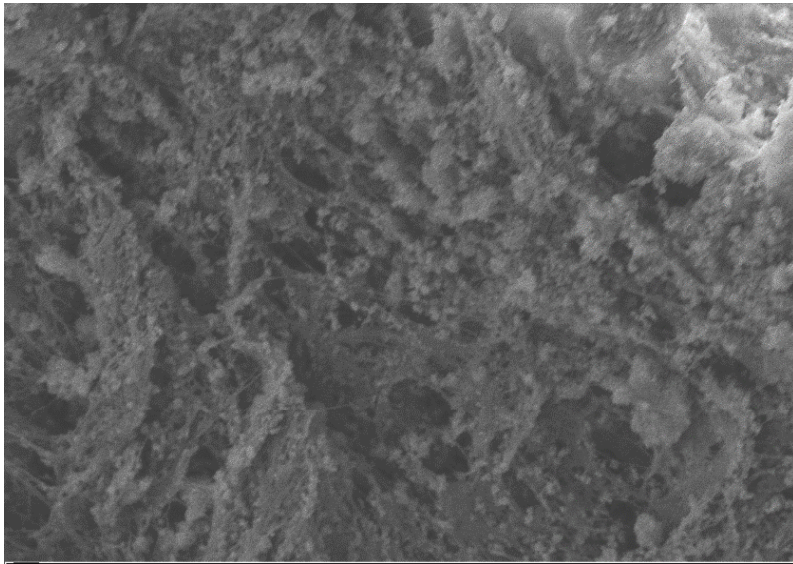
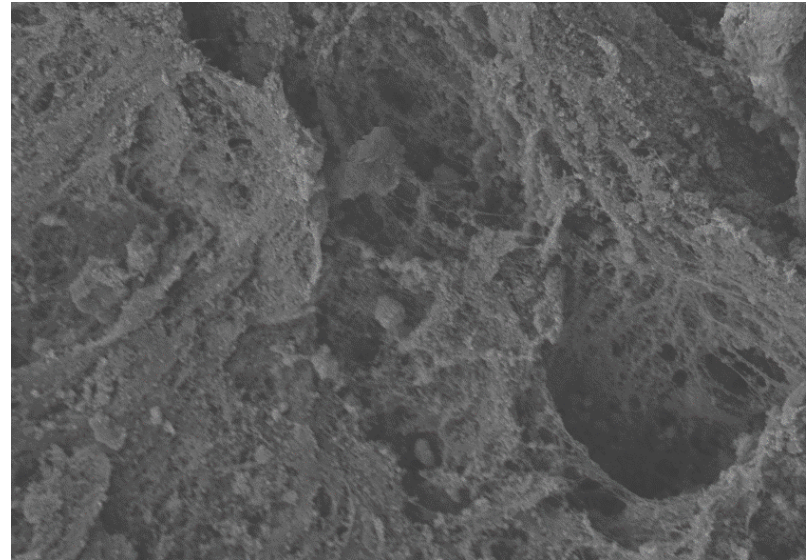
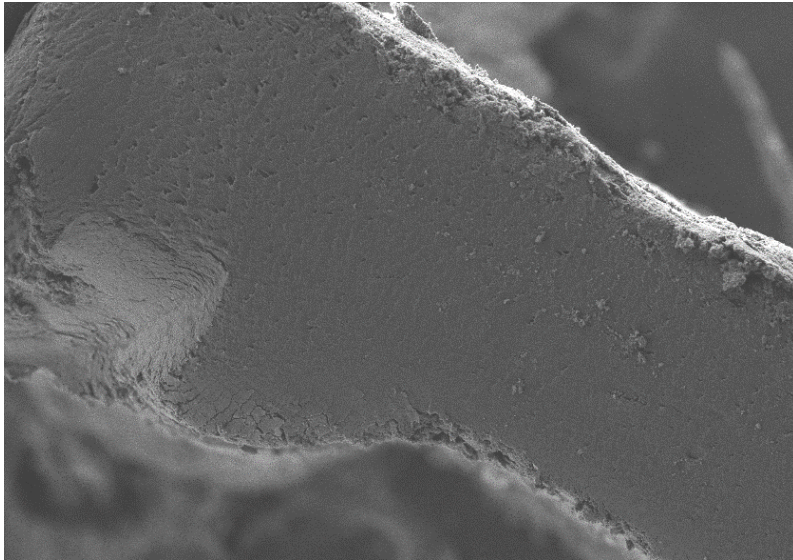
$P$ : pore structure, chain orientation, silica particle distribution, etc.

$C$ : surface interaction b/w silica and polymer, etc.

# CellForce<sup>®</sup> HT Development Process

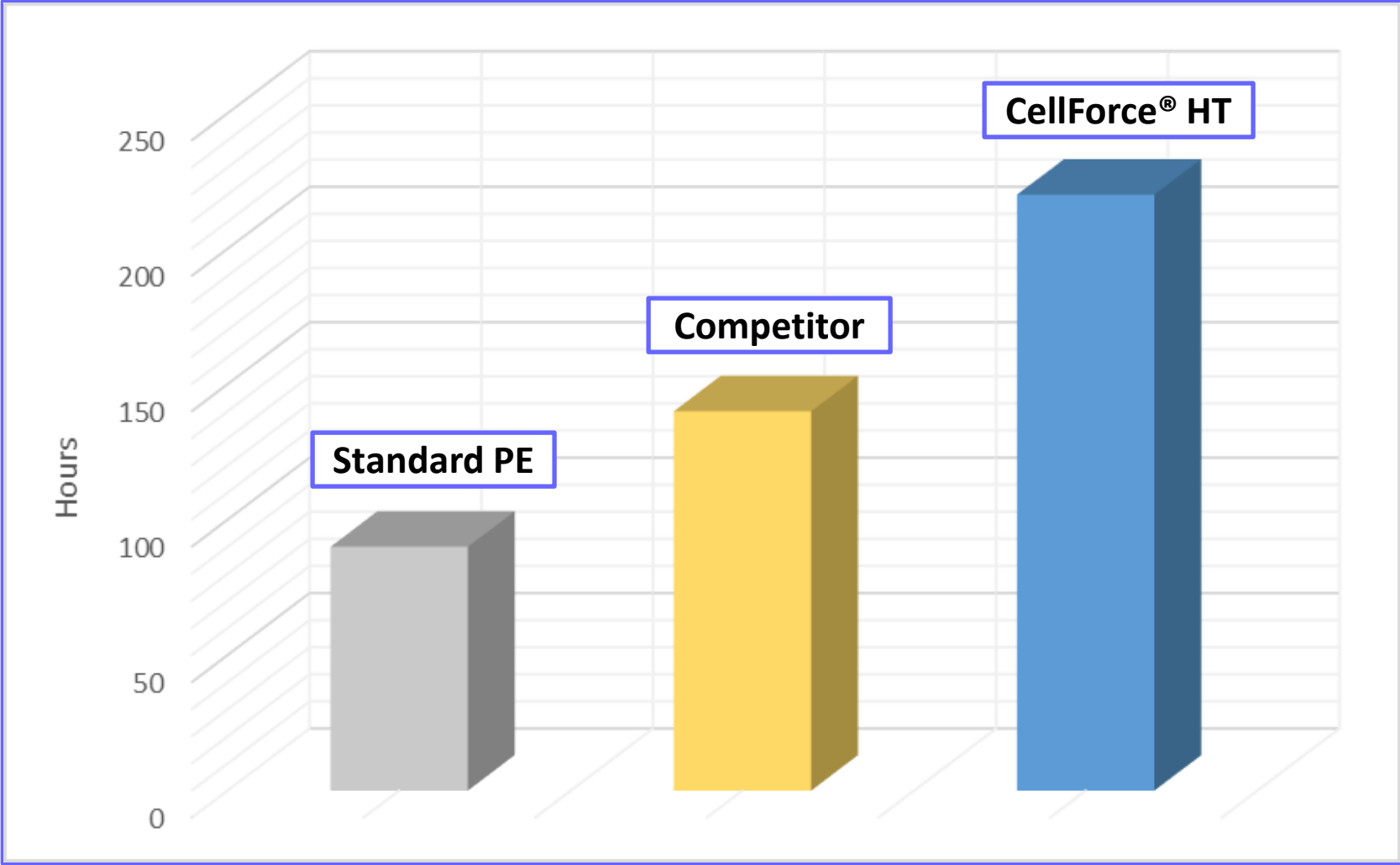


# CellForce® HT Microstructure: SEM Micrographs

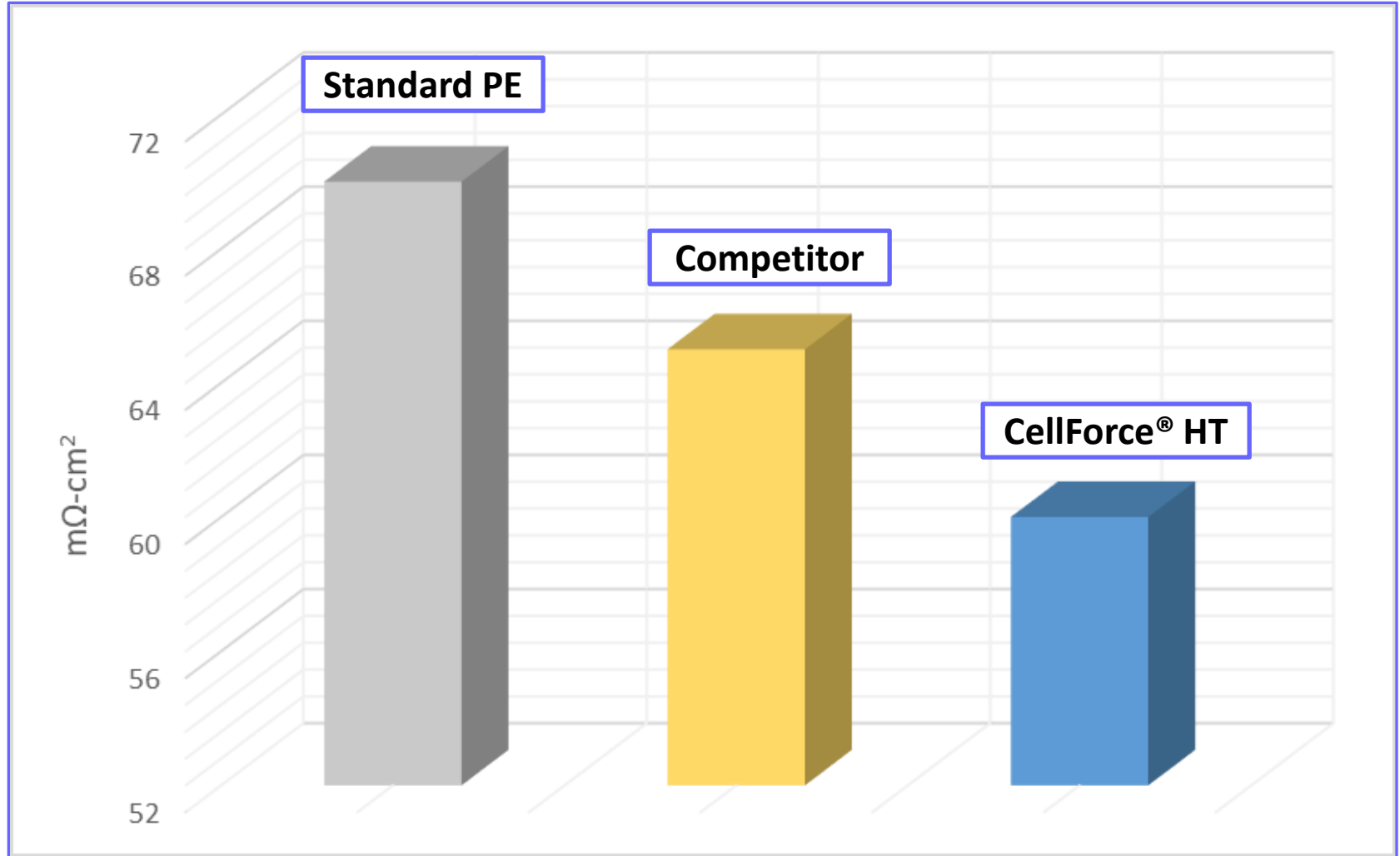




# Key Results: Oxidation Resistance Kill Test



# Key Results: Electrical Resistance



# Conclusion

- We, at Microporous, have been one of the most innovative companies in battery separator industry during the last 50 years
- We have an extensive product lineup tailor-made for various customers' needs, including the separators for automotive, motive power, and stationary
- We recently developed a new product, CellForce® HT™ , which is positioned as a low ER separator with the top of the line high temperature oxidation resistance
- CellForce® HT is a proud outcome of our R&D department, which is developed via:
  - fundamental understanding of separator's structure-property-relationship
  - shifting a perspective to view separators as a more complex system
  - simulating separator's properties as a function of multiple variables
  - developing proprietary ingredients for fine-tuning of separator's properties