DAIKIN | Positively Innovative

Feb 21
2024

Performance-Enhancing Materials for LiIon Batteries

NAATBatt Annual Meeting & Conference 2024

Ken Zemach, PhD -- Daikin Application Development

DAIKIN AMERICA, INC.

Daikin America, Inc.

Daikin Industries (Worldwide)

Daikin Industries, Ltd.

- Founded **1924**
- **$28 Billion** revenue
- **88,698** employees
- **322** subsidiaries

Chemicals Division

- **$1.5 Billion** revenue
- **4,000** employees

Technical battery program support covering the entire US
US-based production of Daikin products

One Of The Largest Global Manufacturers Of Fluorochemical Products

Cathode Binder Modifier

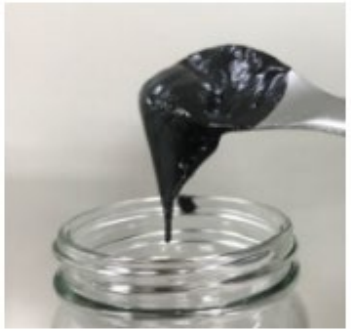
NEOFLON VT-475

Problem: Gelation of high-Ni cathode slurries

- Design for manufacturability not always part of R&D!

Solution: NEOFLON VT-475

- Greatly increase slurry stability -> reduce scrap
- Improve your manufacturing/production window



Homo or
Modified PVdF
Poor flow

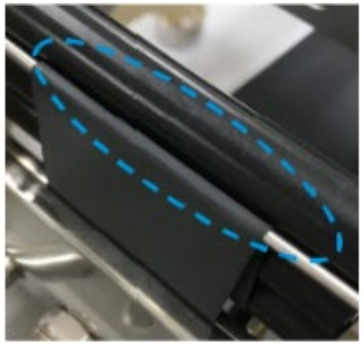
NEOFLON VT-475 with
homo PVdF
Optimal flow

Problem: Electrode cracking/inflexible

Solution: NEOFLON VT-475

- Increased electrode flexibility -> reduced scrap

Homo or
Modified PVdF
Cracked completely



NEOFLON VT-475 with
homo PVdF
Wounded w/o cracking

2mm mandrel bend test

Daikin's Binder Materials Solve Problems

Opportunity: SWCNTs enhance many cell properties

- Increased conductivity with minimal volume fraction
  - Increase charging speed
  - Increase cell capacity (less conductive agent required)
    - 98.5+% active material

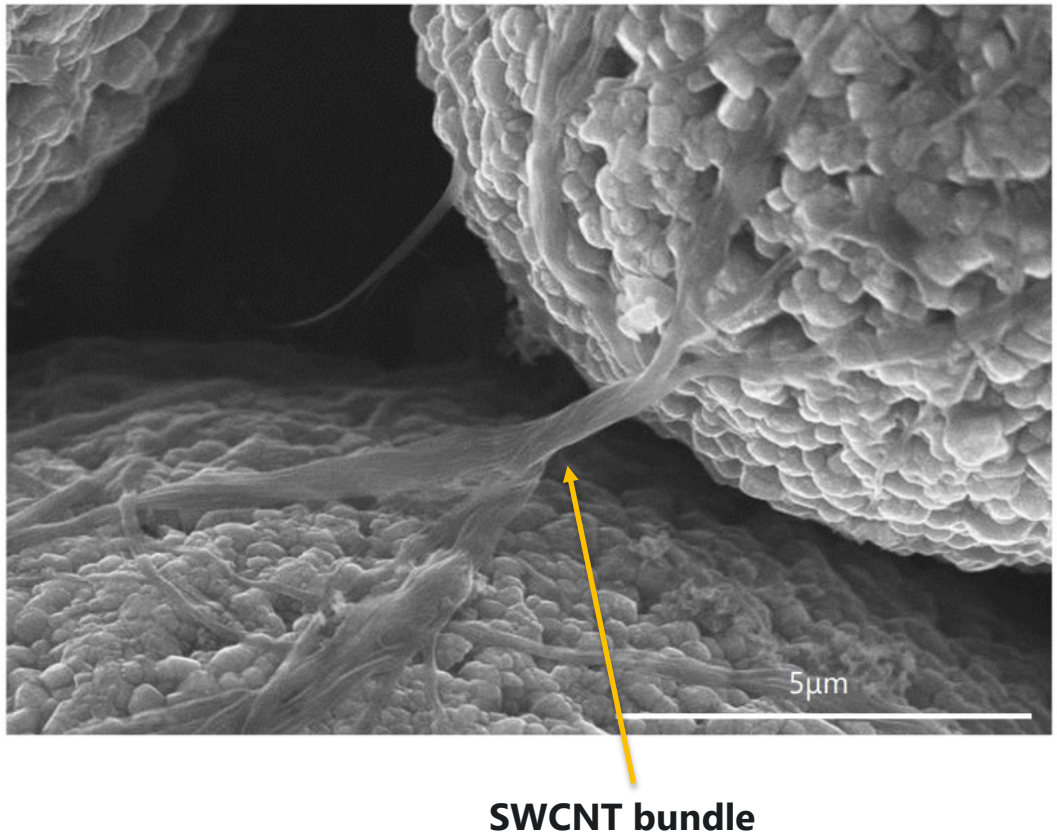
Problems: Handling and dispersion

- Handling of dry CNTs is restricted in many areas
- Even dispersion of CNTs in slurries can be difficult

Solution: NEOFLON VTD-475N

- OCSiAl SWCNTs pre-dispersed in VT-475 solution
- All the advantages of VT-475, plus…
- Easy, even dispersion
- No dry CNT handling
- Increased conductivity, increased cell capacity, increased adhesion

Cathode SEM image of NEOFLON VTD-475N (VT-475 with TUBALL™)



Daikin's Binder Materials Solve Problems

Cathode Binder Modifier: For LFP

VT-475 added to any type of binder for LFP:

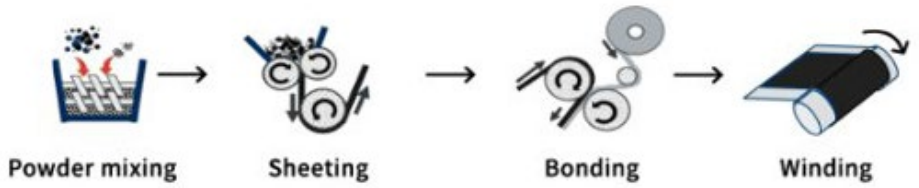
- ✓ Significantly **increase the adhesion strength** at the same total binder concentration
  - ➢ PVdF Binder Type "A" ➔ replace 20% with VT-475 ➔ **19% increase in adhesion**
  - ➢ PVdF Binder Type "B" ➔ replace 20% with VT-475 ➔ **20% increase in adhesion**

or…

- ✓ Can **reduce the total binder** concentration required to achieve the same adhesion
  - ➢ Results in **increased cell capacity** (less binder, more active material)
  - ➢ Results in **overall lower binder cost/capacity**
- ✓ **Increases long duration slurry stability**

LFP is a cost play, but suffers from lower capacity…
VT-475 can help address BOTH simultaneously.

PTFE Dry Battery Electrode Binders



Opportunity: Dry battery electrode process can reduce OPEX/CAPEX

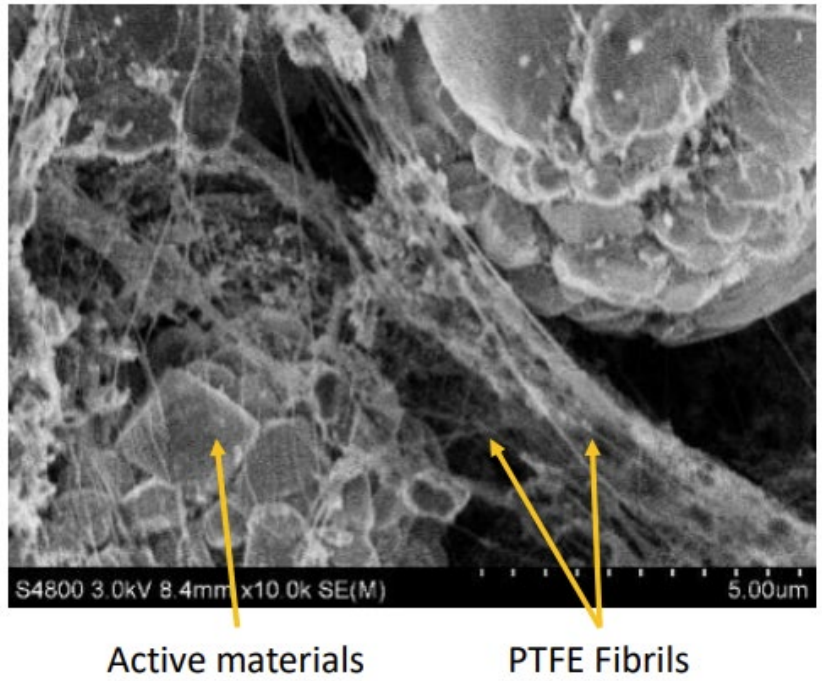
- Removes NMP from cathode electrode production

Problems: PTFE fibrillization is extremely process variable dependent

- Can be difficult to optimize process window
- Scale up can change process window due to shear and temperature differences

Solution: Daikin "family" of PTFE products

- Broad range of PTFE products, spanning both molecular weight and modifier chemistries
  - Results in different fibrillization "windows" (easier/harder, higher/lower temp, etc.)
  - Better match your particular process to the dry binder characteristics



Daikin's Binder Materials Increase Processing Windows

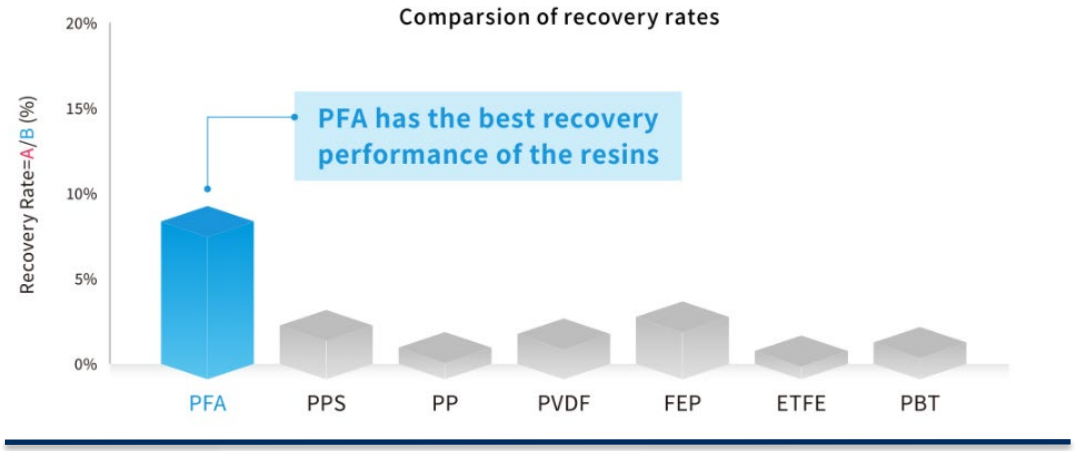
PFA Gasket Materials

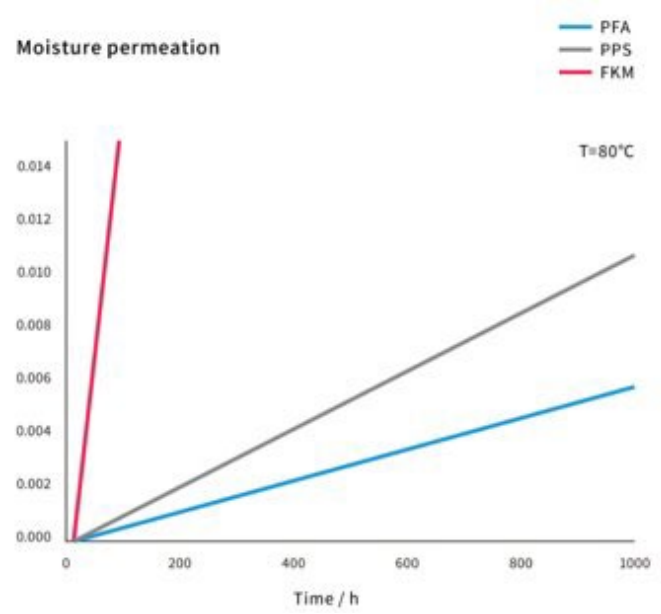
Problem: Sealing larger cells, high heat conditions

- "Dynamic sealing range" of most gaskets is limited after compression
- Heat deflection temperature can be insufficient near laser welding

Solution: NEOFLON PFA

- Excellent sealing performance: moisture and electrolyte
- Best dynamic range of sealing
- High temperature performance





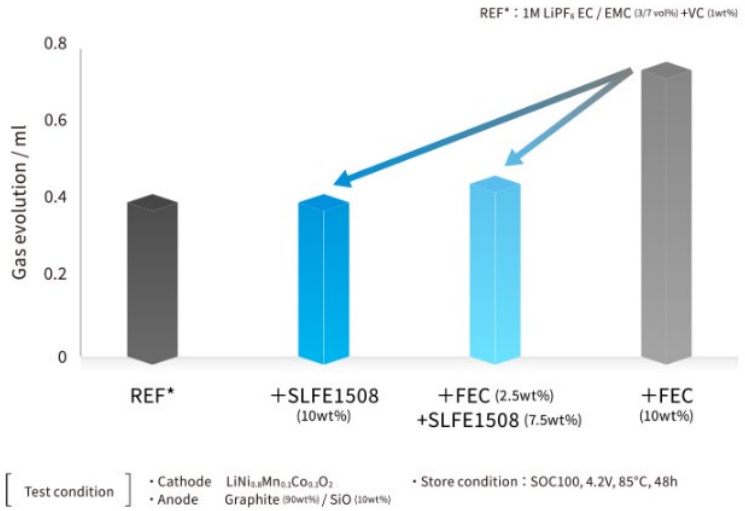
Daikin's Gasket Materials Provide Best-in-Class Performance

Fluorinated Electrolyte Additives

Problem: Gas generation in high Si-containing anodes

Solution: Daikin fluorinated electrolyte additives

- Suppression of gas generation in Si-containing anodes



Problem: Voltage stability of electrolytes, cathodes above 4.2V

Solution: Daikin fluorinated electrolyte additives

- Stable cycling demonstrated up to 4.6V
- Greatly increases specific & volumetric energy density

Problem: Flammability of electrolyte blends

Solution: Daikin fluorinated electrolyte additives directly address flammability issues

Daikin's Electrolyte Additives Enable Entirely New Cell Capabilities

Daikin Contacts – Lithium Ion Battery Materials

Let us help you solve problems.
Increase yield, capacity, manufacturability, and performance.

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Ready to Collaborate and Open for Visits in NA, Japan, and Germany

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