



DOLPHIN Workshop

Chemours

Jan Lenders – June 16th 2023

Fuel Cell Membrane Specifications

Membrane		NR211	NC700	NDP8001	NDP8002	NDP 8011
Thickness (µm)		25	15	10	10	10
Ionomer EW (g/mol)		High	Moderate	Lower	Lowest	Lower
Reinforcement		No	Yes	Yes	Yes	Yes (+)
Stabilizing Additive		No	Yes	Yes	Yes	Yes (+)
Areal Resistance at 80C, 40%RH (mOhm-cm ²)		46	30	N/A	N/A	22
Expansion (%)	MD	20	3	N/A	N/A	0
	TD	20	3	N/A	N/A	3
Ultimate Tensile Strength (MPa)	MD	25	45	N/A	N/A	70
	TD	25	45	N/A	N/A	67

Legacy Commercial

Previous Development Product

Dolphin Development Product

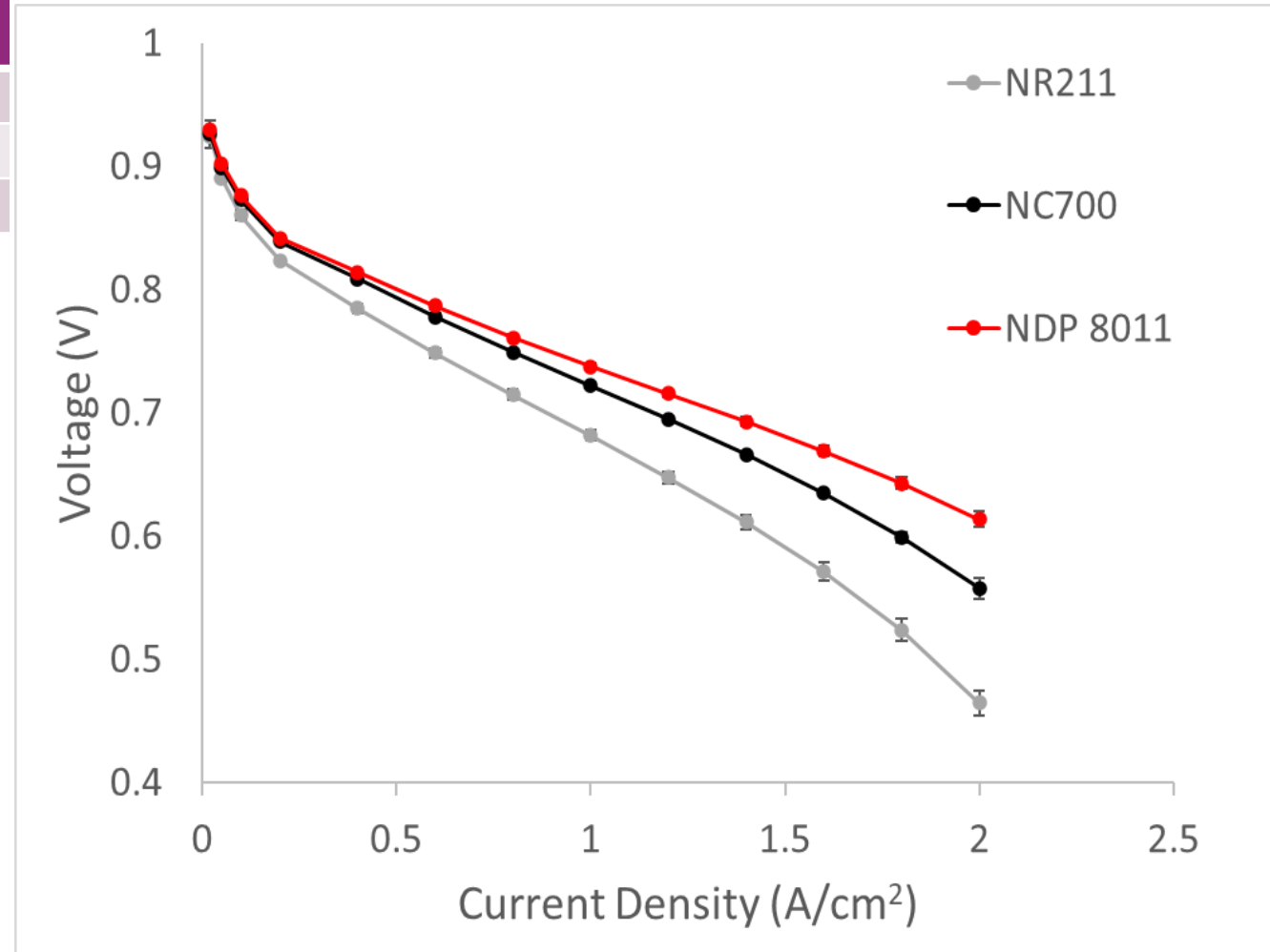
MEA Polarization Curve Performance

Membrane Name	Membrane Thickness [μm]	Current Density at Rated Power (0.67 V)
NR211	25	1.07
NC700	15	1.34
NDP 8011	10	1.59

MEAs prepared via decal transfer of electrodes:

- Anode: 0.1 mg/cm² Pt/HSC (47 wt% Pt), I:C = 1.0. Ionomer = D2020
- Cathode: 0.5 mg/cm² Pt/HSC (67 wt%), I:C = 1.16. Ionomer = D2020
- Active Area: 25 cm²
- Pol Curve Procedure: FCTT Nov '17
 - H₂ anode, Air cathode
 - 80°C Cell temperature
 - 59 Dew Point (**40 RH**)
 - 250 kPa absolute pressure
 - H₂ stoich 1.5, O₂ stoich 1.8 (in air)

NDP 8011 represents a performance improvement over NC700 due to reduced proton transport resistance



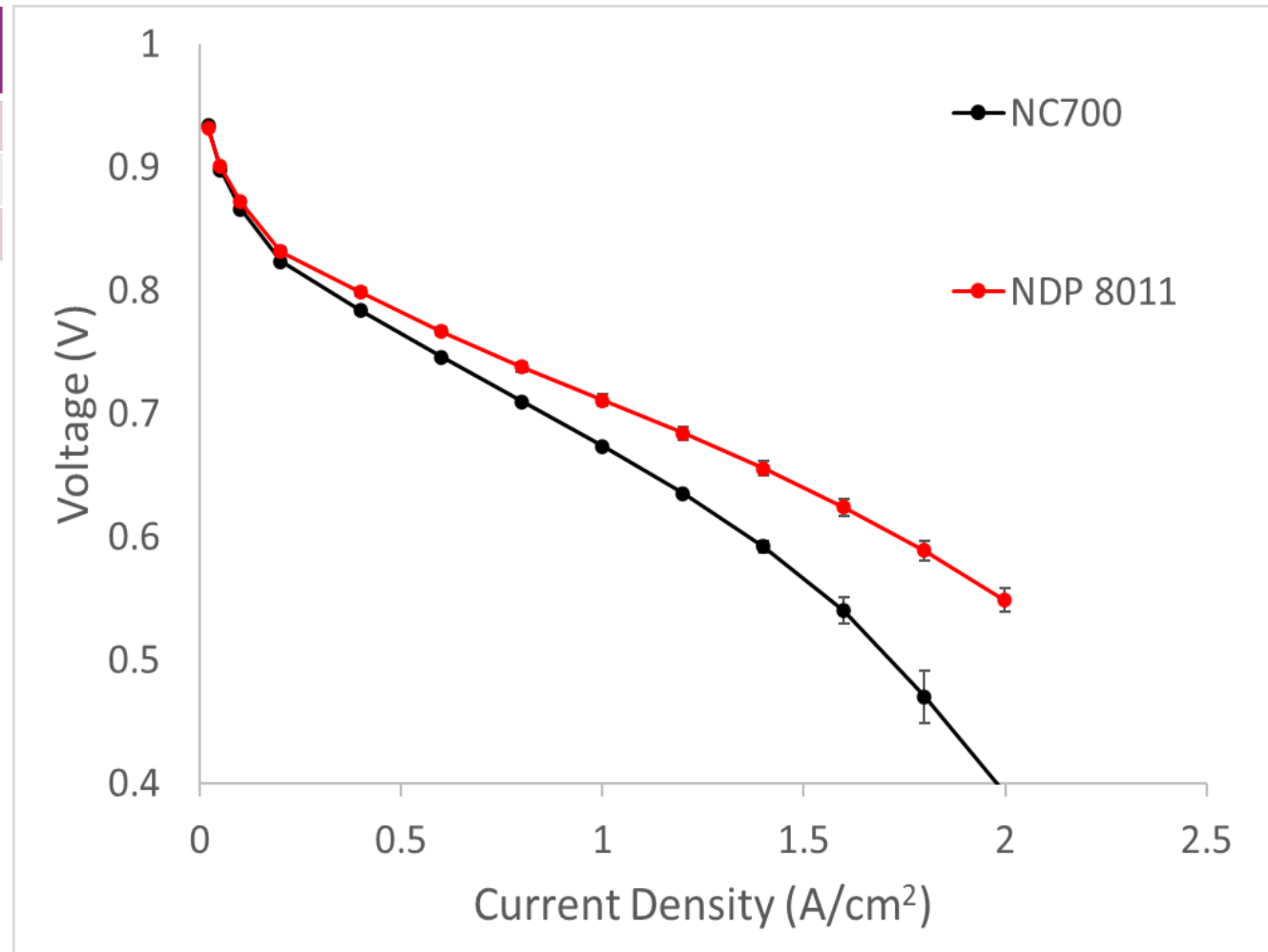
High Temperature MEA Performance

Membrane Name	Membrane Thickness [μm]	Current Density at Rated Power (0.67 V)
NR211	25	1.07
NC700	15	1.34
NDP 8011	10	1.59

MEAs prepared via decal transfer of electrodes:

- Anode: 0.1 mg/cm² Pt/HSC (47 wt% Pt), I:C = 1.0. Ionomer = D2020
- Cathode: 0.5 mg/cm² Pt/HSC (67 wt%), I:C = 1.16. Ionomer = D2020
- Active Area: 25 cm²
- Pol Curve Procedure: FCTT Nov '17
 - H₂ anode, Air cathode
 - 95°C Cell temperature
 - 65.3 Dew Point (25 kPa pH₂O, 30% RH)
 - 250 kPa absolute pressure
 - H₂ stoich 1.5, O₂ stoich 1.8 (in air)

At high temperature conditions, performance losses due to increased proton transport resistance are far lower for NDP 8011 compared to NC700



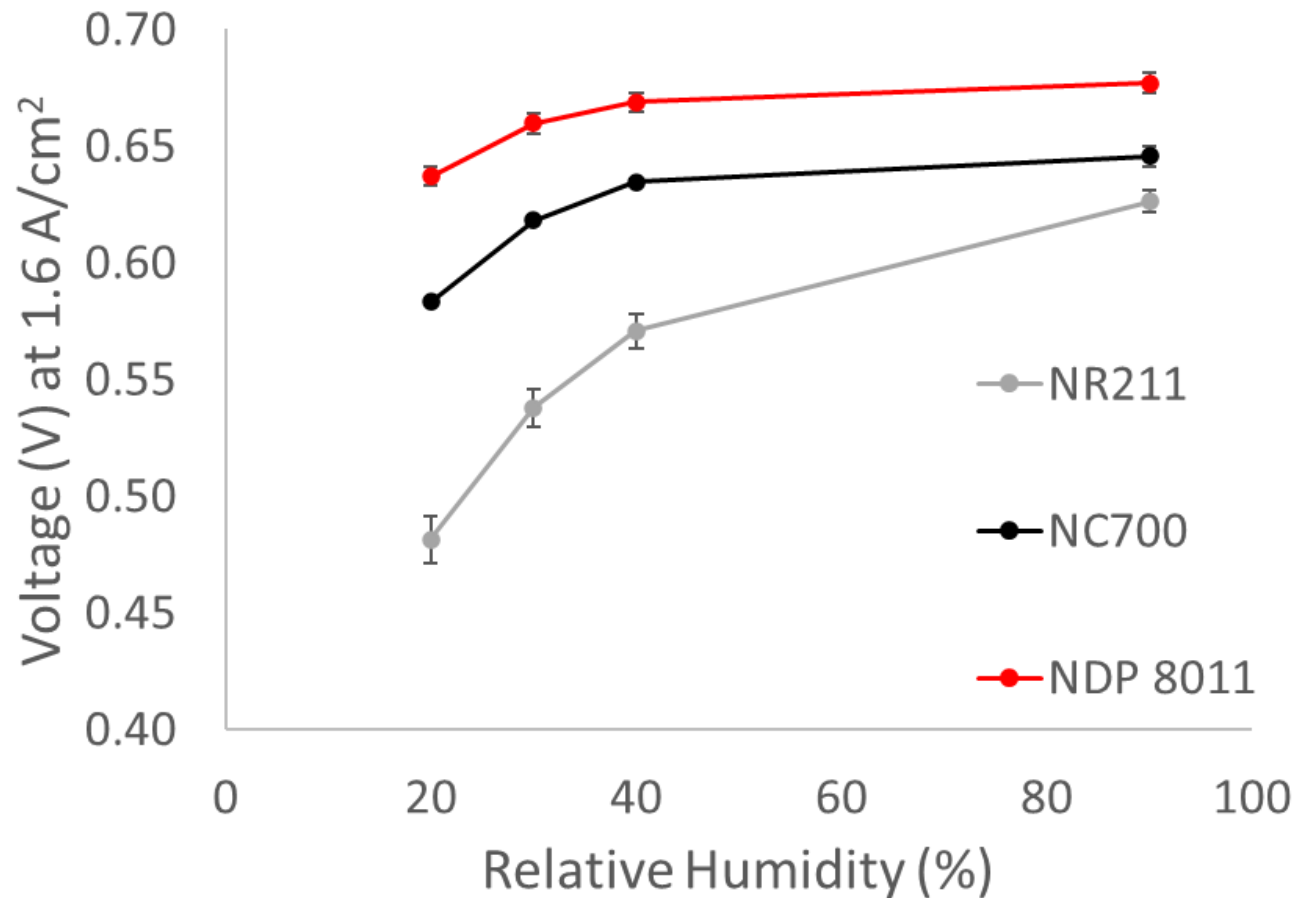
Effect of Humidity on Performance

Membrane Name	Membrane Thickness [μm]	Current Density at Rated Power (0.67 V)
NR211	25	1.07
NC700	15	1.34
NDP 8011	10	1.59

MEAs prepared via decal transfer of electrodes:

- Anode: 0.1 mg/cm^2 Pt/HSC (47 wt% Pt), I:C = 1.0. Ionomer = D2020
- Cathode: 0.5 mg/cm^2 Pt/HSC (67 wt%), I:C = 1.16. Ionomer = D2020
- Active Area: 25 cm^2
- Pol Curve Procedure: FCTT Nov '17
 - H_2 anode, Air cathode
 - 80°C Cell temperature
 - 44.8-77.2 Dew Point (**20% - 90% RH**)
 - 250 kPa absolute pressure
 - H_2 stoich 1.5, O_2 stoich 1.8 (in air)

NDP 8011 performs better than previous Nafion™ membranes across wide range of humidity, particularly at low RH



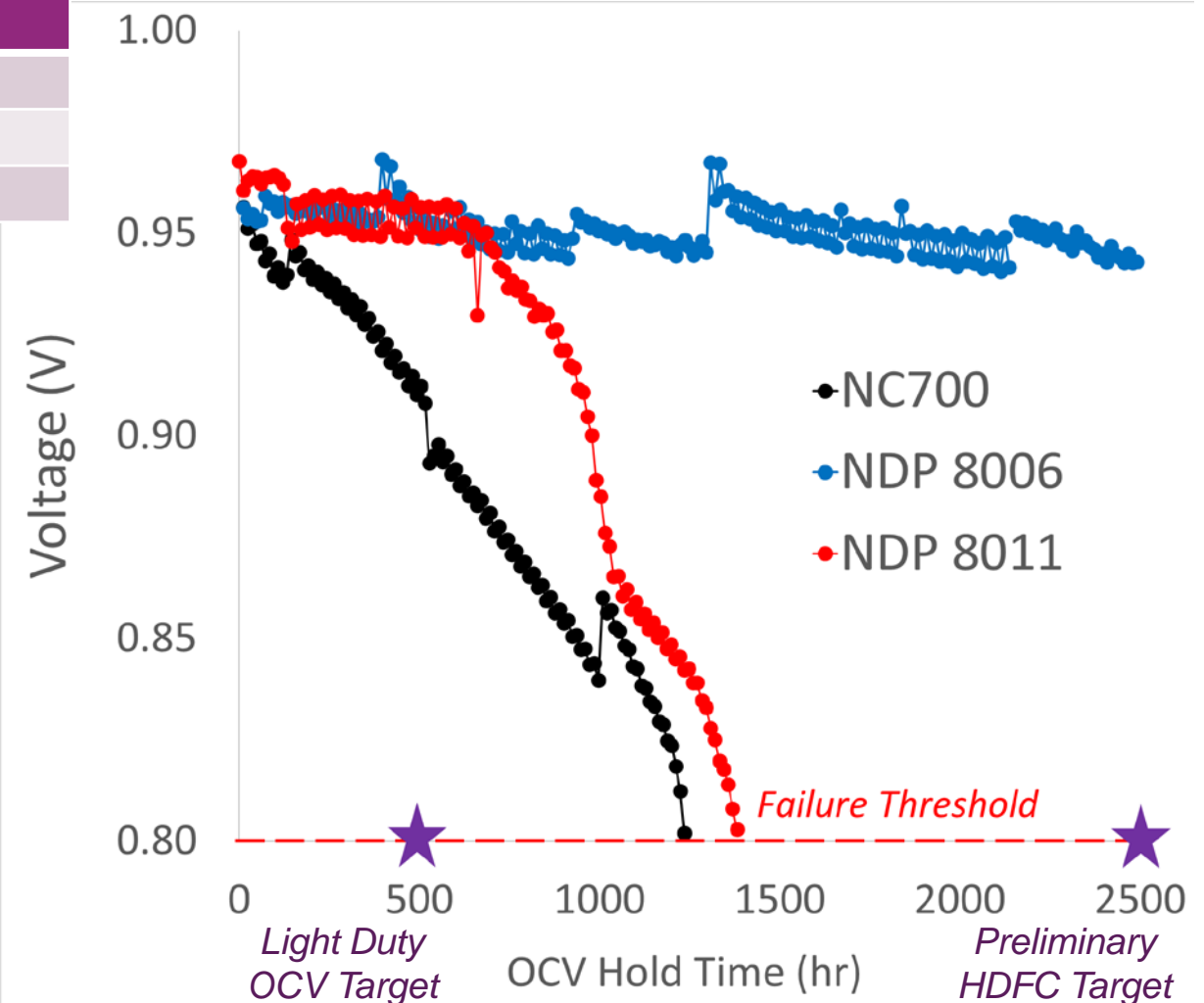
MEA Chemical Durability

Membrane Name	Membrane Thickness [μm]	Hours to Failure
NC700	15	1250
NDP 8006	15	3400
NDP 8011	10	1380

- DOE Chemical Accelerated Stress Test (AST)
 - H_2 anode, Air cathode
 - 90°C Cell temperature
 - Open Circuit Voltage
 - Humidity: 30% RH
 - Ambient pressure (101 kPa absolute)
- Failure: 0.8 V

NDP 8006 exceeds 5x US DOE light duty target

10 μm NDP 8011 surpasses 15 μm NC700 chemical durability

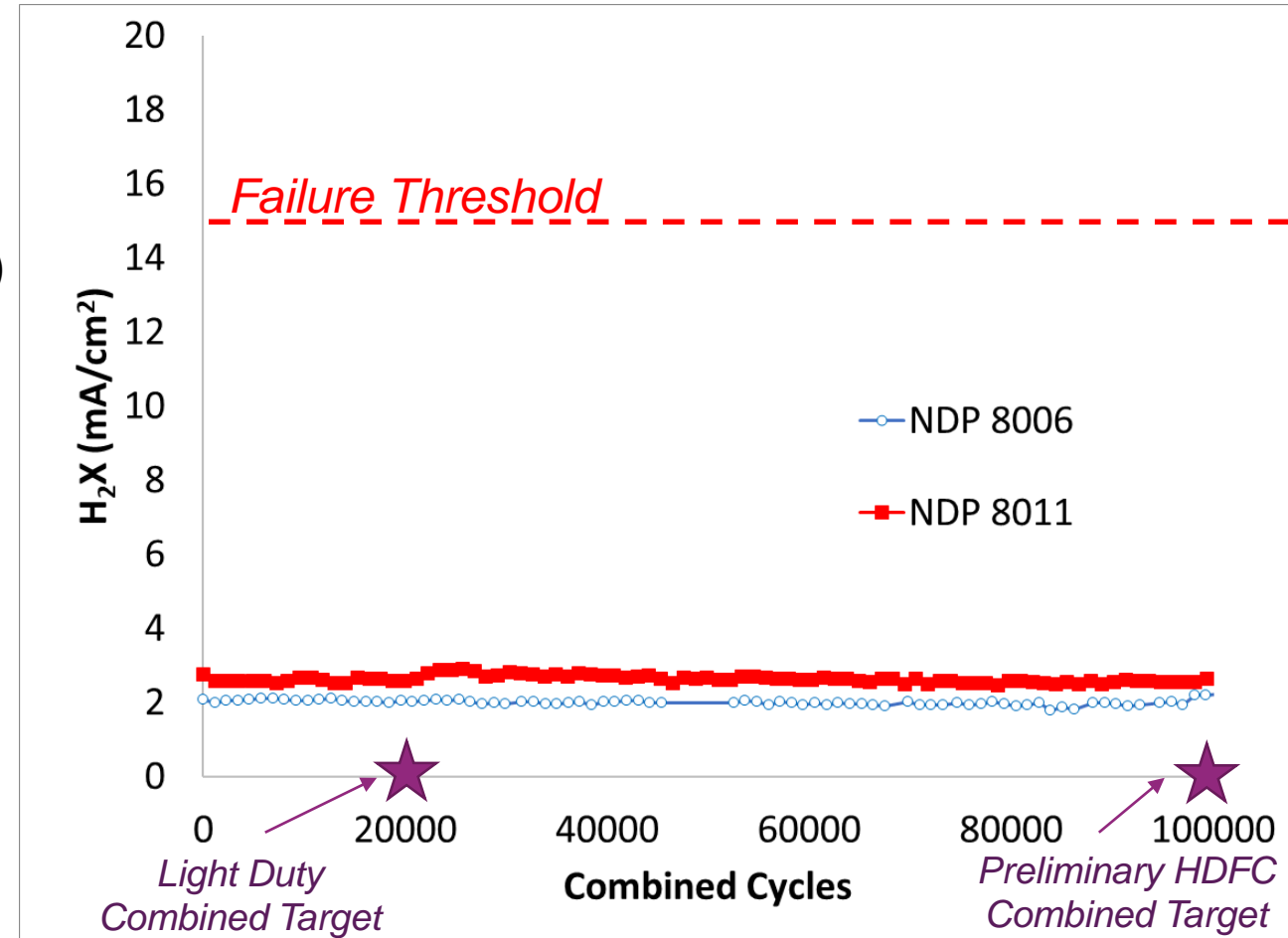


MEA Combined Chemical/Mechanical Durability

Membrane Name	Membrane Thickness [μm]	Cycles to Failure
NDP 8006	15	~115000
NDP 8011	10	~110000

- DOE Combined Chemical/Mechanical Accelerated Stress Test (AST)
 - H₂ anode, Air cathode
 - 90°C Cell temperature
 - Open Circuit Voltage
 - Cycle Humidity: 100% RH (45s), ~0% RH (30s)
 - Ambient pressure (101 kPa absolute)
- Failure: 15 mA/cm² hydrogen crossover current

NDP 8006 and NDP 8011 achieve >5x light duty combined cycle target for chemical/mechanical



Chemours JV with BWT Fumatech

- **The Mobility F.C. Membranes Company**
- Approved by European Commission and China State Administration for Market Regulations
- 85+ years of combined experience in fuel cell innovation
- 50-50 Joint Venture combining Technological expertise from two world-class companies
- The JV will provide fuel cell membranes and humidifier membranes to OEMs

