

Nouryon CEKOL CMC for Li-ion Battery

Dec 2021



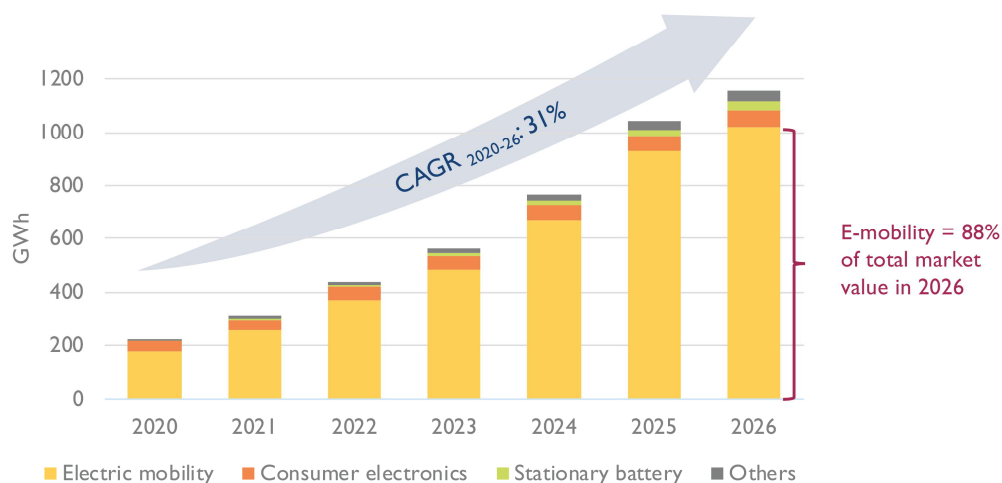
Market Outlook and Technology Overview



Market Outlook

2020 - 2026 total Li-ion battery cell demand in GWh

(Source: Status of the Rechargeable Li-ion Battery Industry 2021 report, Yole Développement, 2021)

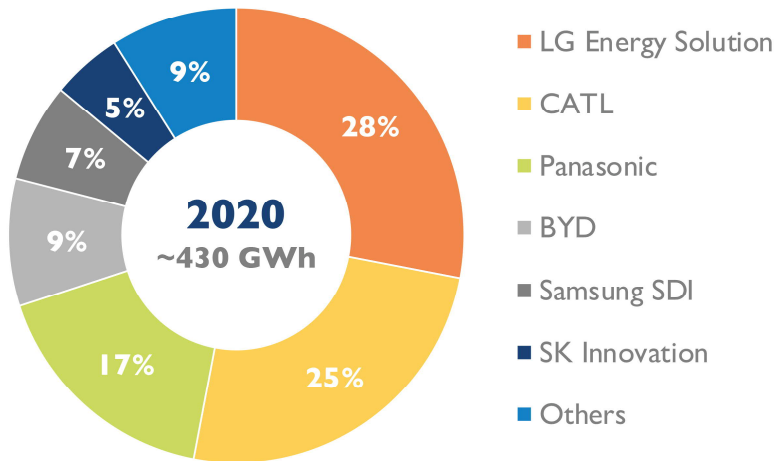


- ❑ Lithium-ion batteries are employed to electrify transportation, consumer electronics and stationary energy storage for electrical grids.
- ❑ The global Li-ion battery market size is estimated to reach US\$105.6 billion by 2026, with a 23% CAGR 20-26.
- ❑ The market for Li-ion battery cells in EV is expected to reach US\$ 86 billion by 2026. The stationary market is expected to be almost US\$ 3.8 billion by 2026, at a 32% CAGR 20-26.

Market Outlook

2020 top battery manufacturers market shares in GWh

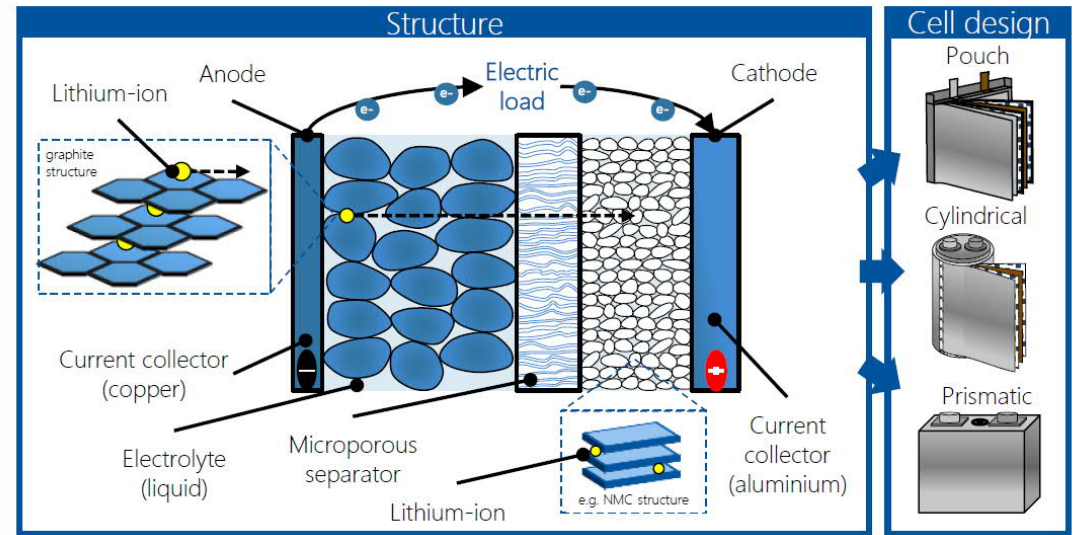
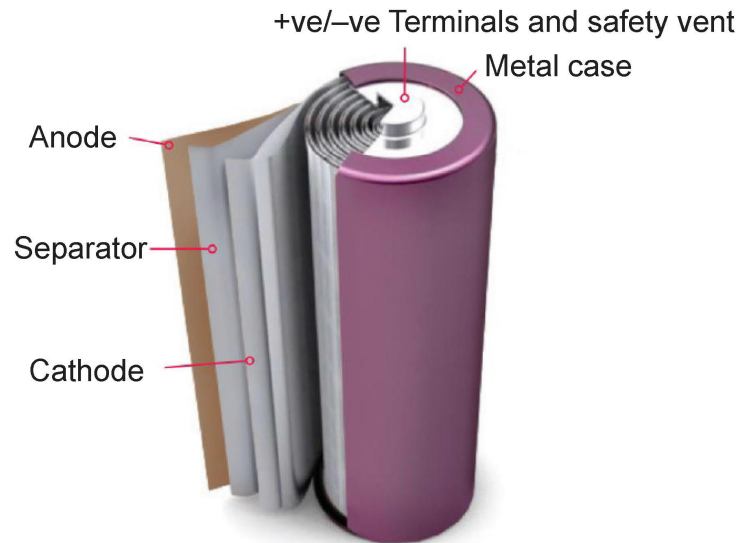
(Source: Status of the Rechargeable Li-ion Battery Industry 2021 report, Yole Développement, 2021)



- ❑ In 2020, more than 91% of the battery cell production capacity was distributed among 6 large companies (LGES, CATL, Panasonic, BYD, Samsung SDI, SKI), all of them are Asian companies.
- ❑ Other players, including start-up companies like Northvolt, Farasis and SVOLT have also identified a huge business opportunity in supplying battery cells for e-mobility markets, and are increasing their battery production capacity.
- ❑ EV makers like Tesla, Volkswagen Group, BMW, General Motors, Ford, etc., are also investing billions of dollars to secure raw materials.

Technology Overview

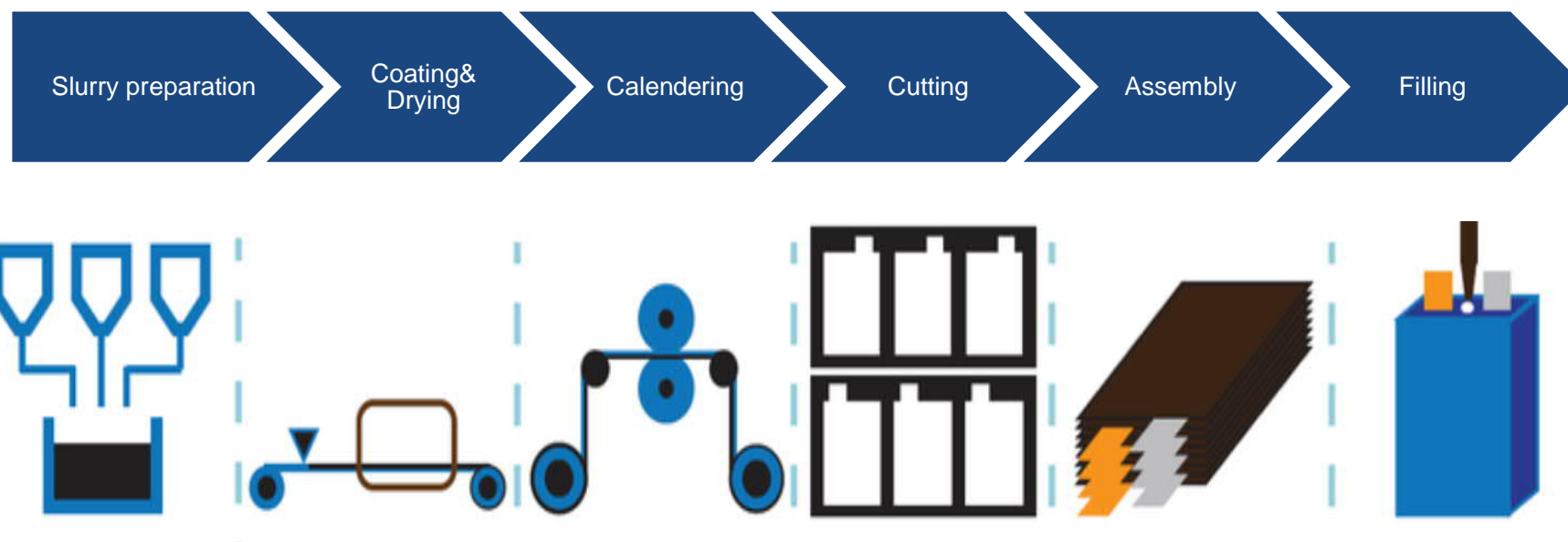
Structure



LIB operating principle *

Technology Overview

Process



Technology Overview

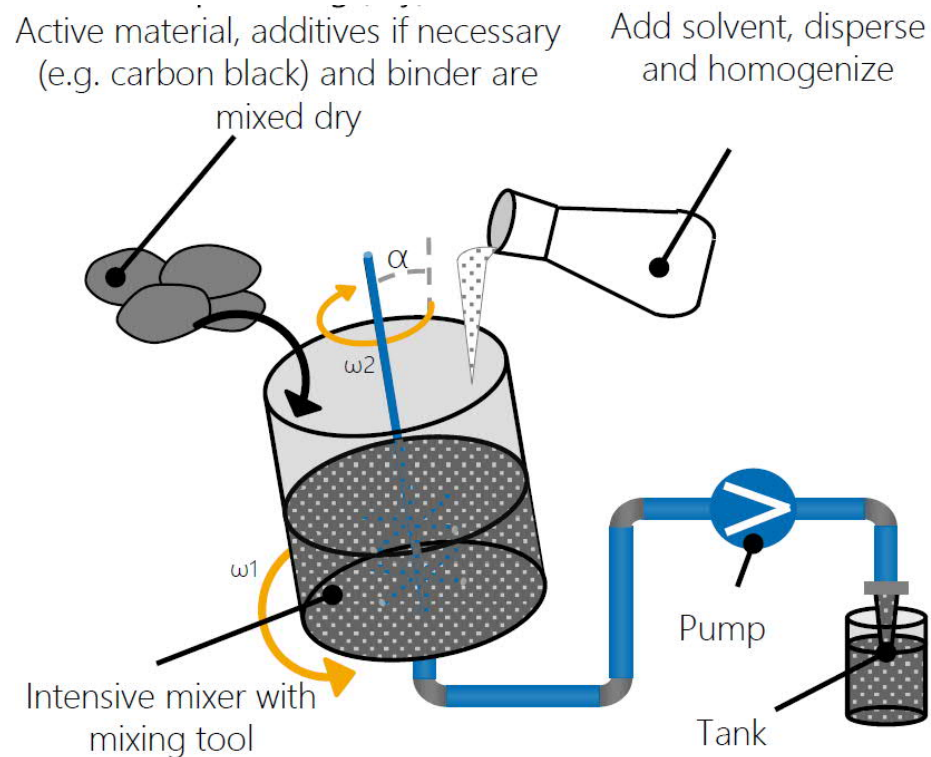
Electrode slurry preparation

Anode formulation*

Active material:
Graphite (90 wt.%)
Conductive carbon black: Nano microscopic carbon, e.g. Super P® (5 wt.%)
Solvent: Deionized water
Binder: CMC (3 wt.%)
Additive: SBR (2 wt.%)

Cathode formulation*

Active material: $\text{Li}(\text{NiMnCo})\text{O}_2$ (90 wt.%)
Carbon black: Nano microscopic carbon, e.g. Super P® (5 wt.%)
Solvent: N-Methyl-2-Pyrrolidone (NMP)
Binder: PVDF (5 wt.%)

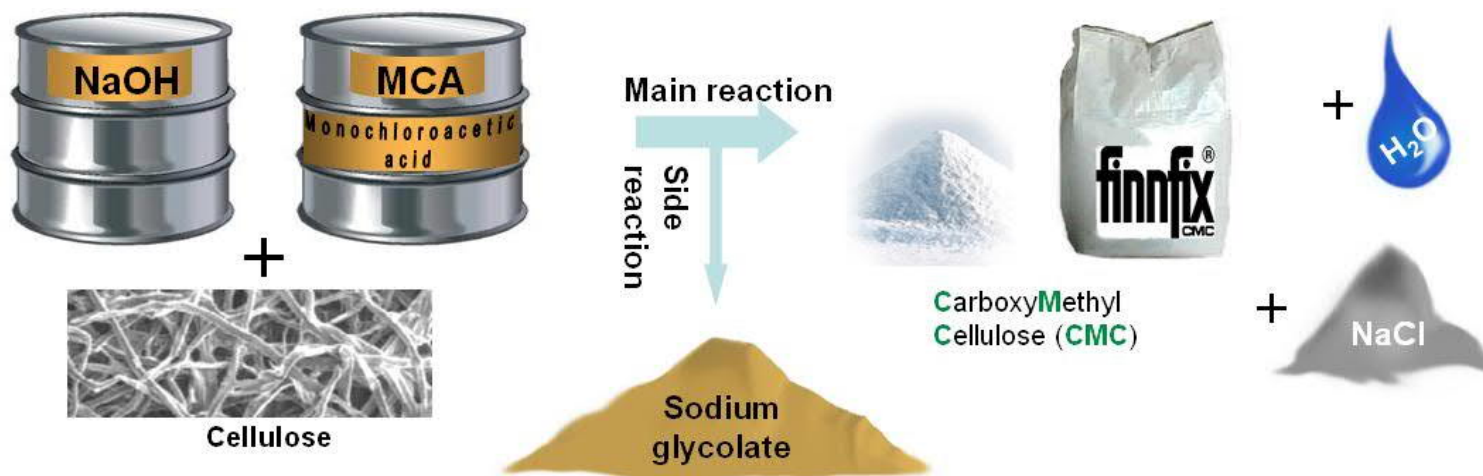


CEKOL Carboxymethyl Cellulose

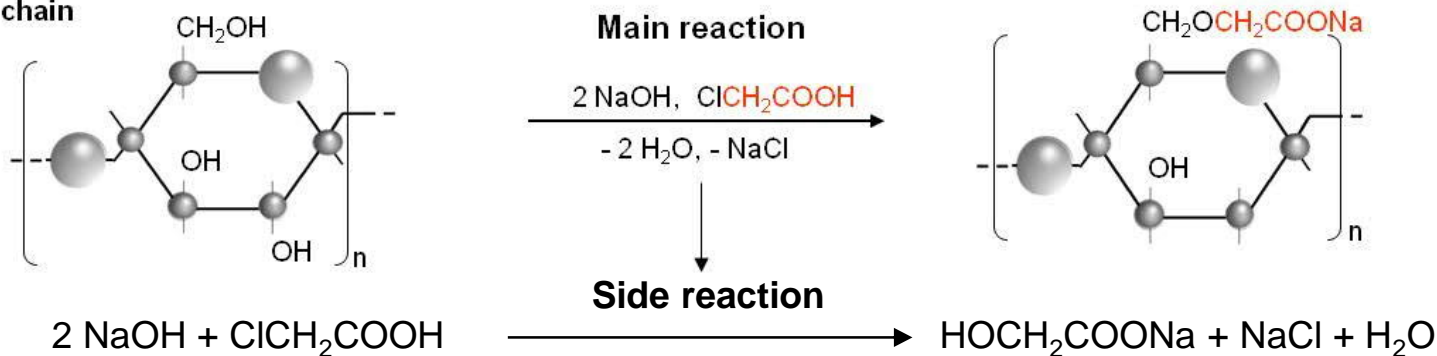


CMC Chemistry

- CMC = CarboxyMethyl Cellulose



Anhydroglucose unit of cellulose chain



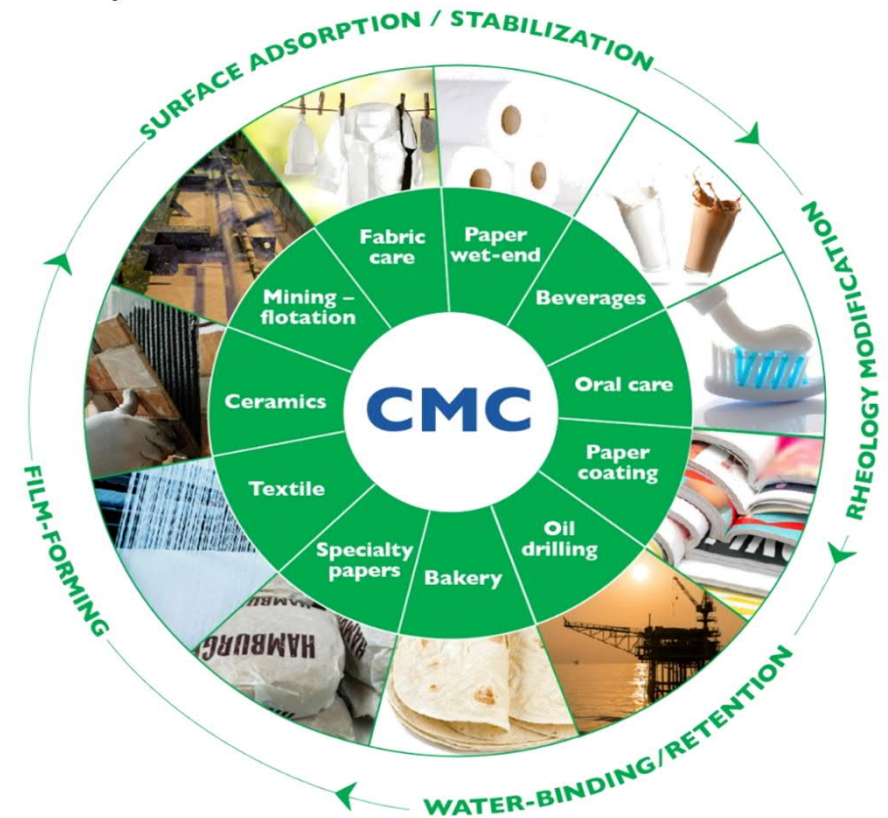
Product Lines and Trade Names

Purified CMC (Regulated & Consumer applications)

- Min. 99.5% purity (CMC-content)
 - Regular and micro-grinded products
 - Medium to high viscous grades
 - Trade name: **CEKOL®**
- **Min. 98% purity (CMC-content)**
 - Granulated, regular and micro-grinded products
 - Low to high viscous grades
 - Trade names: **finnfix®**

Technical CMC

- Min. 55-75% purity (CMC-content)
 - Medium to high viscous grades
 - Trade names: **finnfix®**



Tools to Control the Performance

Chemical parameters

- Cellulose source
- Molecular weight
- Degree of substitution
- Substitution pattern
- Molecular modifications/design

Physical parameters

- Particle size distribution
- Surface modification
- Bulk density

CMC performance

- Rheology
- Water binding capacity
- Stability
- Interaction with other ingredients
- Adhesion
- Dispersibility
- Dissolution speed
- Processing
- Powder flow properties
-

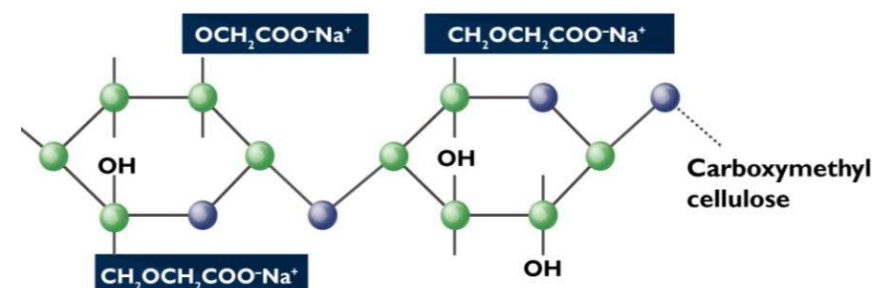
CEKOL CMC for Li-ion Battery

Application	Product	Viscosity (mPas)	Purity	pH	High Clarity (less insolubles)
Anode	CEKOL 30000A	2500 - 3500 (1%, Br LV 3/30)	≥ 99.5%	6.5 – 8.0	
	CEKOL 20000 (P)	1500 – 2500 (1%, Br LV 3/30)	≥ 99.5%	6.5 – 8.0	
	CEKOL CLR 20000S	1000 – 3000 (1%, Br LV 3/30)	≥ 99.5%	6.5 – 8.0	√
	CEKOL CLR 80000S	6000 – 10000 (1%, Br LV 4/30)	≥ 99.5%	6.5 – 8.0	√
Separator	CEKOL 30	25 – 50 (2%, Br LV 1/60)	≥ 99.5%	6.5 – 8.0	
	CEKOL 150	150-300 (2%, Br LV 2/60)	≥ 99.5%	6.5 – 8.0	

(P) : Micro-grinding grade is available.

CEKOL CMC Benefit for Anode

- **Bio-based**, water-soluble polymer made from renewable cellulosic raw material, harmless to health and environment
- **Efficient rheology modifier** with customized molecular weight
- **Better binding power**: Good synergy with SBR, PAA and graphite
- **Excellent stability**: wide range of pH, high-shear resistance
- **Excellent filtration performance**: High clarity and less insoluble/Micro-gel in solution



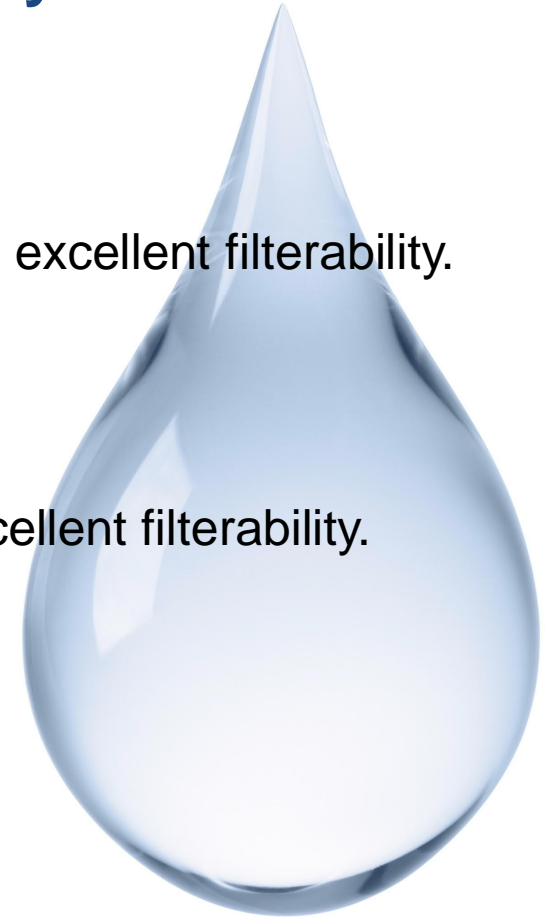
CEKOL® CLR products – New Launch for High Clarity Solution

CEKOL® CLR 20000S Cellulose Gum

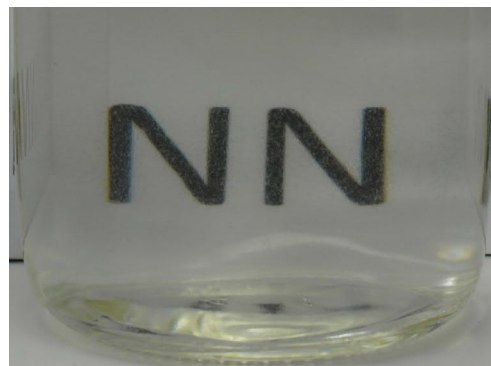
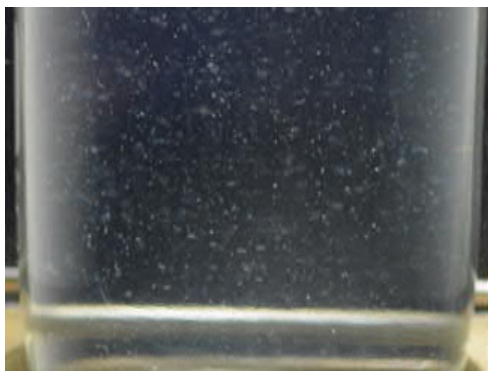
- a medium viscosity cellulose gum providing good binding power with excellent filterability.
(example for battery appl.)

CEKOL® CLR 80000S Cellulose Gum

- a high viscosity cellulose gum providing good binding power with excellent filterability.
(example for battery appl.)

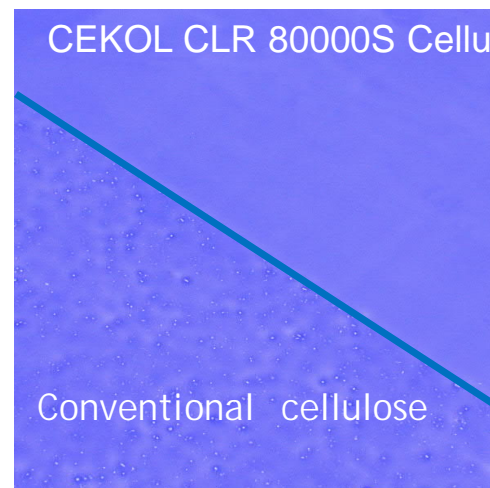


Solution clarity, 1% solution

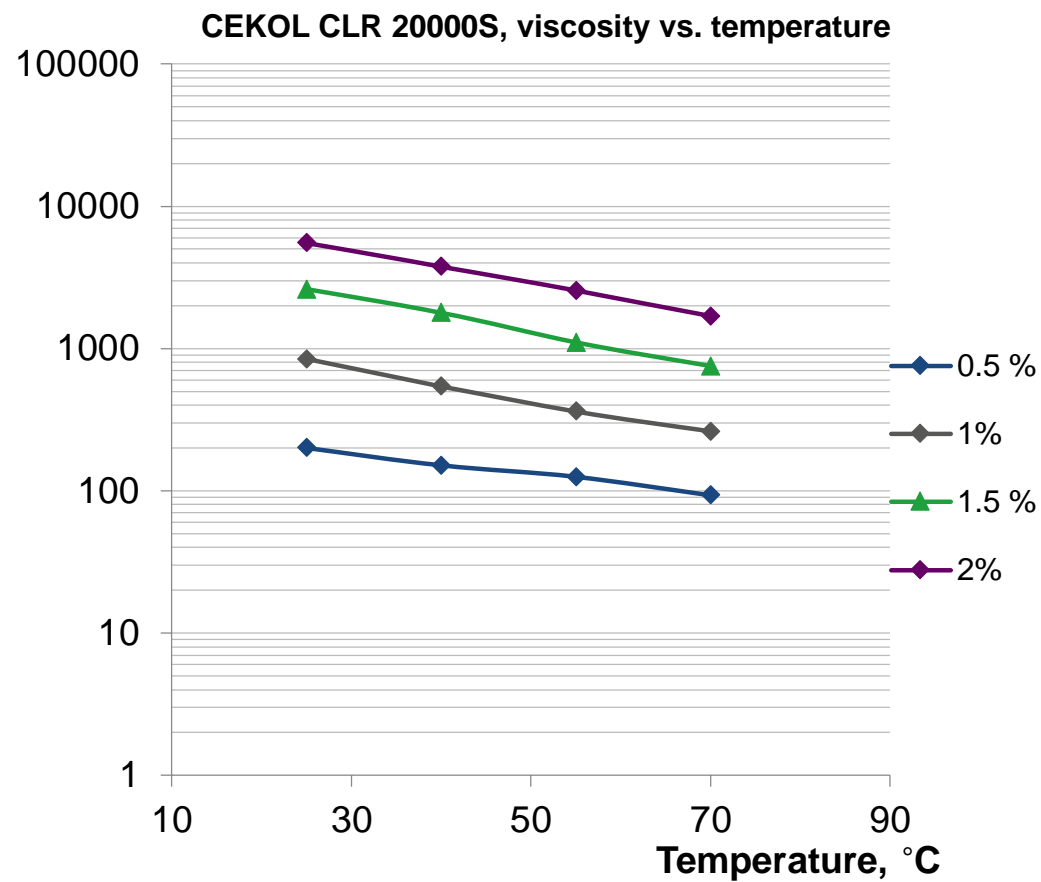
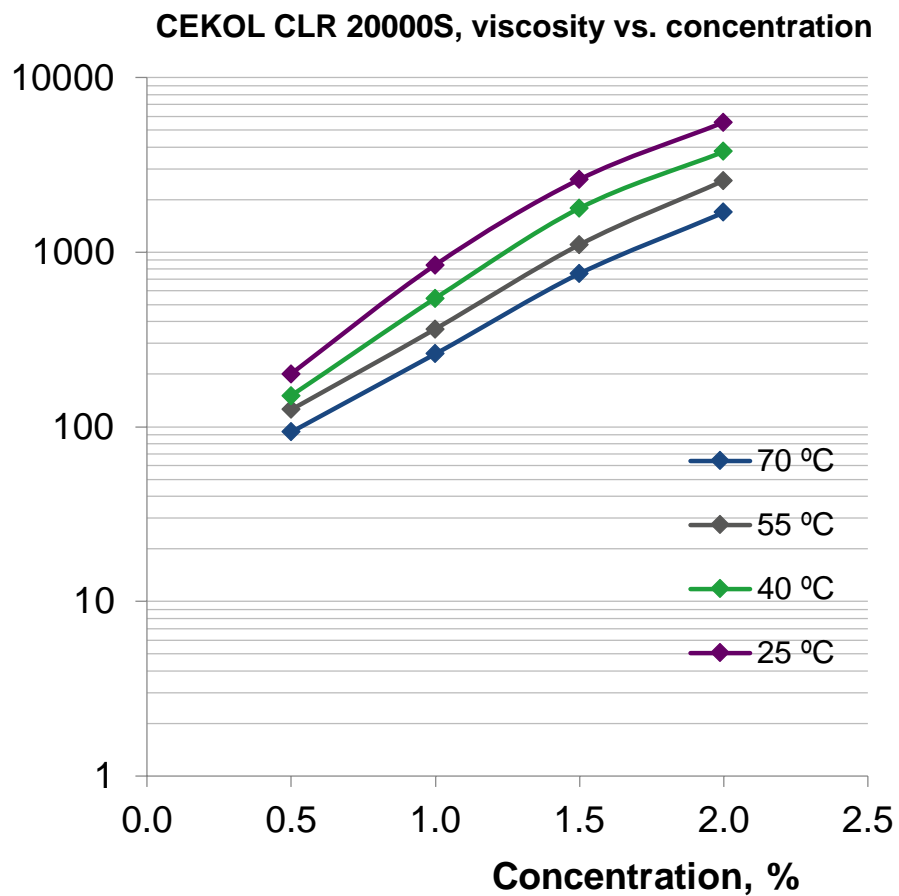


CEKOL CLR

Conventional



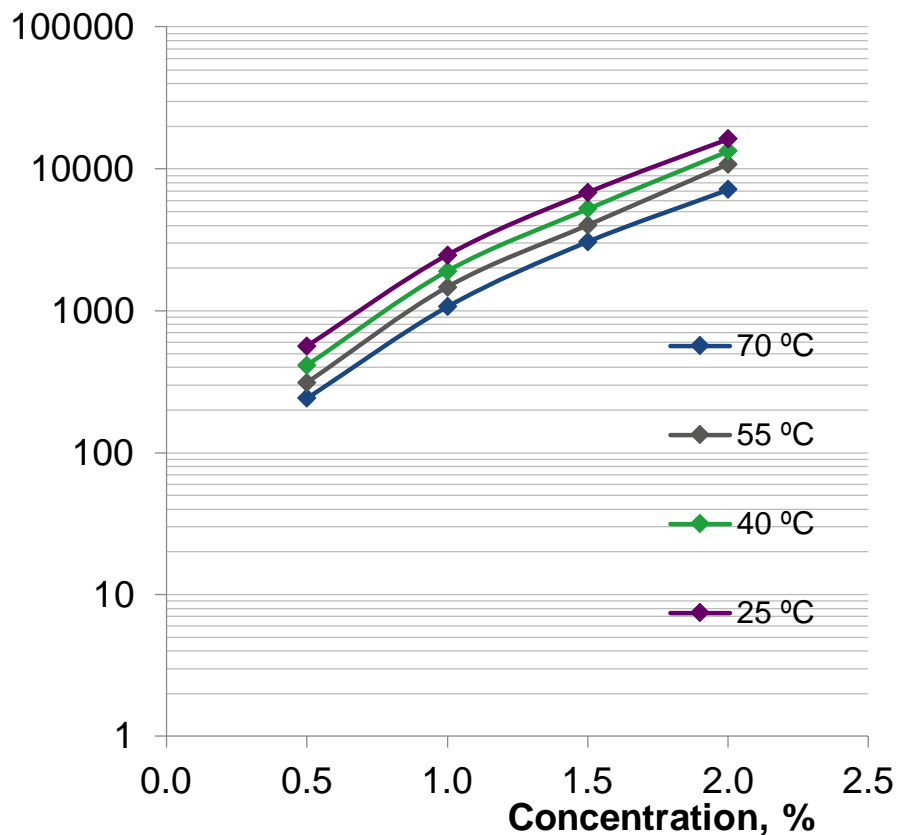
Viscosity Curve - CEKOL CLR 20000S



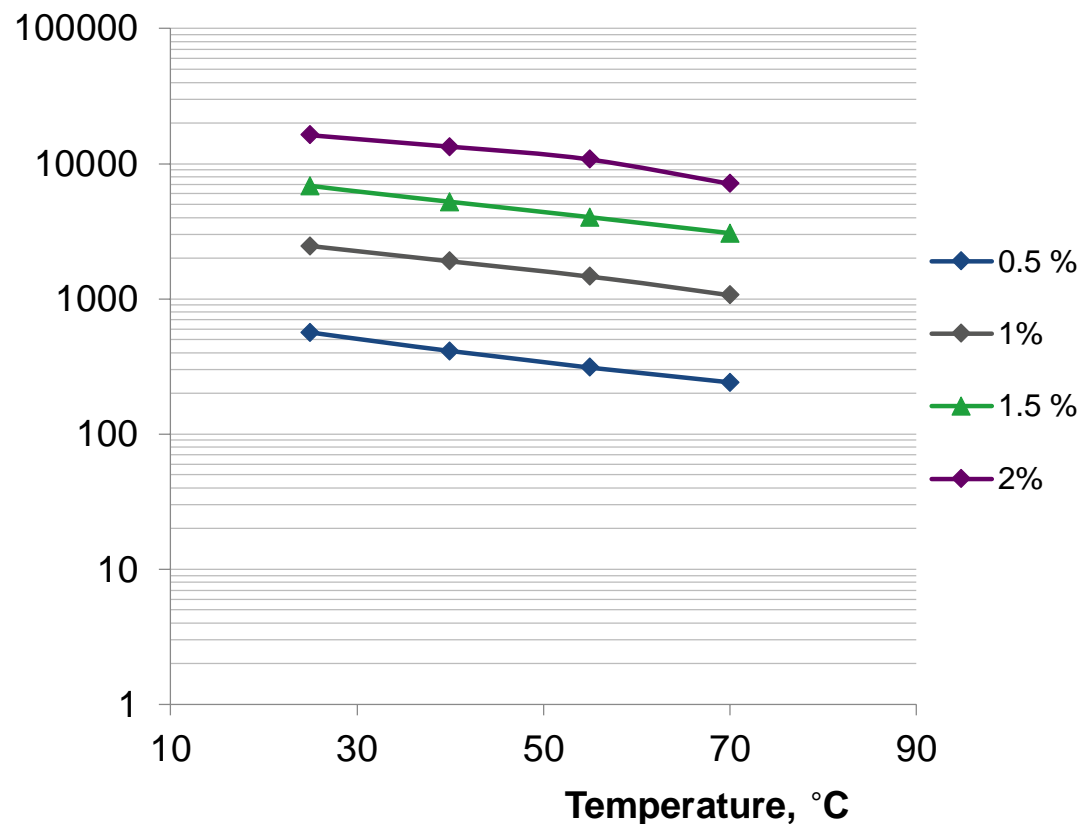
Measured with a Brookfield RV viscometer at 100 rpm.

Viscosity Curve – CEKOL CLR 80000S

CEKOL CLR 80000S, viscosity vs. concentration



CEKOL CLR 80000S, viscosity vs. temperature



Measured with a Brookfield RV viscometer at 100 rpm.

Thank you

Nouryon