

Commercialization of Dry Re-dispersible CNF at Sappi - Challenges and Opportunities



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Sappi at a glance



We produce and deliver specialised cellulose, paper and paper-based solutions to our direct and indirect customer base in over 100 countries

The world's leading producer of high-quality coated fine paper. Founded in South Africa in 1936. Manufacturing operations on three continents.

Sappi Limited

#2 Global producer of coated woodfree paper



*Forecast: Capacity and demand down 1.5% through 2019**

#1 Global producer of dissolving wood pulp



*Forecast: Demand up 6% and capacity up 3.3% through 2016***

#1 Global producer of Lignosulphonate



The Pulp Mill Biorefinery

Energy ←

→ Chemicals / Materials

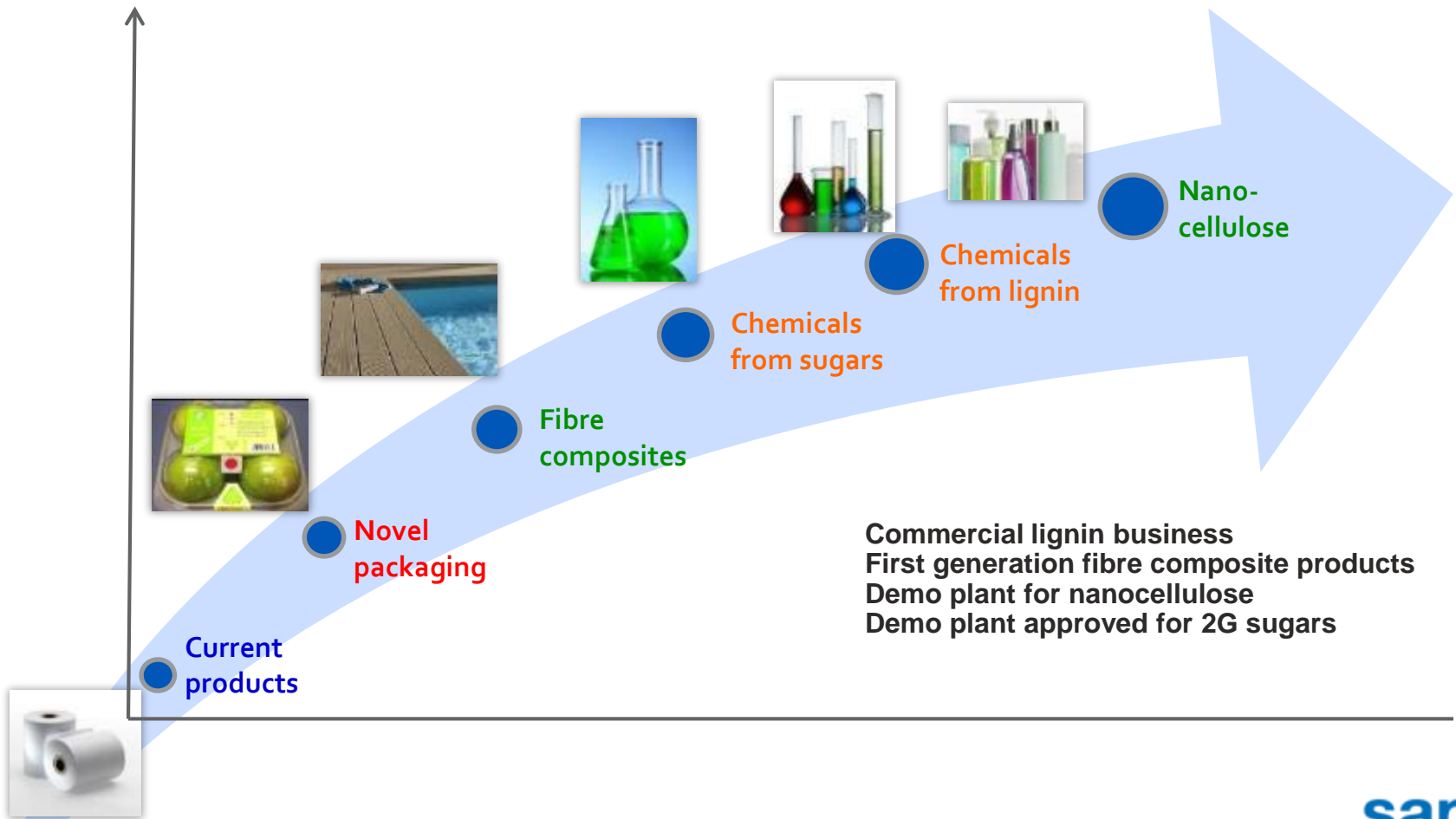


- Bio-oil
- FT-Diesel
- Bio-ethanol
- Bio-gas
- Electricity
- Solid fuel

{ Cellulose
 Lignin
 Bark
 Forestry residues

- | | |
|-----------------------|---|
| Cellulose | <ul style="list-style-type: none"> • Fibers • Derivatives • Nanocellulose |
| Lignin | <ul style="list-style-type: none"> • Phenols • Carbon fiber • Binders • Dispersants • Activated carbon |
| Hemi-Cellulose | <ul style="list-style-type: none"> • Fiber additives • Barriers • Hydrogels |
| Extractives | <ul style="list-style-type: none"> • Functional polymers • Bioactive compounds |

Sappi New Business pipeline



Sappi CNF – Current Position



Why nanocellulose?

Abundant

Biodegradable-sustainable-biocompatible

Non-toxic

Low cost

Light weight and stiff (like Alumina)

Dimensional stability and high strength (like Kevlar)

Stable against temperature and salt addition

High optical transparency, high thermal conductivity and oxygen permeability

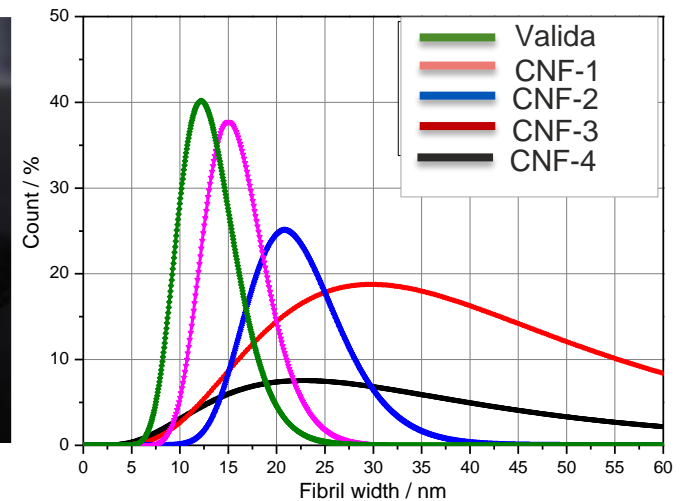
Recyclable-reusable

Sappi Valida Characteristics

Powder, slurry, or aqueous suspension.



Size distribution curve



- Logistic advantage
- Less water in process
- Longer shelf-life
- Re-dispersible

What is nanocellulose?

Cellulose	Abbreviation	L	d	Modulus of elasticity (GPa)	Tensile strength (MPa)
Microfibril	CMF or MFC	1-100 μm	10-100 nm	40	400
Nanofibril	CNF or NFC	70 nm-5 μm	4-30 nm	70	700
Nanocrystal	CNC or NCC	100-300 nm	3-5 nm	130-250	800-10000

Material	Tensile strength (GPa)	Modulus of elasticity (GPa)	Density (g/cm^3)	Specific tensile	Specific modulus	Thermal exp. coe. (ppm/K)
CNC	7.5	145	1.6	4.7	90.6	3-22
Glass fiber	4.8	86	2.5	1.9	34.4	13
Steel wire	4.1	207	7.8	0.5	26.5	15
Kevlar	3.8	130	1.4	2.7	92.9	-4
Graphite	21	410	2.2	9.5	186	2-6
CNT	11-73	270-970	1.0	11-73	270-970	-

Sappi Valida Offers Functionalities

- Rheology modifier
- Suspension stabilizer
- Gas barrier
- Grease barrier
- Moisture barrier
- Transparent reinforcing agent
- Dimensional stabilizer
- Water retainer
- Gradual releaser
- Odor remover
- Carrier
- Filter

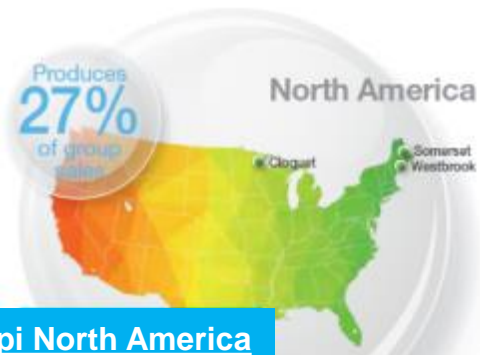


What differentiates Sappi Valida

- Feedstock control
- Functionalization
- Application support
- Sappi - R&D Global Centers of Excellence

Sappi Europe

- Pilot plant
- Characterization
- Functionalization
- Application support



Sappi North America

- Coating Chemistry
- Filler technology
- Application support



Southern Africa



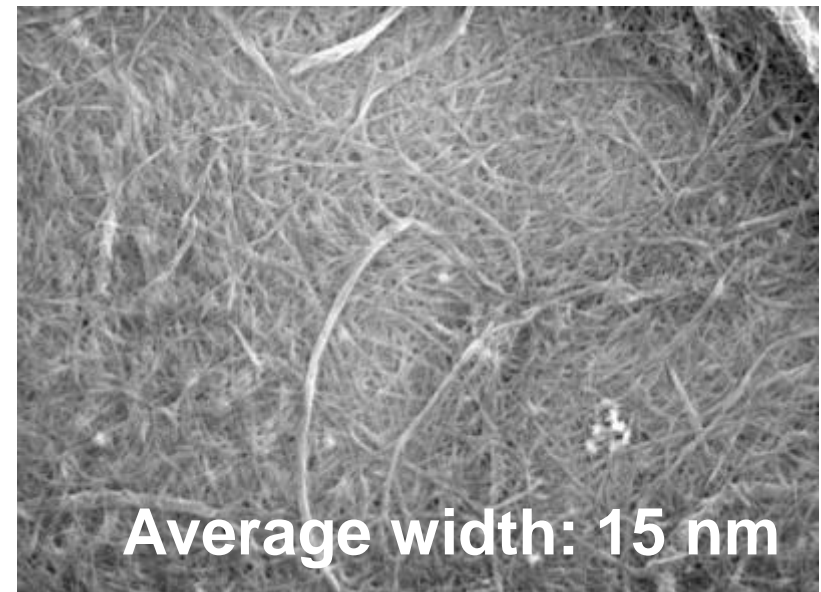
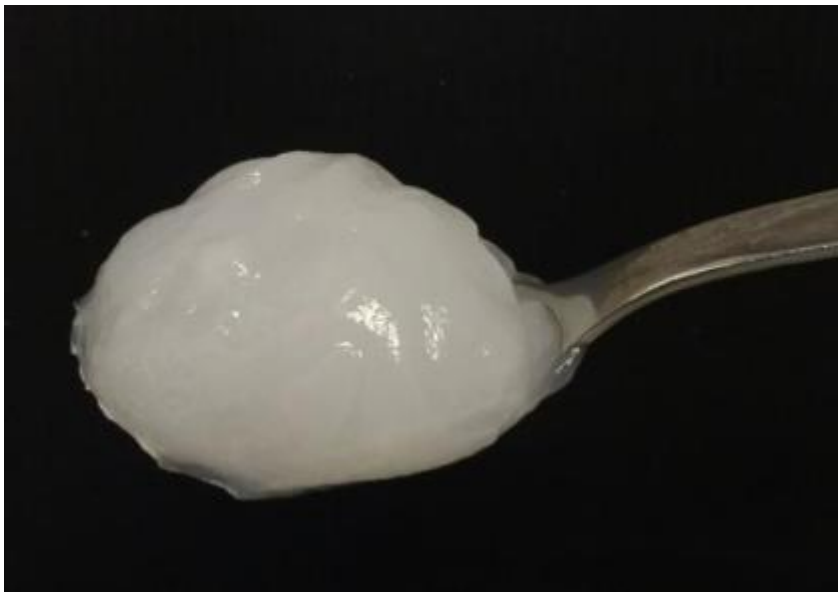
Sappi South Africa

- Forestry
- Pulping technology
- Fiber processing

● Mills

Key factors from lab to market

– Understanding of the Characteristics



- Size / Aspect ratio / Crystallinity
- Surface area / Surface chemistry
- Water retention / Degree of fibrillation
- Electric charge / Purity

- Link characteristics with performance

Key factors from lab to market

— Demonstrate Functionalities



Key factors from lab to market

- Consistent performance from batch to batch

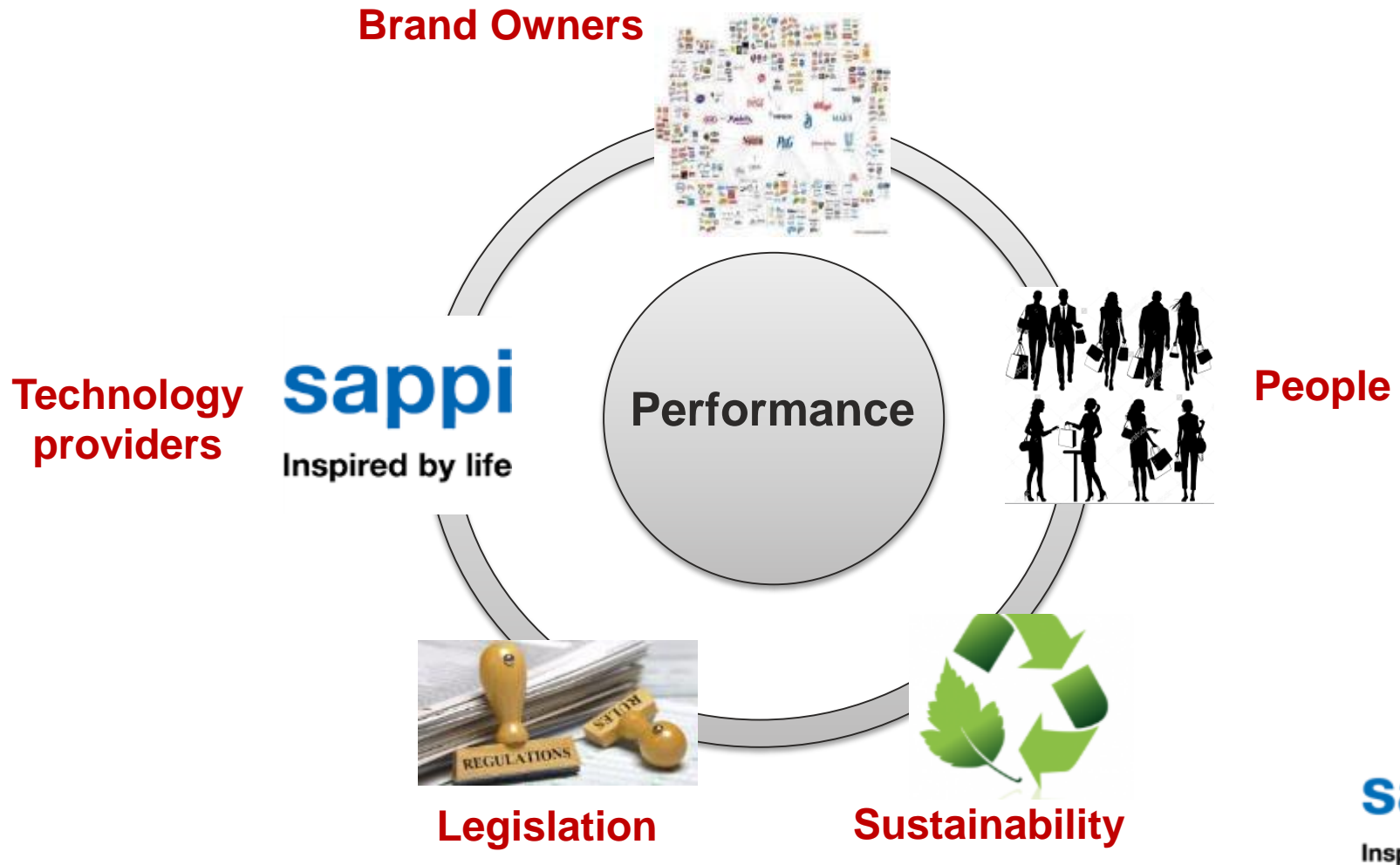


Key factors from lab to market

- Ability to scale up in production



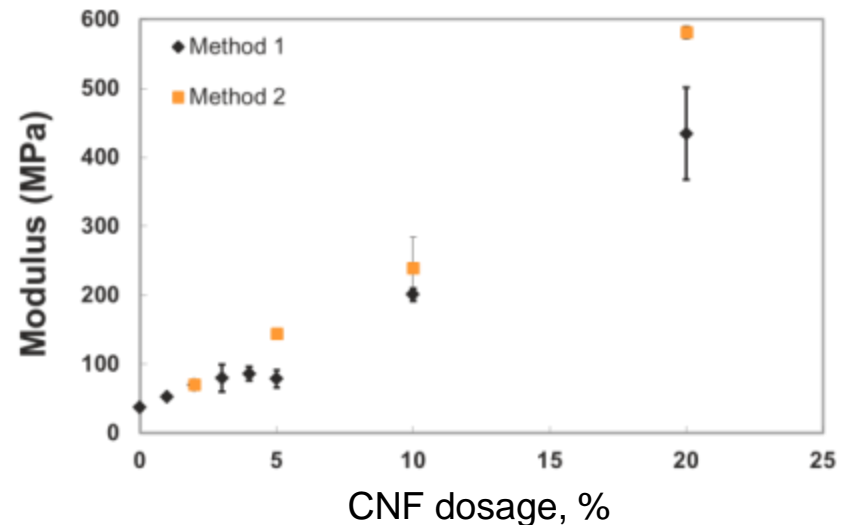
Driving Forces for CNF Commercialization



Sappi Valida in Transparent Films

CNF is an opportunity for enhancement of mechanical properties of transparent films

- Opportunity for fully bio-based solutions
- Enhancement of bio-based transparent films (stiffness, strength)
- Challenge is elongation: mixing with special polymers/additives
- Also opportunity enhancement non bio-based films (PE, PP based)



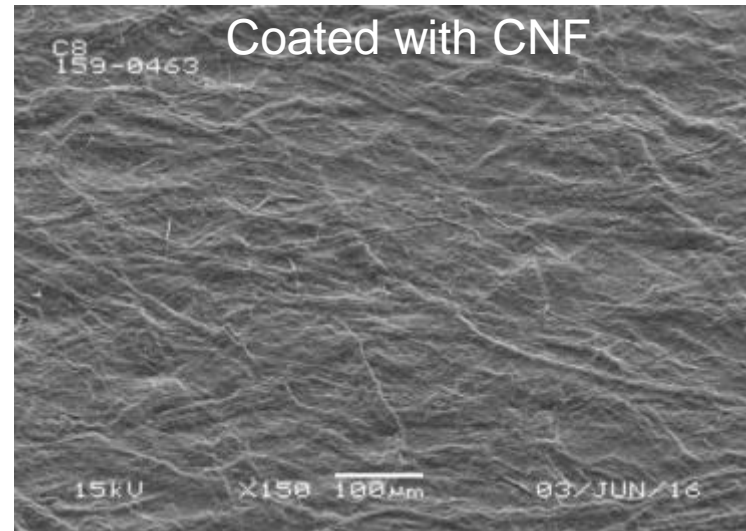
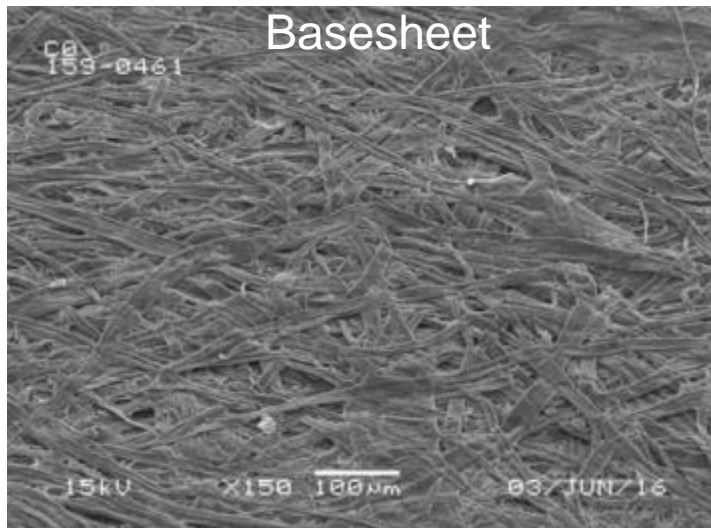
5% CNF reinforced film

Sappi Valida in Barrier Applications

High performance bio-based barrier on film

- Oxygen barrier created by thin CNF layer
- Combination of grease & moisture barrier also possible

Sappi has experience in food packaging where technology has been developed for barrier applications on paper. CNF presents further opportunities for bio-based barrier solutions.



Sappi Planet Friendly Packaging Solution



*Driven by EU commission position on landfilling
High barrier, paper based packaging solutions for brand owners*



*Natural
resources*



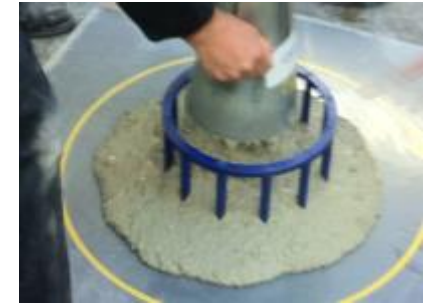
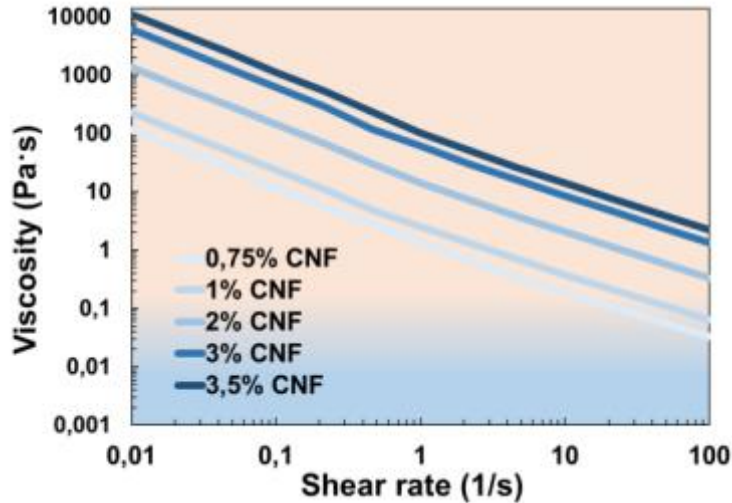
*Sealing & barrier
functionalities*



Recyclable

Sappi Valida in Concrete Admixtures

Sappi Valida increases yield stress with minimal effect on plastic viscosity.



Feature and Benefits

- Reduce slump flow
- Prevent segregation and bleeding
- Stabilize suspension
- No impact to setting time

Sappi Valida

viscosity modifying admixture

— SCC

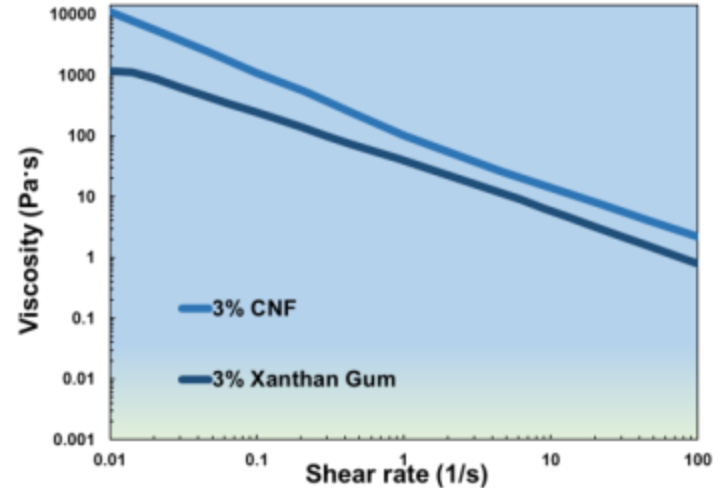
Stabilizer

— Light weight concrete
— Ultra high performance concrete
— Fiber cement

Reinforcement

— Ready mixed Concrete

Sappi Valida in Cosmetics



Matching properties and opportunities

Water binding capacity
pH stability
Structural stability
High aspect ratio



Rheology modifier

Water holding capacity
High barrier
Skin compatibility
Active interaction with active ingredients



**Moisturizing/
Anti-aging additive**

Surface functional groups
Surface charge
Affinity for water soluble active ingredients
pH response



**Active ingredient
delivery system**

Sappi Valida in Food

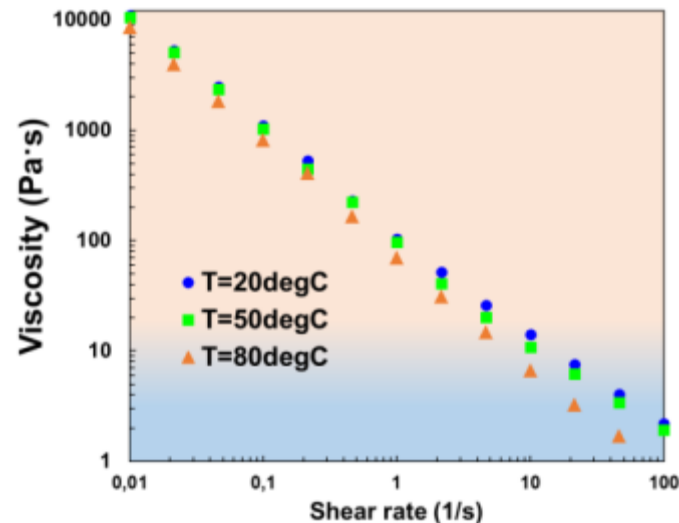


Feature and Benefits

- Thickener
- Foaming agent
- Bulking agent
- Temperature stability
- Freeze/thaw stability

Current focus

- Safety and health
- Chemicals legislation
- Standardization
- Market development



Summary

Nanocellulose, “Yes we Can.”

We look forward to building a mutually beneficial relationship with you

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