Mineral/ microfibrillated cellulose composite materials: High performance products, applications and product forms

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Presented by:

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Outline

• Introduction
• New mineral/ MFC composite products
• Comparison of mineral/ MFC composites with other MFCs
• Mineral/ MFC composite product forms
• Performance of high solids mineral/ MFC composite product forms
• Conclusions
Introduction

• MFC use has been limited by high process energy requirement and equipment complexity

  - Cellulose fibres are co-processed with mineral particles. The mineral particles act as a micro-grinding media, thus, reducing the energy requirement
  - The process can be accomplished using robust, industrially proven grinding equipment

• We have been able to produce mineral/ MFC composites with a wide range of pulps and minerals (TAPPI Nano 2016)

• FDA FCN for food contact paperboard

• 8000 dry metric tonnes pa of fibril capacity (40 000 dry metric tonnes of mineral/ MFC composite) installed and operational across three continents. Further capacity under construction
Product characterisation and test methods 1

• Processing and handling of mineral/MFC composites are dominated by the high viscosity of MFC arising from presence of high surface area hydrophillic fibrils. Typical fibre solids is ~2%

Photograph (a) and micrograph (b) of mineral/MFC composite showing the high viscosity and fibrillar structure
Performance observations

Typically, use of mineral/ MFC composites with a concomitant filler increase is associated with:

• Excellent performance stability
• Increased initial wet web strength
• Minimal impact on wet end chemistry
• Overall positive impact on drainage
• Improved dry mechanical properties
• Improved opacity
• A much tighter sheet (reduced porosity)
• Improved coating hold out
• Improved smoothness
• Maintaining bulk when fibre is replaced by higher specific gravity filler is a challenge but can be managed
Performance observations: Wood free filler top-up

Mineral/MFC composites can be used to increase filler loadings in wood free sheets.

- Graph shows data from 16 full scale machine trials in wood free applications.
- Typically achieve approximately 10 part filler increase with a 2% MFC dose.
- There are new product development opportunities. SEMs show conventional 17% GCC filled sheet (left) and a 55% GCC filled sheet with 4.5% MFC dose (right) from a pilot study.
Product characterisation and test methods 2

- Product characterisation is straightforward; solids, percent of solids that is fibre, viscosity and in-house tensile test

In-house tensile test and handsheet data show good correlation for a range of mineral/ MFC composites samples prepared with varying processing conditions

(Handsheet conditions: 70/30 Eucalyptus/NBSK, 550 csf, 80 gsm, 20% 60%<2µm GCC filler, 5% MFC)
Running full-scale trials with low solids products

- Running full-scale paper machine trials with MFC difficult due to low solids, viscous product
- Our solution was to build a production plant producing a dewatered crumble product
- Approximately 80 full-scale paper machine trials to date

Mineral/ MFC composite filter cake product form

Mineral/ MFC composite production plant in the UK, 2000 dry metric tonnes pa of fibril capacity. Operational since Q4 2013
Product forms for trials

- **Slurry (~2% MFC fibre solids)**
- **Bottles and barrels, Transitanks, Trucks and ISO tanks**
- **Filter cake (~10-15% MFC fibre solids)**
- **Buckets, barrels, big bags**
Product forms for trials

- Slurry (~2% MFC fibre solids)
- Bottles and barrels, Transitanks, Trucks and ISO tanks

Bottles
10 liter (2.65 US Gallon) = 200 g (~8 oz) dry MFC

Barrels
220 liter (60 US Gallon) = 4.4 kg (~10 lb) dry MFC

Transitanks
1000 liter (265 US Gallon) = 20 kg (~44 lb) dry MFC

Trucks/ ISO tanks
25 meter$^3$ (6600 US Gallon) = 500 kg (~1100 lb) dry MFC

Largest shipments to date
80 Transitanks = 1600 kg (~3500 lb) dry MFC
7 Trucks = 3500 kg (~7700 lb) dry MFC
Product forms for trials

- Filter cake (~10-15% NFC fibre solids)
- Buckets, barrels, big bags

**Filter cake**
Bag weight ~ 1000 kg (~2200 lb) = 150 kg (~330 lb) dry MFC

**Largest shipments to date**
292 bags = ~44 tonnes (~48 short tons) of dry MFC
New product health and safety assurance

- Cleared through Environment Canada, Health Canada, US EPA and US FDA (FCN 1582, for 5 wt.% fibrils in packaging board)

- BfR application filed for consideration under recommendations XXXVI, XXXVI/1, XXXVI/2, and XXXVI/3
It is possible to prepare effective mineral/MFC composites from a wide range of fibres.

Mineral/ MFC composites with a range of minerals

It is possible to prepare effective mineral/ MFC composites from a wide range of minerals.

Scanning electron micrographs of mineral/ MFC composites samples prepared with a range of different minerals (80:20, mineral/ NBSK, mineral/ MFC composite).
New mineral/ MFC composite products 1

• There have been improvements in product tensile and viscosity performance since the initial launch in 2014

![Graphs showing tensile and viscosity performance](image)

Tensile and viscosity performance of a series of laboratory and pilot scale prototype mineral/ MFC composite products

(80:20, mineral/ MFC composite)
New mineral/ MFC composite products 2

- Improvements in mineral/ MFC composite tensile properties translate to improved sheet properties allowing improved products or dose reductions

Paper sheet burst index at 20 wt.% filler content versus MFC content for two mineral/ MFC composite product prototypes

(30% pine, 70% eucalyptus, 550 csf, 80 gsm handsheets, [80:20, 60%<2um GCC/ NBSK, mineral/ MFC composite])
Comparison of mineral/ MFC composites with other MFCs

- Mineral/ MFC composites give at least equivalent performance to that obtained with other MFCs

(30% pine, 70% eucalyptus, 550 csf, 80 gsm handsheets, [80:20, 60%<2um GCC/ NBSK, mineral/ MFC composite])

Paper breaking energy versus mineral filler content for two mineral/ MFC composite products and other MFCs
Mineral/ MFC composite product forms

- A high solids MFC product form is highly desirable since it allows merchant sales.
- It is easy to dry MFC but the challenge is redispersion in water at customer location.

<table>
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<th>Product solids (wt.%)</th>
<th>Tensile (% of control)</th>
<th>Total nib surface area (mm²/g)</th>
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<tr>
<td>High solids product 4</td>
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</table>

Mineral/ MFC composites can be dried to high solids and then redispersed in water with low energy input and the original properties restored.

50% NBSK, 50% GCC composite
High solids mineral/ MFC composite product forms

High solids mineral/ MFC composite product form ((50:50, 60%<2um GCC/ NBSK mineral/ MFC composite, 51% solids))
High solids mineral/ MFC composite product forms: Product stability

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<td>Viscosity control (%)</td>
<td>Tensile control (%)</td>
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Mineral/ MFC composites display performance stability for > 150 days when stored in intermediate bulk containers under ambient conditions.
Performance of high solids mineral/ MFC composite product forms: Paper and board applications

Mechanical properties of sheets containing let-down high solids mineral/ MFC are equivalent to controls
Conclusions

• Mineral/ MFC composites are produced using a cost-effective, robust process and have proven full-scale availability

• Mineral/ MFC composites can be produced using a wide range of minerals and pulps

• The tensile and viscosity behaviours of mineral/ MFC composites have improved since the initial product launch in 2014

• Mineral/ MFC composites give at least equivalent behaviour to other MFCs in paper and board applications

• High solids mineral/ MFC composite product forms can be fully re-dispersed to their original properties and allow the operation of merchant plants

• We believe that mineral/ MFC composites are an important additive for paper and packaging applications
Thank you for your attention

We would like to thank TAPPI for the opportunity to present this work

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