Mineral/microfibrillated cellulose composite materials: Recycled fibres, engineered minerals and new product forms

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Introduction: Mineral/ microfibrillated cellulose (MFC) composites

- MFC: Utility for increased bonding in fibre-based structures, viscosification, re-inforcement......

- A cost effective grinding-based method for the production of mineral/ MFC composites from minerals and cellulose pulp
  - Cellulose fibres are co-processed with mineral particles. The mineral particles act as micro-grinding media, thus, reducing the energy requirement
  - The process can be accomplished using robust, industrially proven grinding equipment

- 10 000 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

- FDA FCN for food contact paperboard
Introduction: Mineral/ microfibrillated cellulose (MFC) composites

- 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
Introduction: Fibrils and fibres

Structure performance relationships

Properties

Engineered fibrils
• Fibril length
• Fibril width
• Microgel-like or discrete
• Surface charge
• Surface hydrophobicity
• Colour
• ……

Performance
• Enhancement of web properties (mechanical, porosity, surface, optical)
• Viscosification/ rheological property modification
• Reinforcement
• Stand-alone objects
• Barrier
• Cost-effectiveness
• Re-use
• ………

Applications
• Paper/ Packaging
• Building materials
• Coatings
• Oil field
• Food and beverage
• Non-wovens
• Composites
• Electrical/ electronic
• ………
Introduction: Fibrils and fibres

Fibre sources
- Wood-free v mechanical
- Kraft v sulphite
- Long fibre v short fibre
- Virgin v recycle
- Tree-based v other biomass
- ...
Introduction: Minerals

Structure performance relationships

Properties
- Particle size
- Particle shape
- Particle packing
- Crystal microstructure
- Colour
- Reflectance
- Absorbance
- Scattering efficiency
- Refractive index
- Specific gravity
- Hardness
- Chemical composition
- Surface character

Performance
- Opacity
- Clarity
- Gloss
- Density modification
- Wear / abrasion resistance
- Barrier
- Blocking
- Flame retardant
- Mechanical reinforcing
- Chemical delivery/ reaction
- .........

Applications
- Paper/ Packaging
- Building materials
- Coatings/ inks
- Oil field
- Food and beverage
- Non-wovens
- Composites
- Electrical/ electronic
- Abrasives
- Filtration
- Ceramics
- .........
**Introduction: Minerals**

**Mineral sources**
- Calcium Carbonate
  - Ground marble/ limestone
  - Ground chalk
  - Precipitated
- Kaolin
  - Hydrous
  - Calcine
  - Halloysite
- Andalusite
- Ball Clay
- Bauxite
- Bentonite
- Clinoptilolite
- Diatomite
- Dolomite
- Expandable Graphite
- Feldspar
- Fused Alumina
- Fullerenes
- Fused Silica
- Mica
- Natural Graphite
- Perlite
- Specialty Carbon Black
- Synthetic Graphite
- Vermiculite
- Zirconia
Introduction: Minerals

Calcium carbonate: Ground and precipitated forms: High level of control over crystal morphs and dimensions
Introduction: Minerals

Kaolin: Can be engineered for very high shape factor
Introduction: Mineral fibril composites

- There are a multitude of options available to the formulator

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Recycle fibres

- Mineral/ MFC composites prepared from mixed office waste and OCC
- Tensile properties at ~ equivalent to/ better than virgin NBSK controls

50% OCC/ 50% kaolin mineral/ MFC composite (right) and control with NBSK

Mixed office waste feed
Applications: Viscosity modification

- 50% NBSK/ 50% mineral/ MFC composites
- Can control viscosity with choice of mineral shape factor.
- Low shape factor for high solids application
- High shape factor for high viscosity
Applications: Barrier

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Applications: Electronics

50% NBSK/ 50% graphite mineral/ MFC composite slurry and sheet

20% NBSK/ 80% mineral/ MFC composite printed electronic substrate
Product forms

• Slurry (~2% MFC fibre solids)
• Bottles and barrels, Transitanks, Trucks and ISO tanks, satellite plant
• Filter cake (~10-15% MFC fibre solids)
• Buckets, barrels, big bags
• High solids powder (~37% MFC solids/ 75% total solids), developmental
• Sacks, bags and bulk
Product forms: Slurry

• Slurry (~2% MFC fibre solids)

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 meter³ (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: Filter cake

- Filter cake (~10-15% MFC fibre solids)

- 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

- 50% OCC/ 50% Kaolin

- 50% NBSK/ 50% GCC
Product forms: High solids powder

50% NBSK/ 50% GCC, 75% solids
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. Variations in the selection of pulp and mineral allow the formulator to select in favour of a wide range of properties

• Recycled pulp streams can be used

• We believe that mineral/ MFC composites are an important additive for a wide range of applications

• These mineral/ MFC composite materials have been commercialised as FiberLean® MFC
Thank you