November 27, 2018

Permanent slip additive for PE films

DOW CORNING™
MB 25-235 Masterbatch

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Agenda

- Multibase and silicone masterbatch introduction
- Challenges
- Features and benefits
- Experimental set-ups
- Technical results
- Conclusions

Multibase

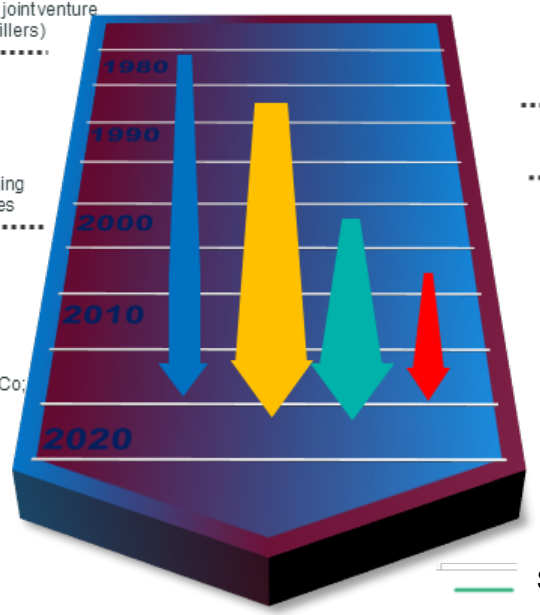
Transforming our innovation

1980
Multibase formed: 50/50 joint venture
Paturle (steel) & Omya (fillers)

2002
Acquisition by Dow Corning
& introduction of siloxanes

2016
Integration in Dow

2018 Transfer to Spec. Co;



1988
Manufacturing expansion
Copley USA

1996
Manufacturing expansion
Daman, India

2010
Manufacturing expansion
Zhangjiagang, China

- Silicone MB
- TPE (SEBS or POE based)
- TPSiV®
- Fillers MB

Bringing Together Two Complementary Portfolios

To create Three Strong Companies

DOW® + DUPONT®

AGRICULTURE
Corteva™ Agriscience

Broad offering and robust pipeline across germplasm, biotech traits and crop protection

MATERIALS SCIENCE
Future Dow

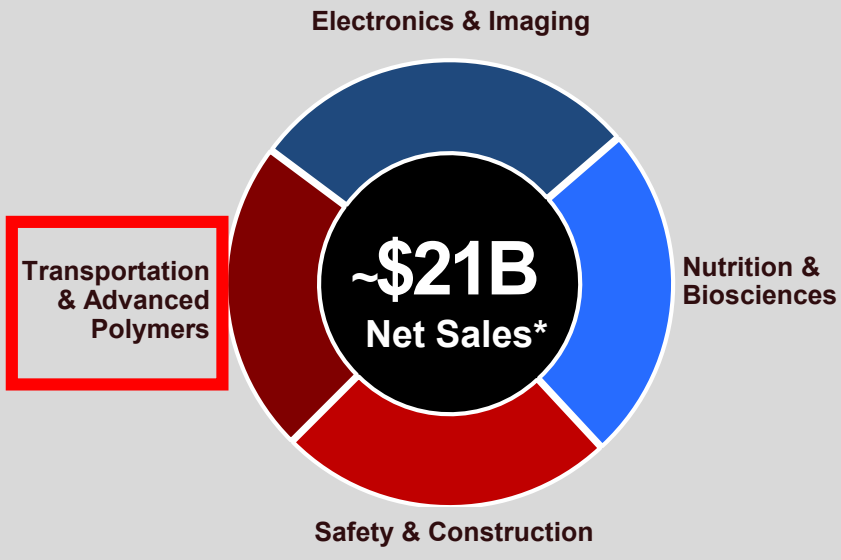
One of the strongest, deepest chemistry toolkits with robust technology and asset integration, scale and competitive capabilities

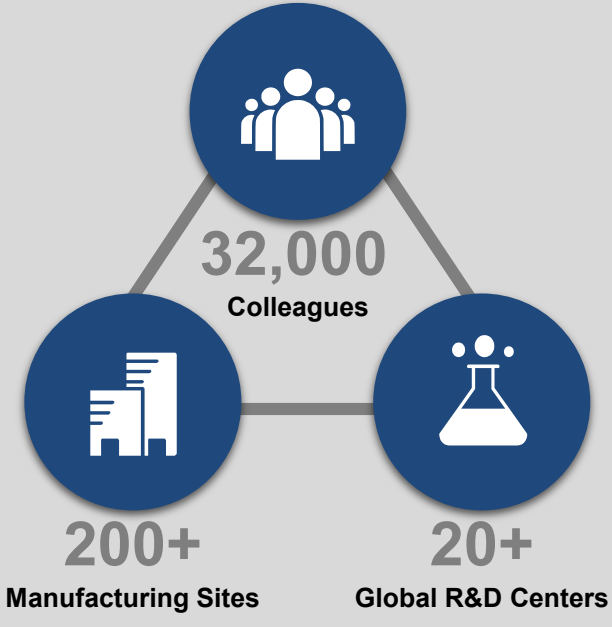
SPECIALTY PRODUCTS
Future DuPont

World-class innovation process and application development capabilities

Specialty Products(future DuPont)

Our Division At-a-Glance





KEY END-MARKETS

- Transportation
- Electronics
- Construction
- Consumer Goods
- Health & Wellness
- Food & Beverage
- Medical & Pharma
- Oil & Gas
- Renewable Energy
- Safety & Protection

**2017 Proforma Sales*

Leading Market Positions in Attractive Growth Markets

INDUSTRIAL MARKETS

TRANSPORTATION

- High-performance polymers
- Structural adhesives
- High-temperature lubricants
- Brake Fluids

INDUSTRIAL

- Perfluoroelastomer Parts
- Aerospace
- Photovoltaics

ELECTRONICS

- Electrical Components
- Semiconductor materials
- Consumer Electronics

CONSUMER

CONSUMER

- Food Contact Materials
- Sportswear and Recreation
- Furniture

MEDICAL

- Medical Devices
- Bio Pharma Processing
- Pharmaceutical Solutions

Multibase

Our Global Presence

Silicone Brings Multiple Benefits to Plastic Materials & Processing

EXTEND

Extending impact resistance, surface improvement, flame-retardant performance and consistency of light diffusion helps customers create higher-performing products.

ENHANCE

Additives from Dow Corning help increase throughput and productivity, while reducing torque issues to enhance processing performance.

REINFORCE

Help customers reinforce mechanical properties, filler incorporation and compatibility of formulations.

The challenge

PE blown film

DOW CORNING™ MB25-235 features & benefits

The Challenge in PE Blown Films

Developing long-lasting low coefficient of friction (COF) is critical to ensure:

- seamless throughput
- high productivity
- consistent quality during post process operation, such as FFS

DOW CORNING™ MB25-235 Masterbatches main features

- ✓ Does not migrate
- ✓ Does not transfer
- ✓ Efficient at low dosage, introduced in one skin layer only
- ✓ Can be used through conventional dosing equipment
- ✓ Designed to be used in combination with antiblock

Expected benefits

- A stable long-term COF will **ease logistics and storage**, and during post production process (e.g. FFS)
- The low content needed allows a **reduced impact on haze**

DOW CORNING™ MB25-235

- ✓ Improves coefficient of friction
- ✓ No impact on mechanical properties
- ✓ No transfer effect: compatible with printing process on the opposite layer
- ✓ Compatible with LDPE and LLDPE

	DOW CORNING™ MB25-235 Masterbatch
Active content	25%
Physical form	Pellets
Process	Pellets mix
Processing temperature	180°C - 220°C
Typically recommended usage level	3%

Experimental Set-ups

Blown Film Fabrication Parameters
COF Measurements
Mechanical Properties
Transfer Test Description

Film Structures

Films without slip additive – base structure

A	12.5µm	LLDPE/LDPE 2/1 + 3000ppm Talc as antiblock
B	25µm	LDPE - d=0.918 - MFI 2.5 g/10min
C	12.5µm	LLDPE - d=0.900 - MFI 3g/10min

- Layer A: Skin layer in which slip properties are desired
- Layer B: Core layer
- Layer C: Opposite skin layer, potentially Corona-treated to be metallized or printed

- *NB: Screw speed and outputs were slightly changed to ensure same layers thicknesses between composition*

Film Structures

Films with organic slip additive – organic reference

A	12.5µm	LLDPE/LDPE 2/1 + 3000ppm Talc as antiblock
B	25µm	LDPE - d=0.918 - MFI 2.5 g/10min + 0.5wt% of organic slip agents
C	12.5µm	LLDPE - d=0.900 - MFI 3g/10min

- Layer A: Skin layer in which slip properties are desired
- Layer B: Core layer
- Layer C: Opposite skin layer, potentially Corona-treated to be metallized or printed

- *NB: Screw speed and outputs were slightly changed to ensure same layers thicknesses between composition*

Film Structures

Films with silicone additive – DOW CORNING™ MB25-235 Masterbatch

A	12.5µm	LLDPE/LDPE 2/1 + 3000ppm Talc + **2, 4 and 6wt% DOW CORNING™ MB 25-235**
B	25µm	LDPE - d=0.918 - MFI 2.5 g/10min
C	12.5µm	LLDPE - d=0.900 - MFI 3g/10min

- Layer A: Skin layer in which slip properties are desired
- Layer B: Core layer
- Layer C: Opposite skin layer, potentially Corona-treated to be metallized or printed

- *NB: Screw speed and outputs were slightly changed to ensure same layers thicknesses between composition*

Film Structures

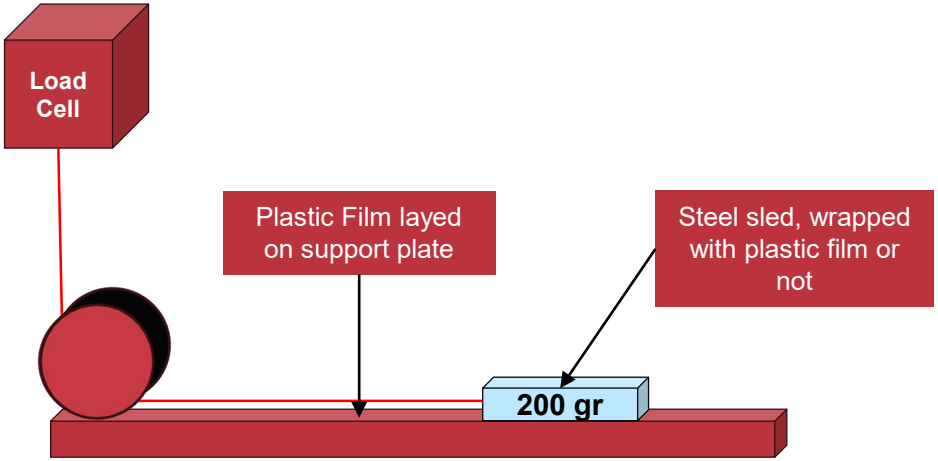
Blown film extrusion process

- Lab scale Colin extruder, 3-layers configuration
- Screw diameter 25mm
- Die diameter 60mm, gap 0.6 mm, Maximum width 350mm
- Skin layer screw speed: 34 rpm
- Skin layer melt temperature: 215°C
- Pulling speed: 4 m/min
- Blow-up ratio (BUR) 2.12, Draw down ratio (DDR) 5.65
- Film total thickness 50µm, output around 4kg/h, depending on the composition extruded

Tests Parameters

Coefficient of friction

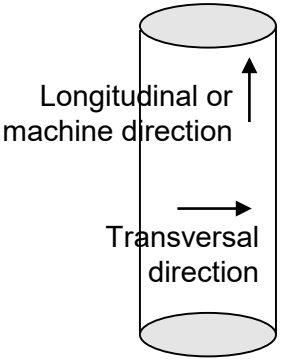
- Zwick coeficient of friction, following ASTM D1894
  - 254 mm x 127 mm 200g Sled
  - Running speed: 150 $mm.min^{-1}$
  - Running length: 60 mm



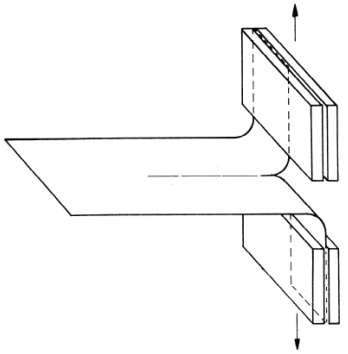
Tests Parameters

Mechanical properties

- Tensile: Zwick equipment, following EN 13655:2002
  - Running speed: 500 $mm.min^{-1}$
  - Samples: 10mm width strips
  - Gap between grips: 50mm



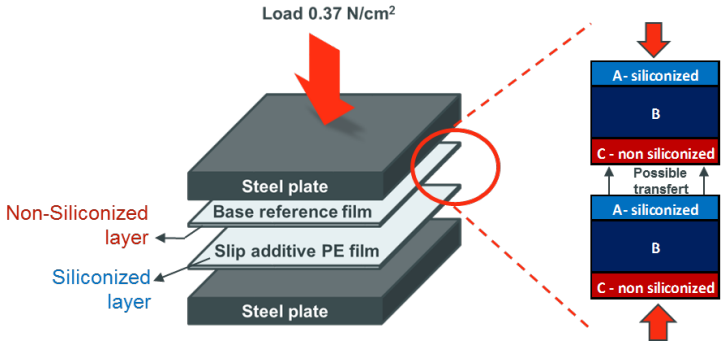
- Tear test: Zwick equipment, following ISO 6383-1:2015
  - Speed: 200mm/min



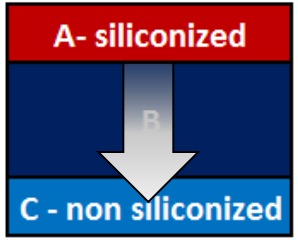
Tests Parameters

Transfer study

- **Contact migration test** (after 2 months at 23°C under weight)
  - Simulation of winding pressure by pressing films between metallic plates.
  - Base reference PE film (containing no slip additive) and SiMB treated PE film are laid together with a 0.37N/cm² pressure. (weight 15 KG/ 20*20 cm)
  - After exposure, IR ATR spectroscopy is conducted to track Si migration



- **Intra-layer migration test** (after 1 month at 60°C)
  - The samples are stored for 1 month in an oven at 60°C to accelerate ageing and degradation
  - Layer C (non-siliconized skin layer) is IR tested to see the presence of silicone or amide, coming from the opposite skin layer and migrating through all layers.



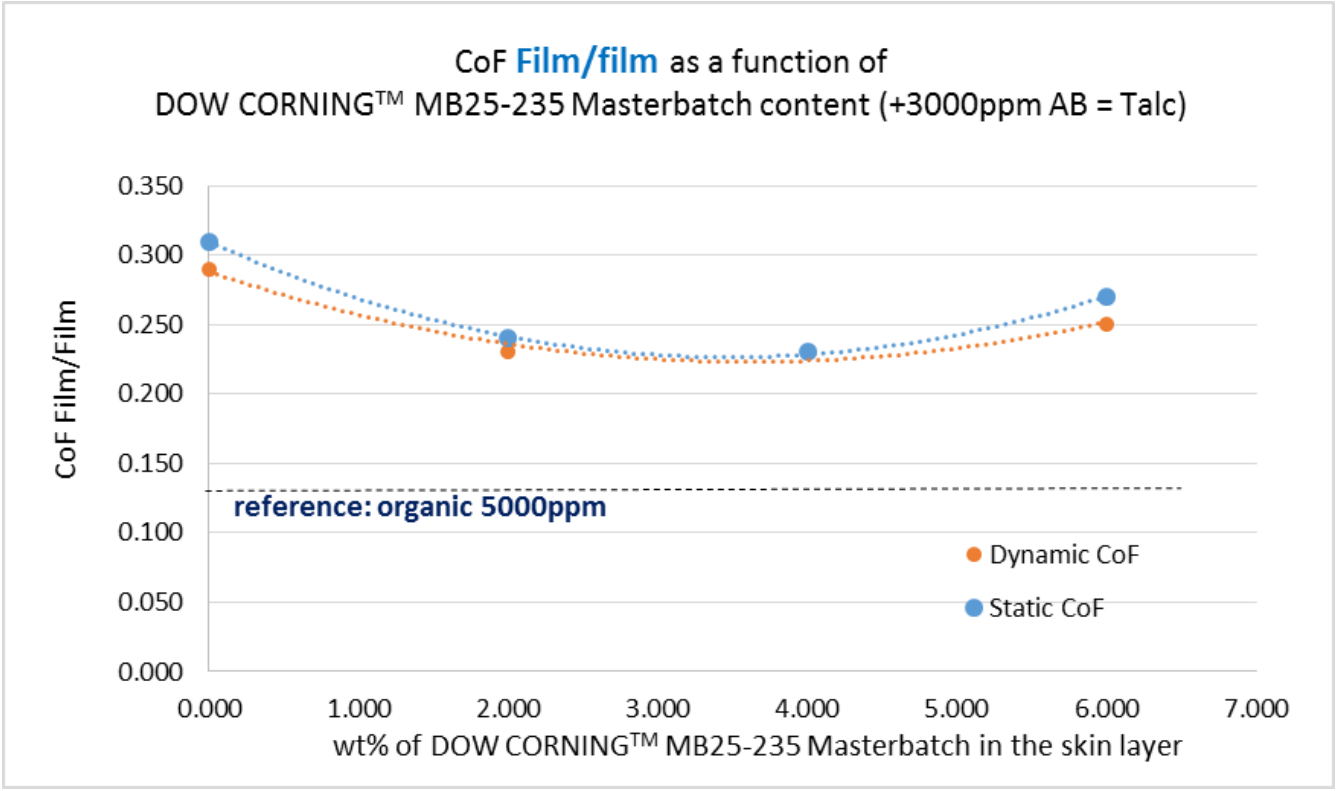
Technical results

COF Comparison

Mechanical Properties

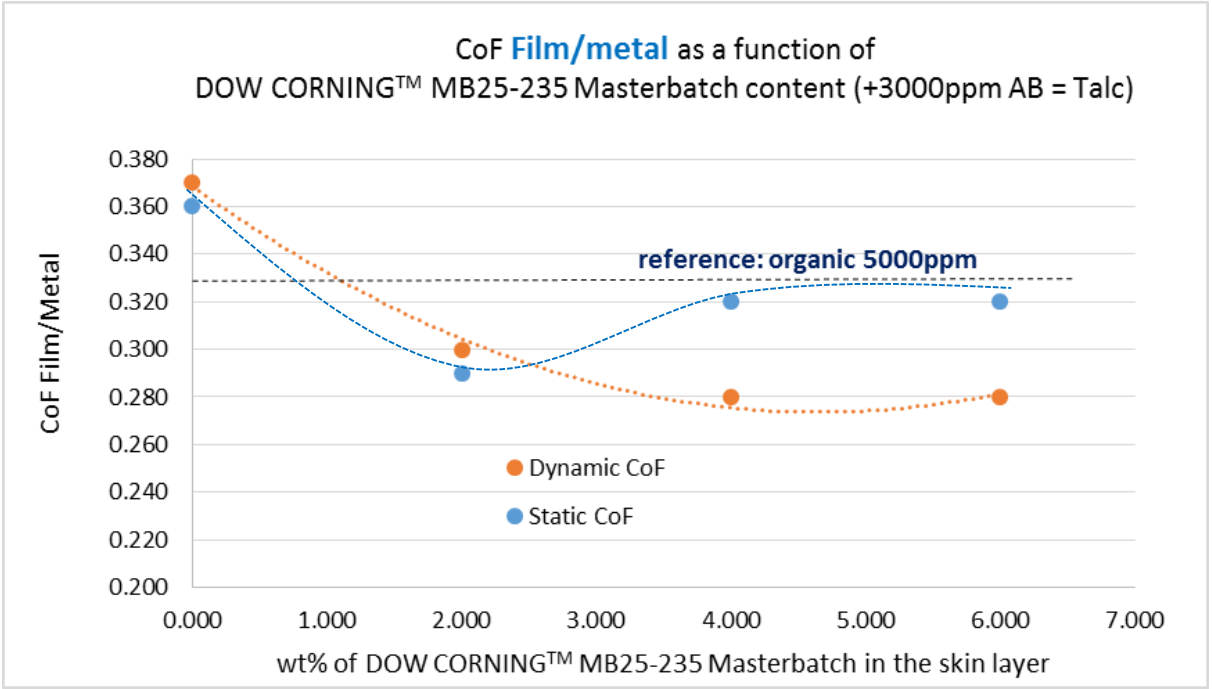
Transfer Analysis

Dynamic and Static COF Film/Film



An optimum is achieved at 2 to 4 wt% of DOW CORNING™ MB 25-235 silicone Masterbtach with a CoF Film/Film around 0.22

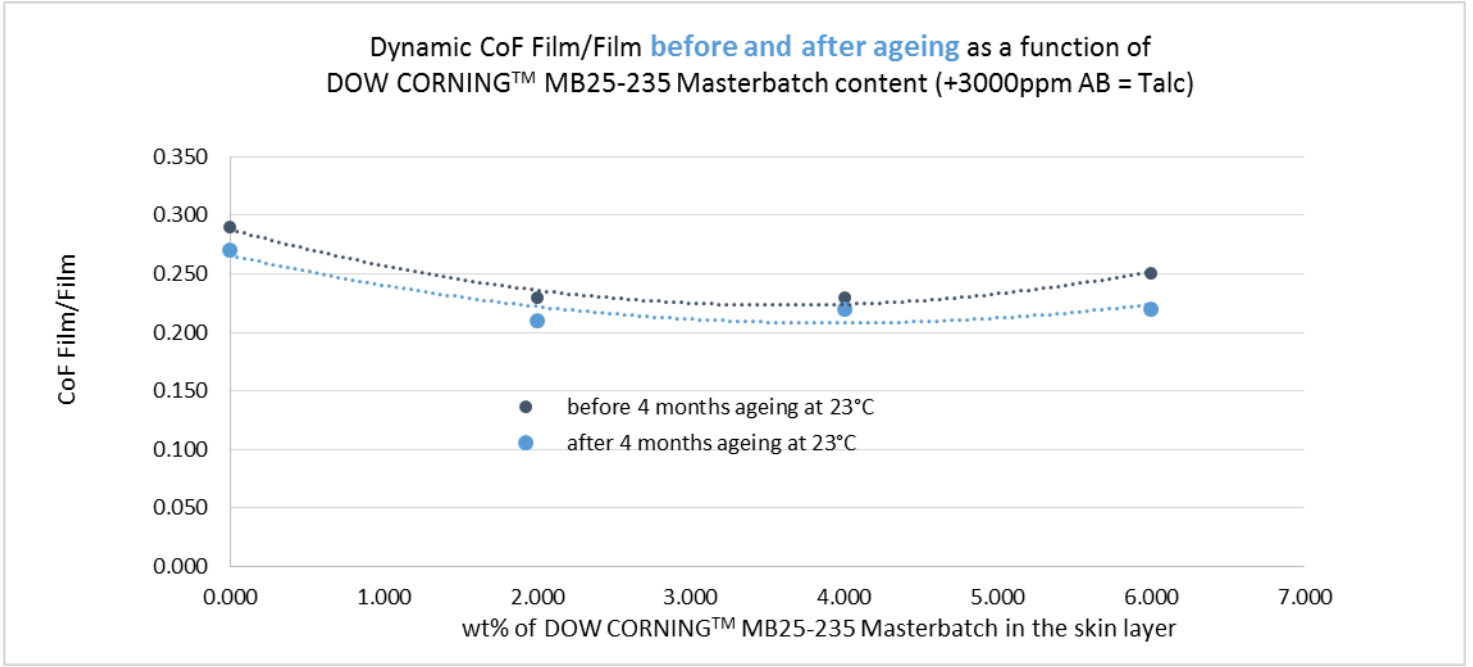
Dynamic and Static COF Film/Metal



*NB: The Film/film COF is higher than reference **BUT** Film/Metal COF is lower than reference*

The silicone additive shows lower COF than conventional solutions

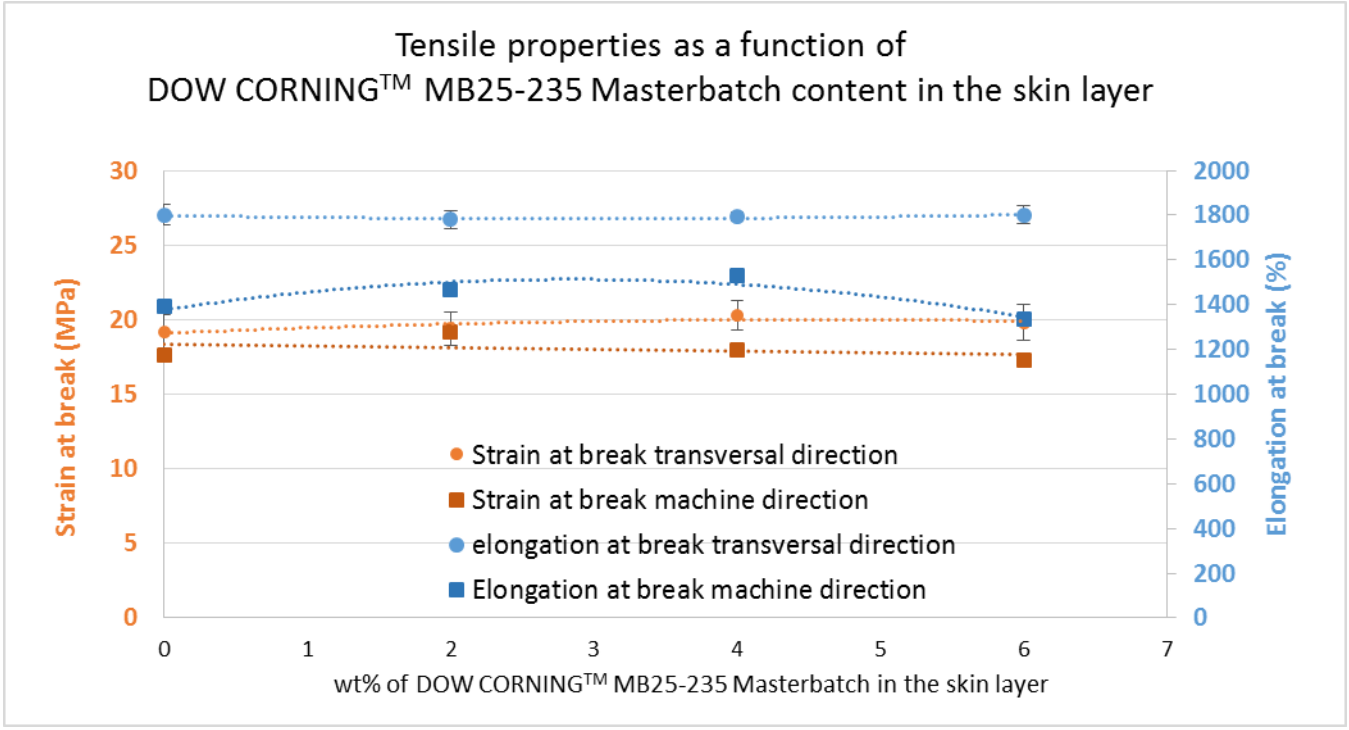
Dynamic COF After 4 Months of Ageing



Film/Film COF remains stable after 4 months of ageing at 23°C

Mechanical Properties

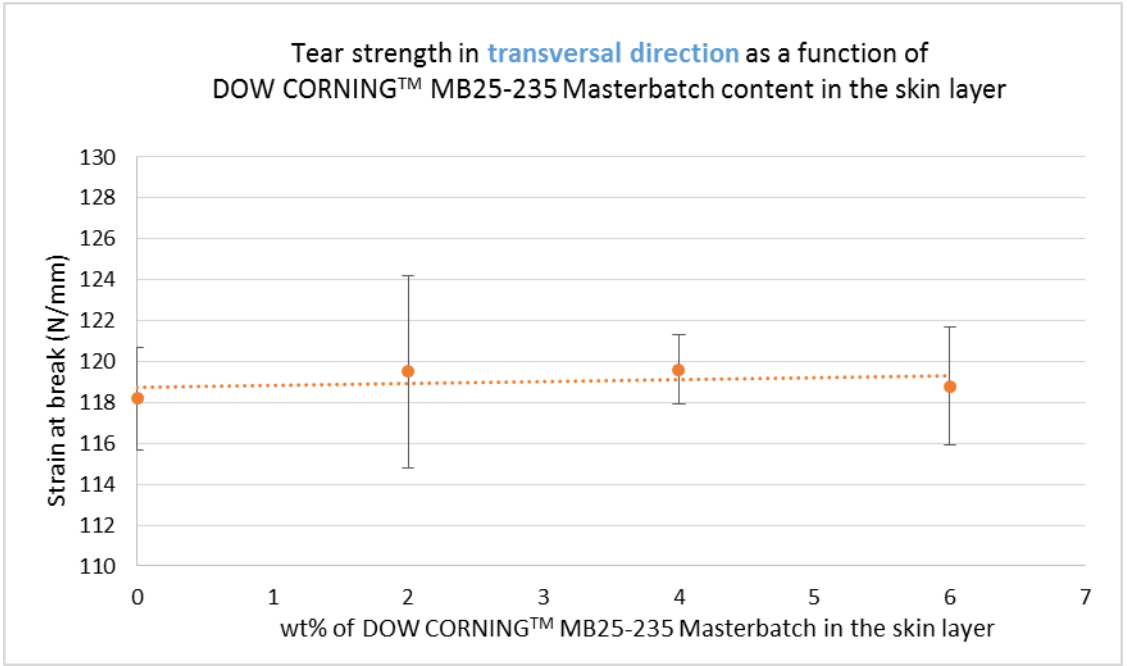
Tensile test



The addition of DOW CORNING™ MB25-035 silicone Masterbatch does not affect tensile properties of the film

Mechanical Properties

Tear strength test

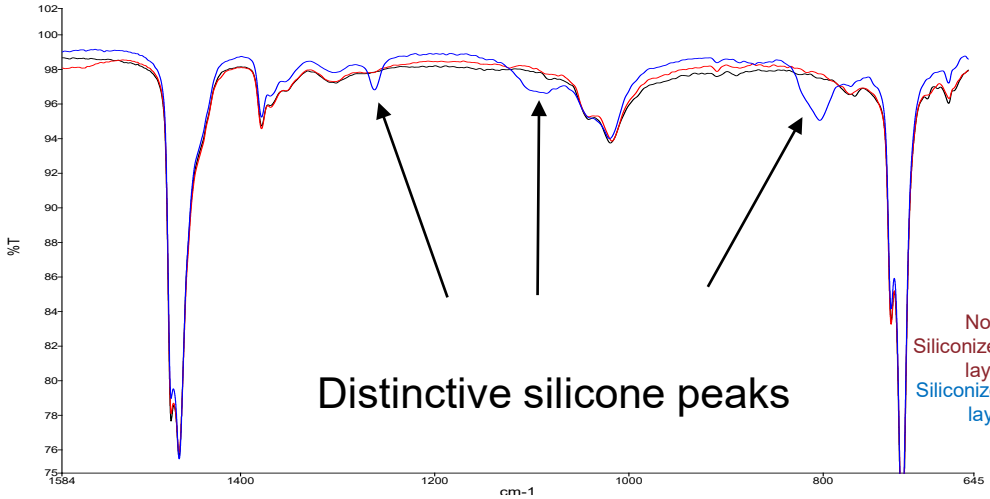


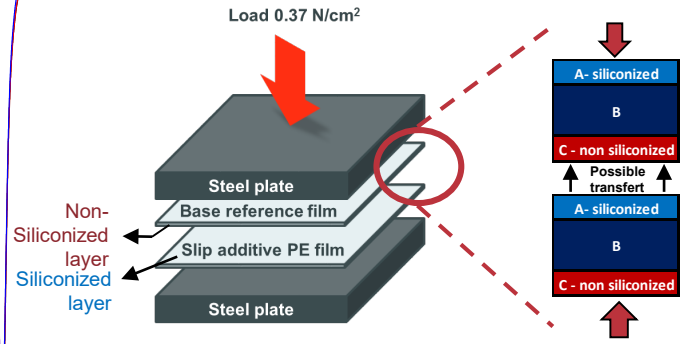
NB: Impossible to run the tests in the longitudinal or machine direction

The addition of DOW CORNING™ MB25-035 silicone Masterbatch does not affect tear strength of the film

Transfer Analysis

Contact transfer (under weight at 23°C for 2 months)





Reference without slip agent

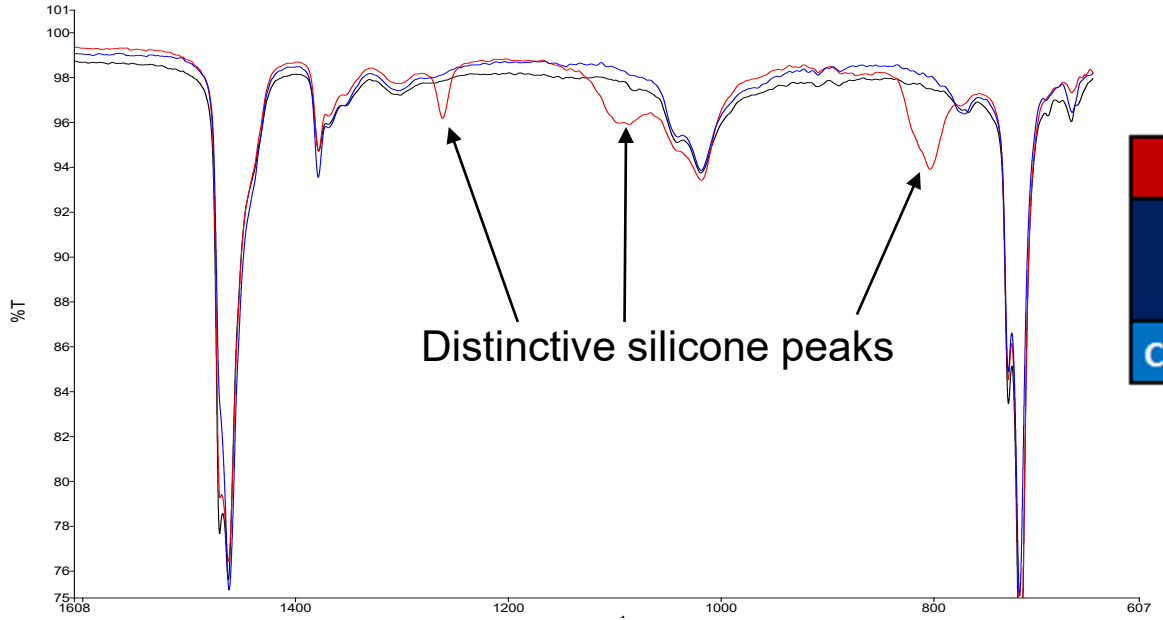
6wt% DOW CORNING™ MB25-235 Masterbatch non siliconized skin layer after 2 months under weight

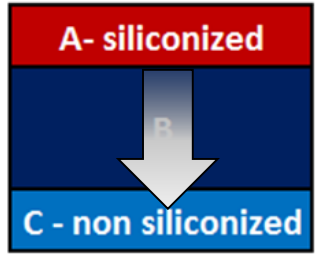
6wt% DOW CORNING™ MB25-235 Masterbatch siliconized skin layer

The silicone does not transfer by contact and under weight to the opposite non siliconized layer; this layer remaining printable and/or metallizable even at high loadings

Transfer Analysis

Intra-layer transfer (after ageing at 60°C for 1 months)





Reference without slip agent

6wt% DOW CORNING™ MB25-235 Masterbatch siliconized skin layer after ageing

6wt% DOW CORNING™ MB25-235 Masterbatch non siliconized skin layer after ageing

The silicone does not migrate through layers, even after ageing at 60°C for 1 month and even at high loadings.

Conclusions

Friction measurement

- Film/Film COF: An optimum level is achieved at 2 to 4 wt% of DOW CORNING™ MB25-235 Masterbatch around 0.22
- Film/Metal COF: The silicone additive shows lower COF than organic solutions
- *NB:* with silicone additive high COF film/film does not mean high COF film/metal.
  We recommend customer measure film/metal COF when this is the desired outcome of using slip agent

Mechanical properties

- The silicone additive does not impact any mechanical property

Transfer

- The silicone does not transfer against a non siliconized layer by contact
- The silicone does not migrate through layer with time and temperature
- **Does not affect printing and/or metalization**

Cost

- The silicone additive is designed to be used at **low dosage** (2-4 wt%) and to be introduced in the desired skin layer **only**.

Contacts

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Our vision
Transforming industries and improving lives through material science

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Thank You