Filled Thermoplastics

Filler-Polymer Interactions

Dr. Chris DeArmitt (FRSC CChem)
Plastics Research BASF AG

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The Chemical Company

Outline

- Introduction
- BASF & Plastics
- General properties of filled polymers
- Importance of agglomeration
- Surface treatment to aid dispersion
- Results
- Conclusions

BASF & Plastics

- BASF is the world´s leading chemical company
- 95,000 employees
- Chemicals, Plastics, Performance Products, Agricultural Products & Nutrition, Oil & Gas
- Turnover 42.7 Billion Euros
- ~28 % of that is Plastics
- Plastics are: PS, HIPS, SAN, ABS, ASA, MABS, ABS/PA, SBS, PA6, PA6,6, POM, PBT, PSU, PES, PUR

Reasons to use fillers

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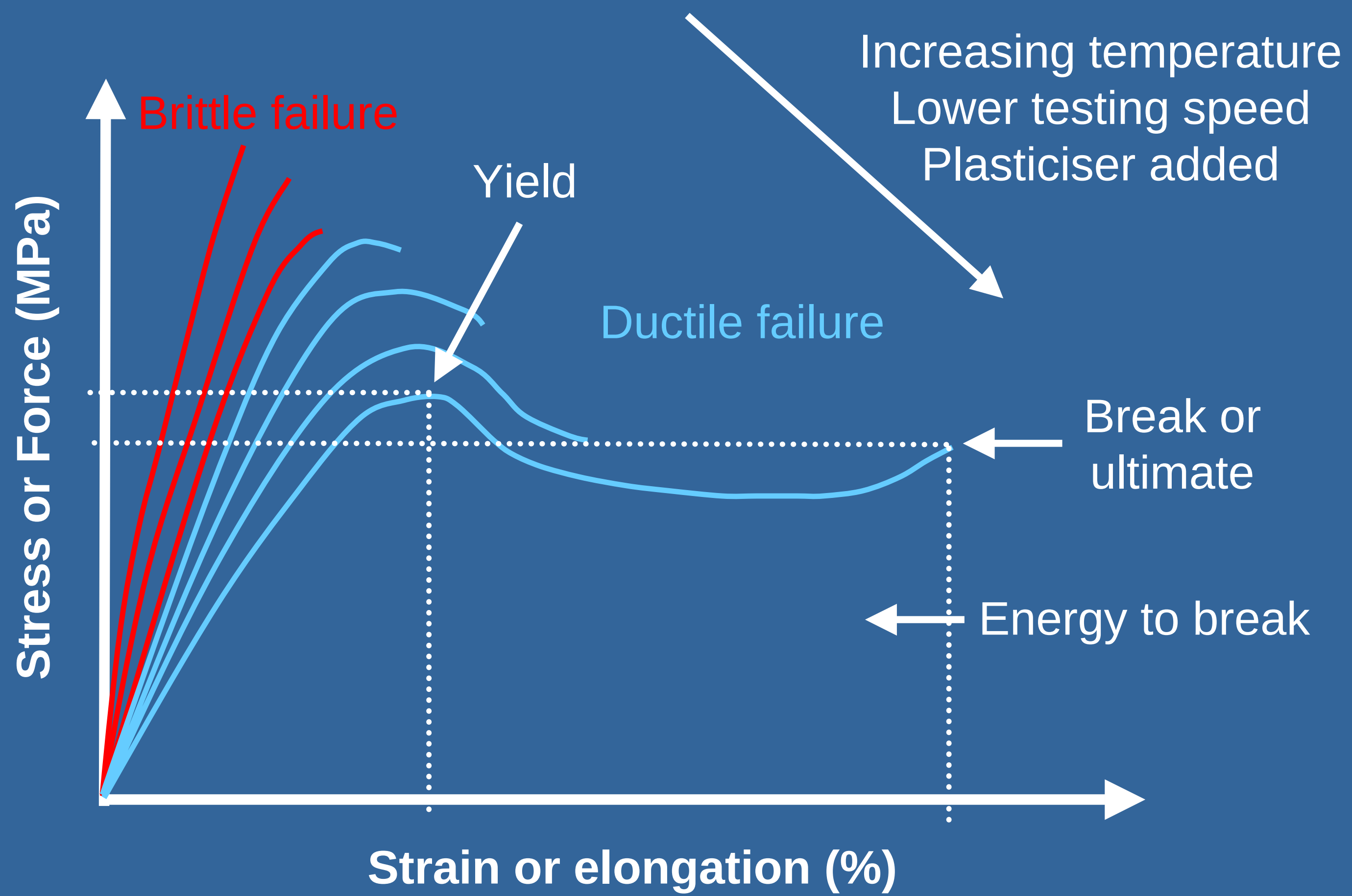
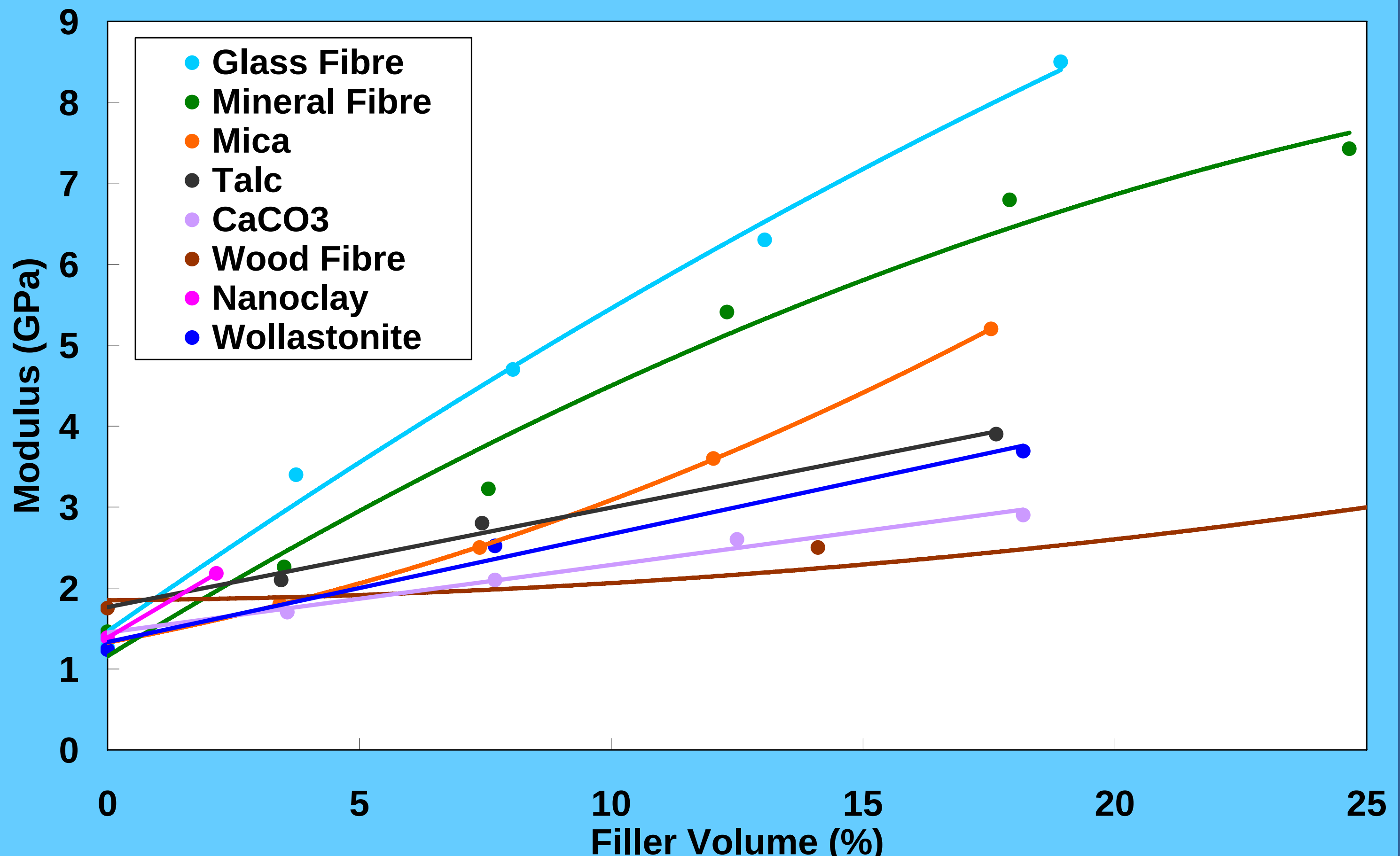
- Raise heat resistance
- Increase stiffness
- Increase strength
- Reduce shrinkage
- Improve dimensional stability
- Reduce flammability
- Modify flow
- Increase lubricity
- Decrease permeability
- Increase degradability
- Improve processability
- Reduce creep
- Change electrical properties
- Modify specific gravity
- Improve abrasion resistance
- Improve impact strength
- Improve thermal conductivity
- Improve moisture resistance
- Increase adhesion
- Appearance, opacity, gloss

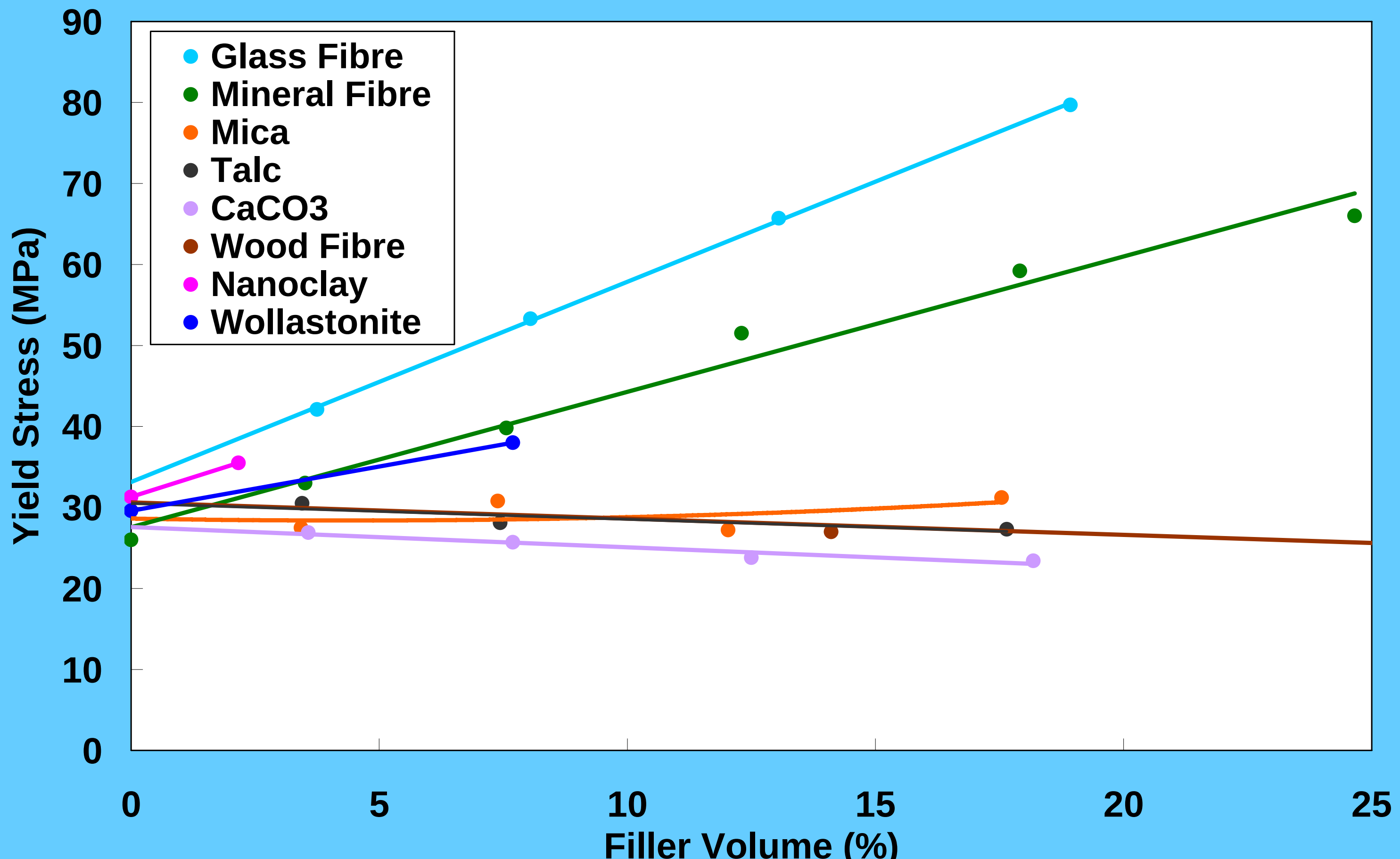
Tensile testing



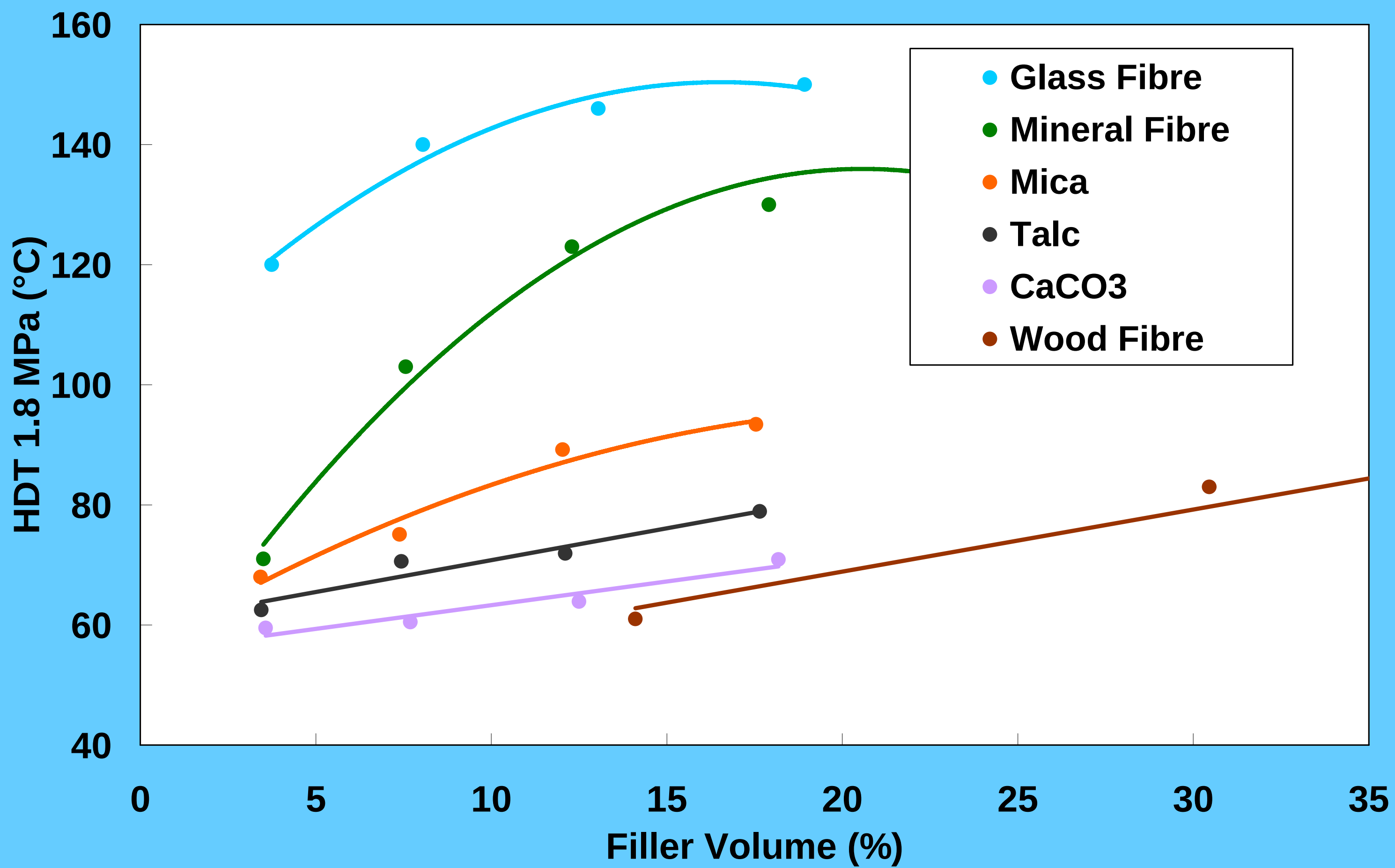
Fillers and Modulus



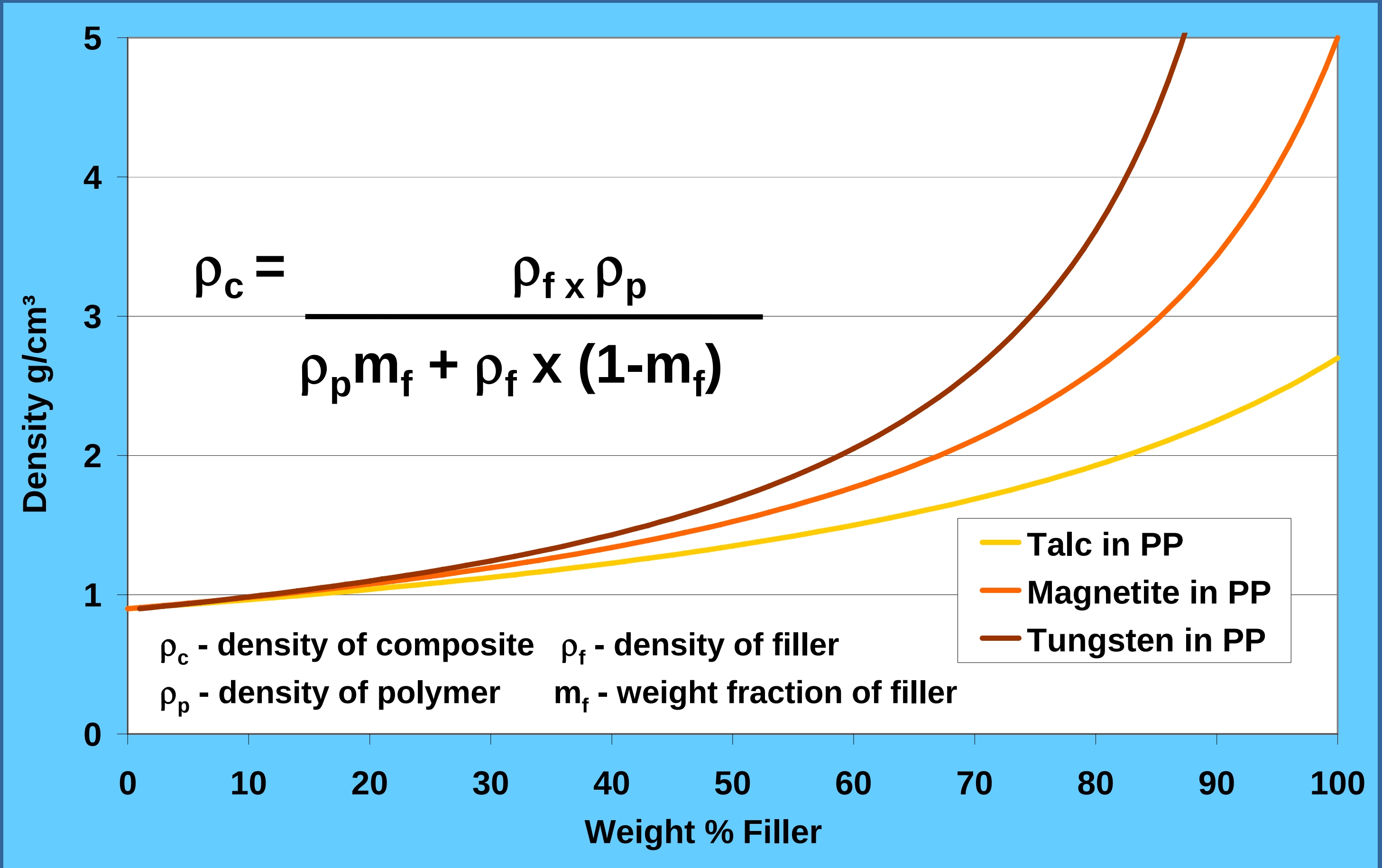
Fillers and Yield Strength



Fillers and HDT



Density & weight % filler



Some reasons to surface modify

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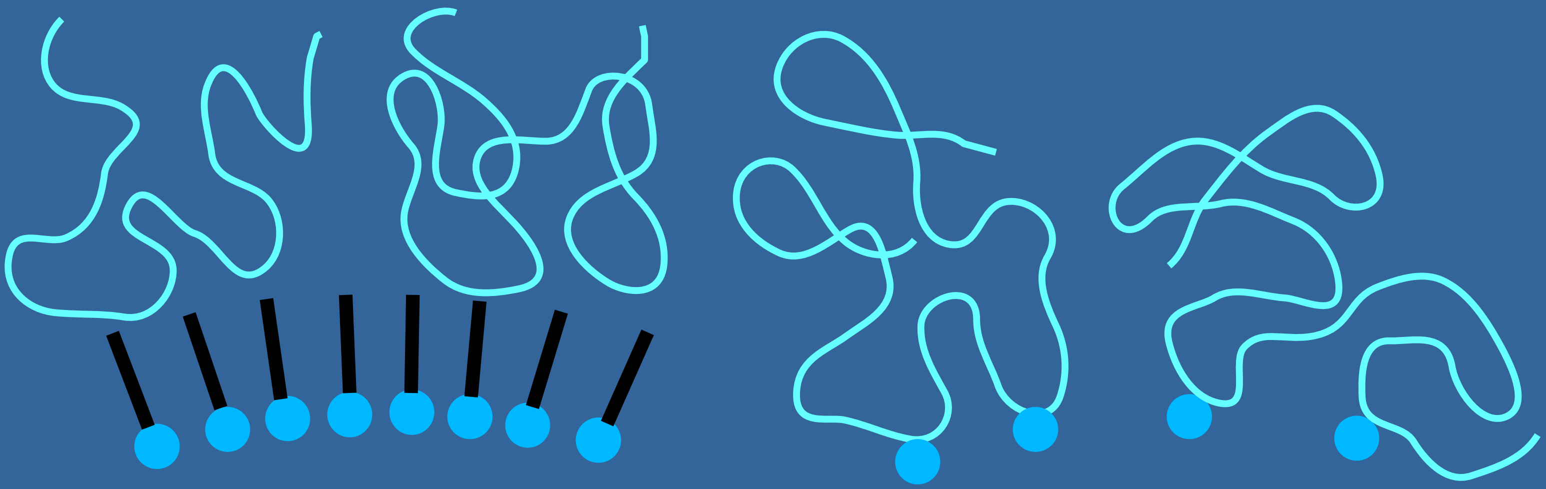
- Improved filler production, e.g. dewatering
- Filler protection (e.g. from water)
- Improved processing in polymer due to better flow (higher throughput)
- Less adsorption of catalysts, curing agents, antioxidants, antistatics and other additives
- Improved composite properties, especially impact strength

Two types of modifier



Dispersant **Coupling Agent**

Surfactant amphiphilicity

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Stearic acid

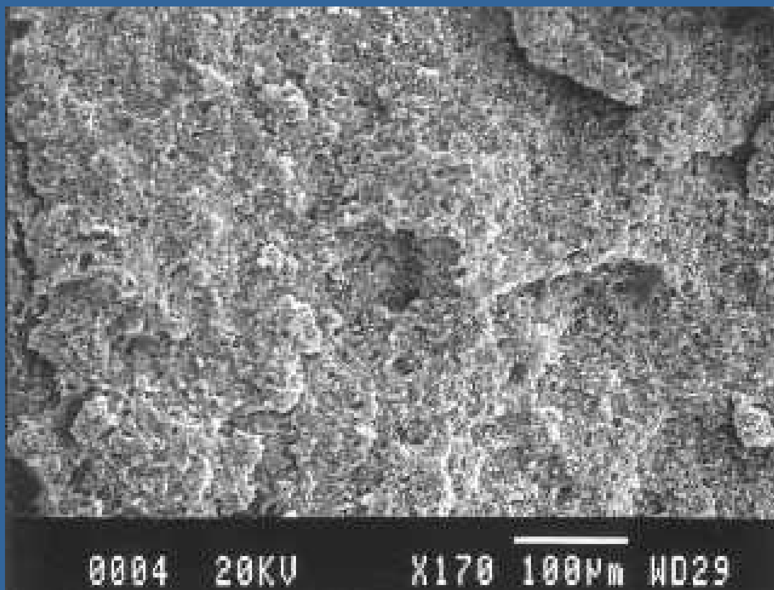
Alkyl silane

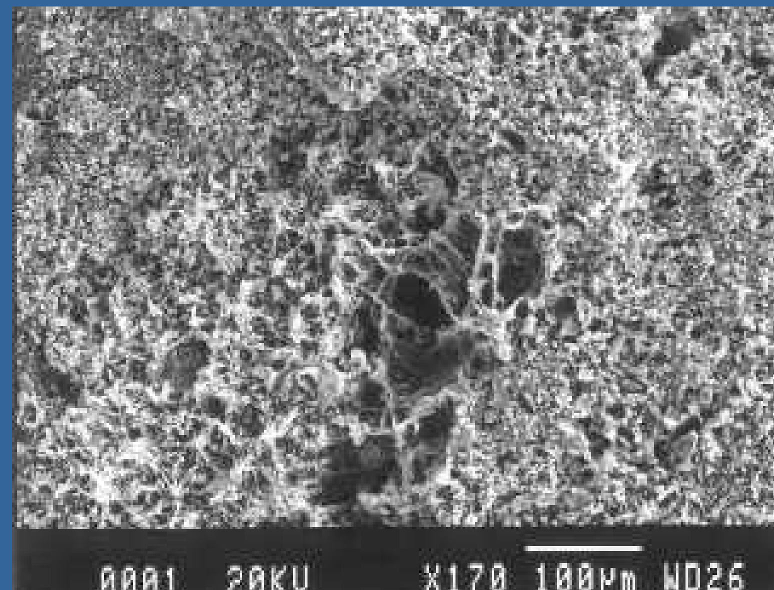
Surfactant tail

Surfactant head

Brittle & ductile fracture (unnotched impact)

40 weight % $CaCO_3$ in PP homopolymer





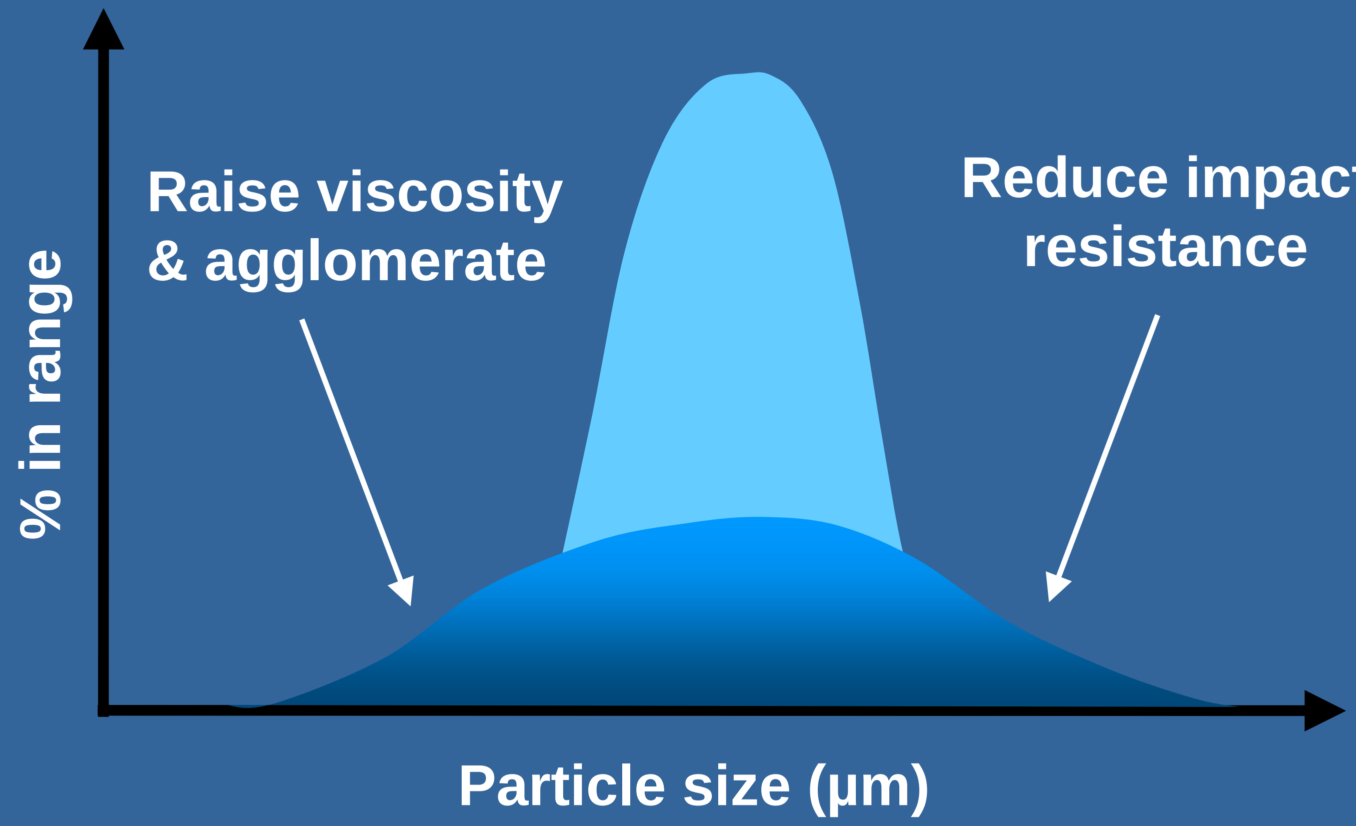
Brittle ~20 kj/m²

Untreated filler

Ductile ~40 kj/m²

Stearate treated filler

Particle size distribution



$CaCO_3$ Size and cost

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Cost Euro / ton	Cost Euro / litre	Size $CaCO_3$ d_{50} microns
100	0.27	~2
200	0.54	~1
300	0.81	~0.5
400	1.08	~0.3
500	1.62	~0.1

Approximate Polymer Prices

PP 0.68

PE 0.74

PS 0.84

HIPS 0.85

PVC 0.98

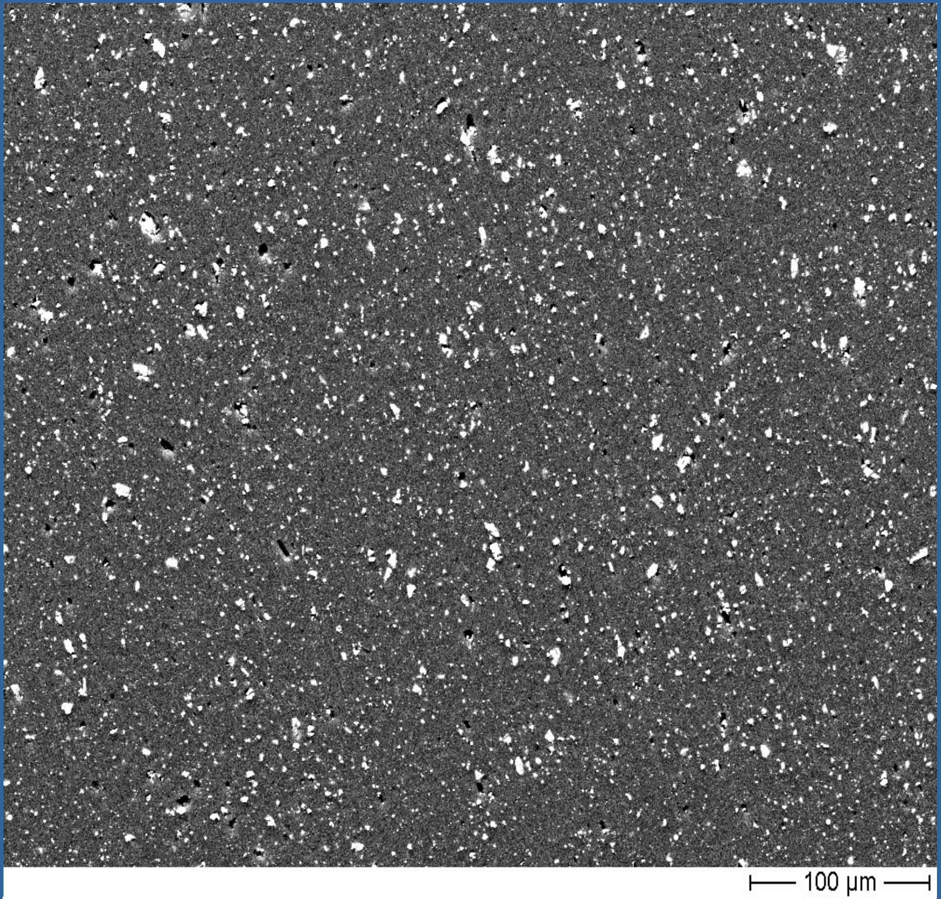
PET 1.4

ABS 1.5

Nylon 2.7

PC 2.8

Twin screw extruded stearate coated $CaCO_3$ in polymer



D_{50} 1.8 micron, D_{98} 10 microns

Twin screw extruded stearate coated $CaCO_3$ in polymer

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D_{50} 0.85 micron, D_{98} 5 microns

Twin screw extruded stearate coated $CaCO_3$ in polymer

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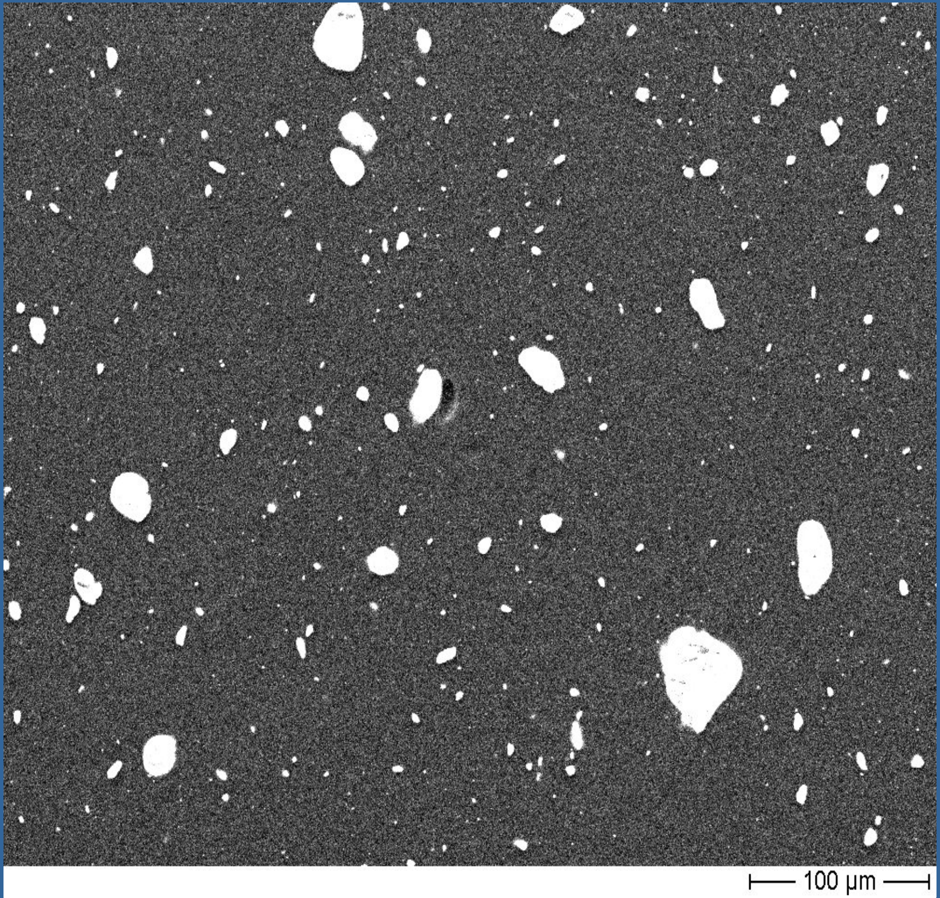


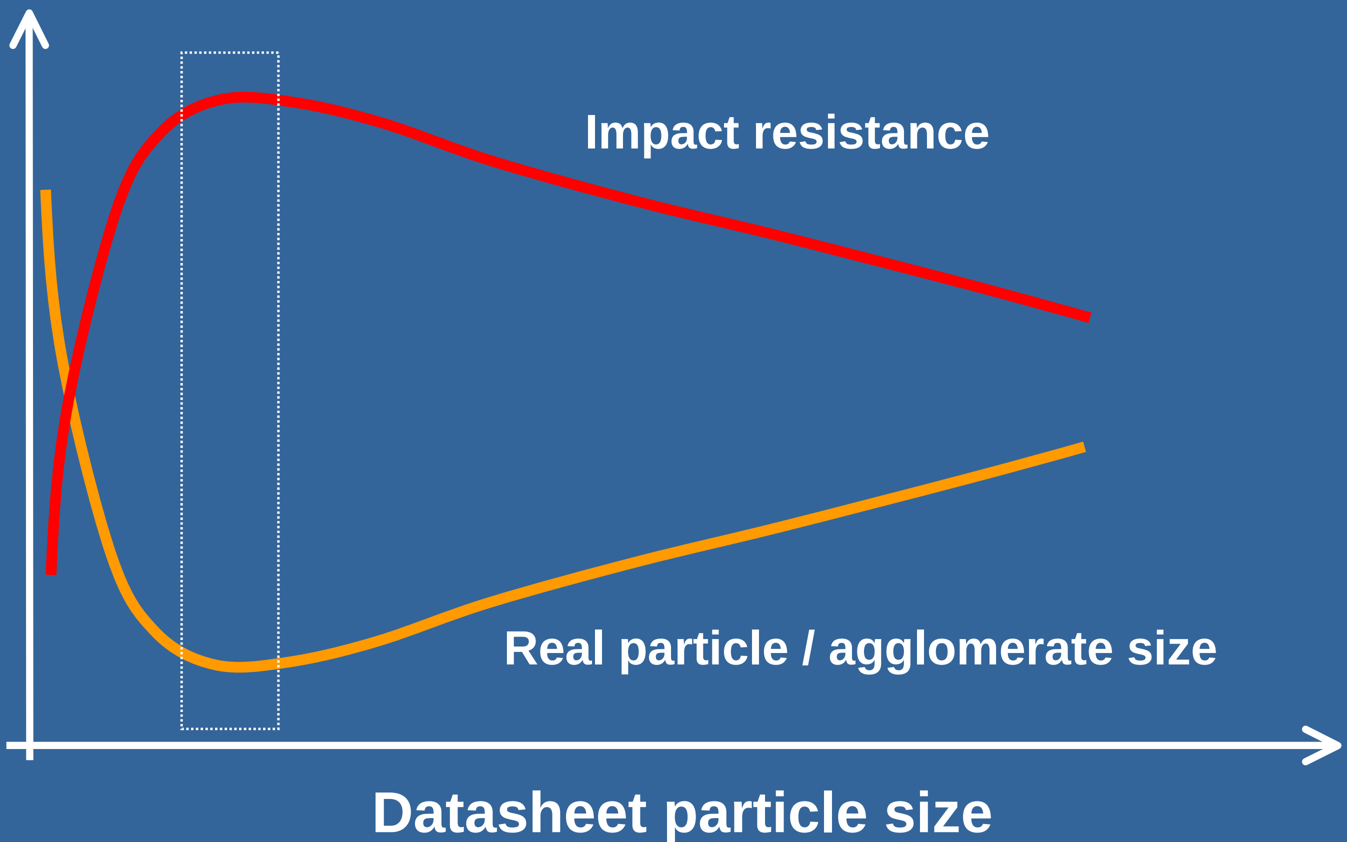
Primary particles 70 nm

PPC Particle size and energy input

Light scattering weak U/S	20	Agglomerates
Light scattering medium U/S	4	Basic Aggregates
Light scattering strong U/S	0.2	Stronger Aggregates
Electron microscopy	0.07	Crystallites
X-Ray	0.07	Crystallites

Courtesy of Rothon Consultants

Actual particle size in composite and impact resistance



Conclusions

- Many properties vary linearly with the volume % of filler added
- Surface treatment of filler improves processing and properties
- Surface treatment can help dispersion and even change to failure mechanism of the material
- The properties are determined by the size of the filler / agglomerates in the polymer not the datasheet values