

GLOXIL light iM16k A
in Polyamide and Polypropylene –
The Easy Way towards Future.

Author: Hubert Oggermüller



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- Introduction
- Experimental
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Status Quo

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- In recent years, the topic of lightweight construction has steadily increased in importance, especially in the area of traffic and transport.
- Thermoplastics play an important role here, including polyamide and polypropylene. These already have relatively low densities and thus component weights.
- Various options are available for further weight optimization, and hollow glass microspheres play a particularly important role here.
- 3M™ Glass Bubbles are used for this purpose due to their positive properties.
- Surface functionalization by means of covalent bonding of organofunctional silane is a suitable method for optimizing mechanical properties.



Objective

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To show positive effects of surface functionalization in

- Polyamide PA6 and
- Polypropylene Copolymer

of **GLOXIL light iM16k A** compared to 3M™ Glass Bubbles iM16k on the mechanical property profile



Surface Functionalization

A special process creates the **GLOXIL light iM16k A** based on the micro hollow glass sphere 3M™ Glass Bubble iM16k

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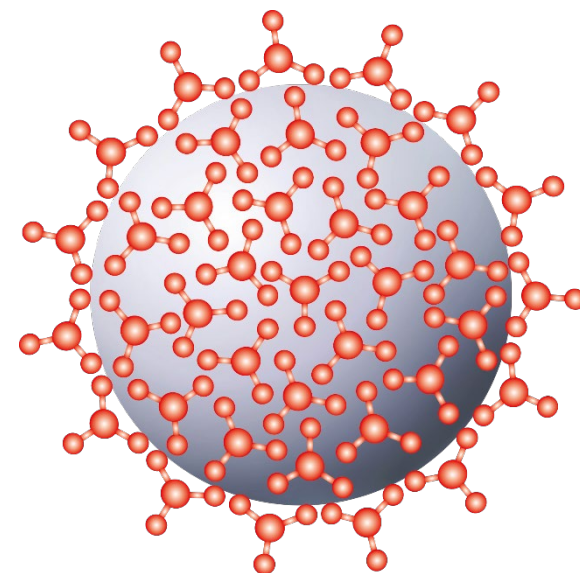
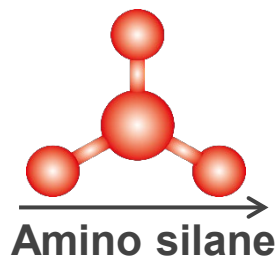
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**3M™ Glass Bubbles
iM16k**



GLOXIL light iM16k A



Characteristics GLOXIL light iM16k A **HOFFMANN MINERAL®**

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Density	[g/cm ³]	0.46
Particle size D ₅₀	[μm]	22
Particle size D ₉₇	[μm]	45
Specific surface area BET	[m ² /g]	2
Air jet screening > 125 μm	[%]	0.2
Flotation rate	[%]	96
pH		10
Color L* (CIELAB)		98
Functionalization		Amino

Typical properties, no specification



Selection

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**Polyamide PA6
Ultramid® B3K**



Hollow glass bubbles only

Combination



Glass fibers + hollow glass
bubbles

**PP Copolymer
Bormod™ BF970MO**



Hollow glass bubbles only

Combination



Talc / hollow glass bubbles

to Overall Summary





PA6 Compound Formulations

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Objective:

Density / weight reduction and still good mechanical properties

PA Compound Ultramid® B3K BASF Melt volume rate MVR 160 cm ³ /10 min (275 °C, 5 kg)		
3M™ Glass Bubbles iM16k	0 to 14 % (m/m) 0 to 29 % (v/v)	---
GLOXIL light iM16k A	---	0 to 14 % (m/m) 0 to 29 % (v/v)
Total	100	100

All results were determined in the freshly molded (dry) state

Data determined by 3M Advanced Materials Division, Special Additives Laboratory

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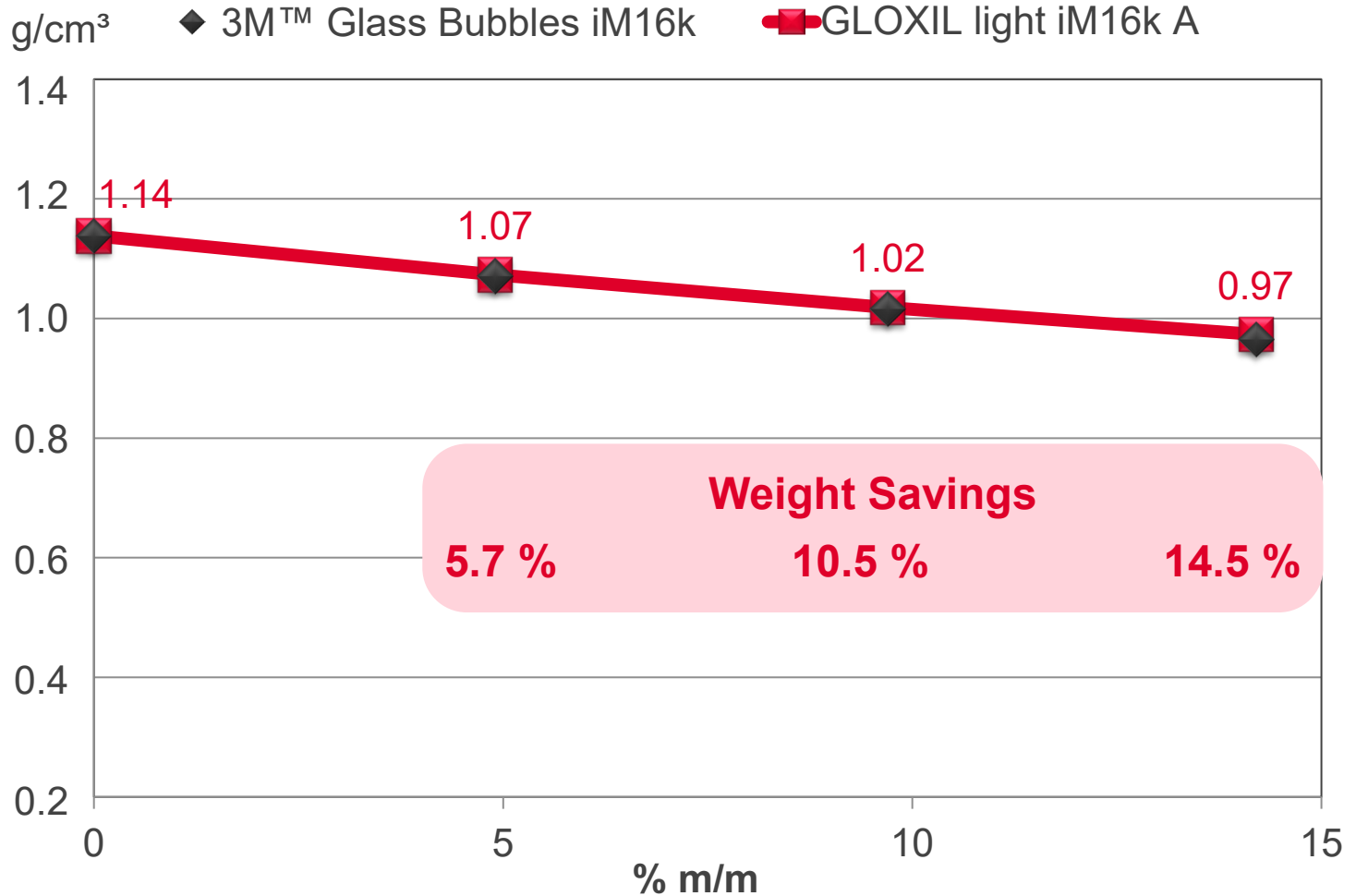
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Density and Weight Reduction

measured





Tensile Modulus

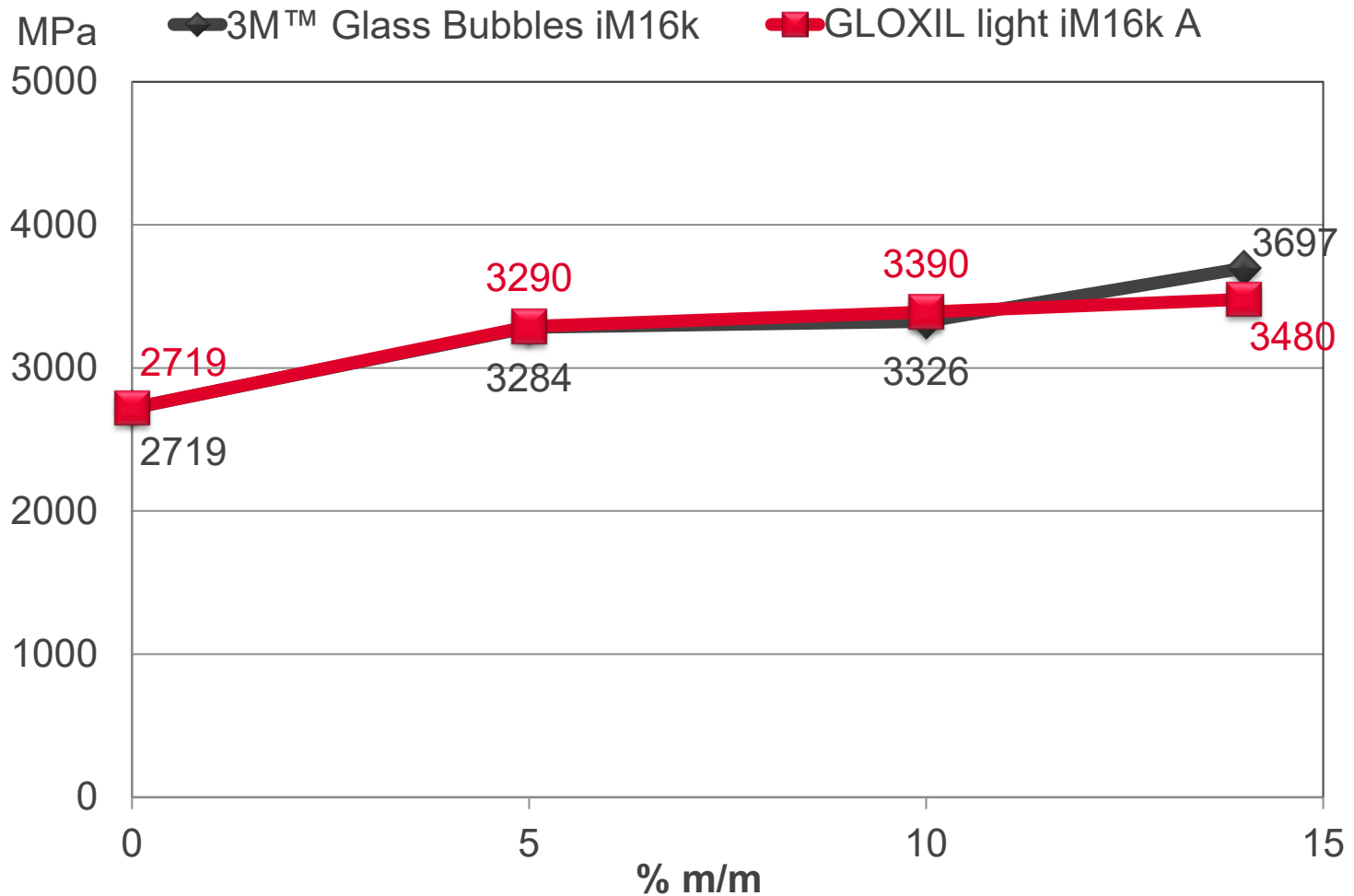
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Flexural Modulus

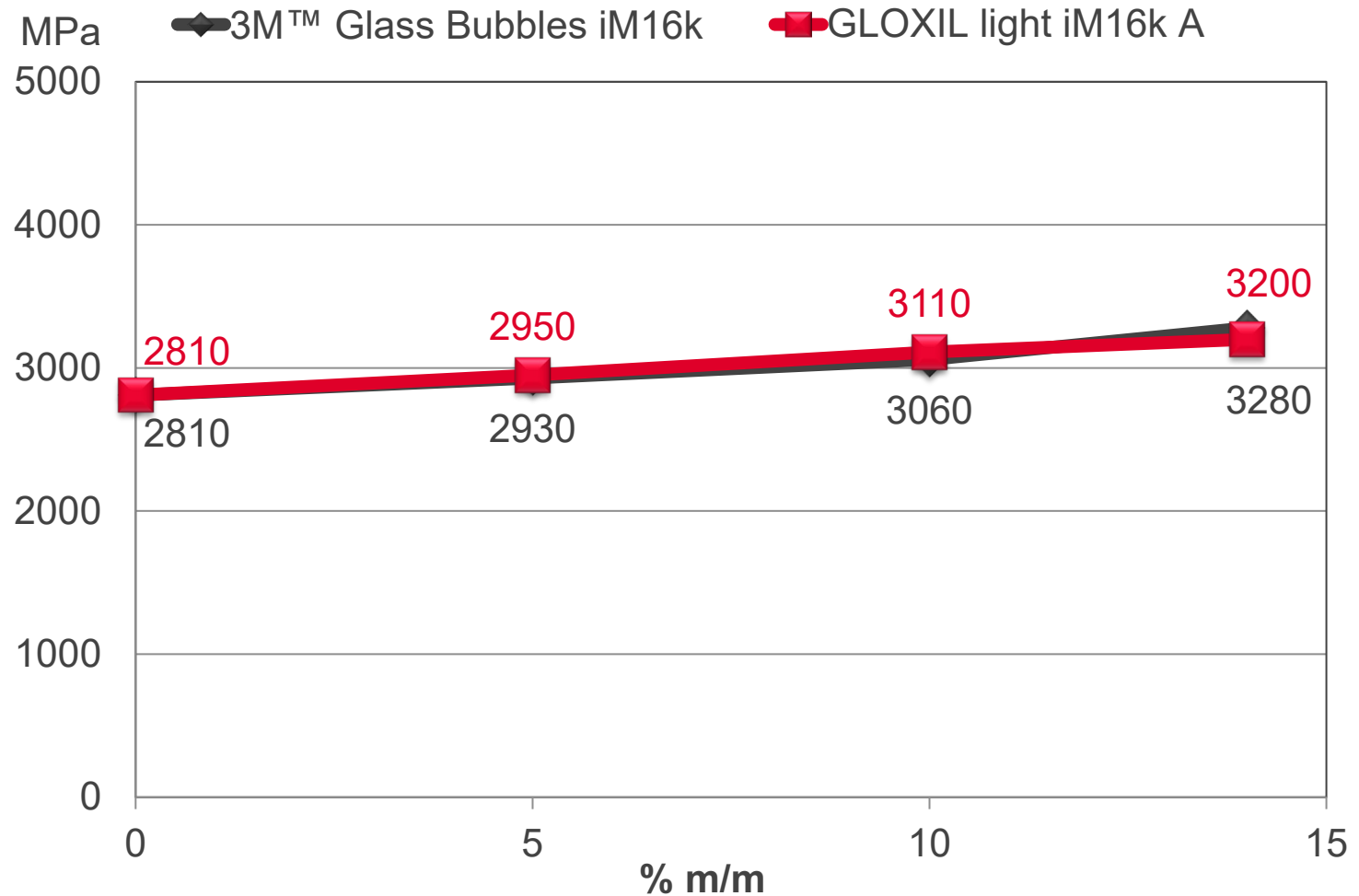
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Yield Stress

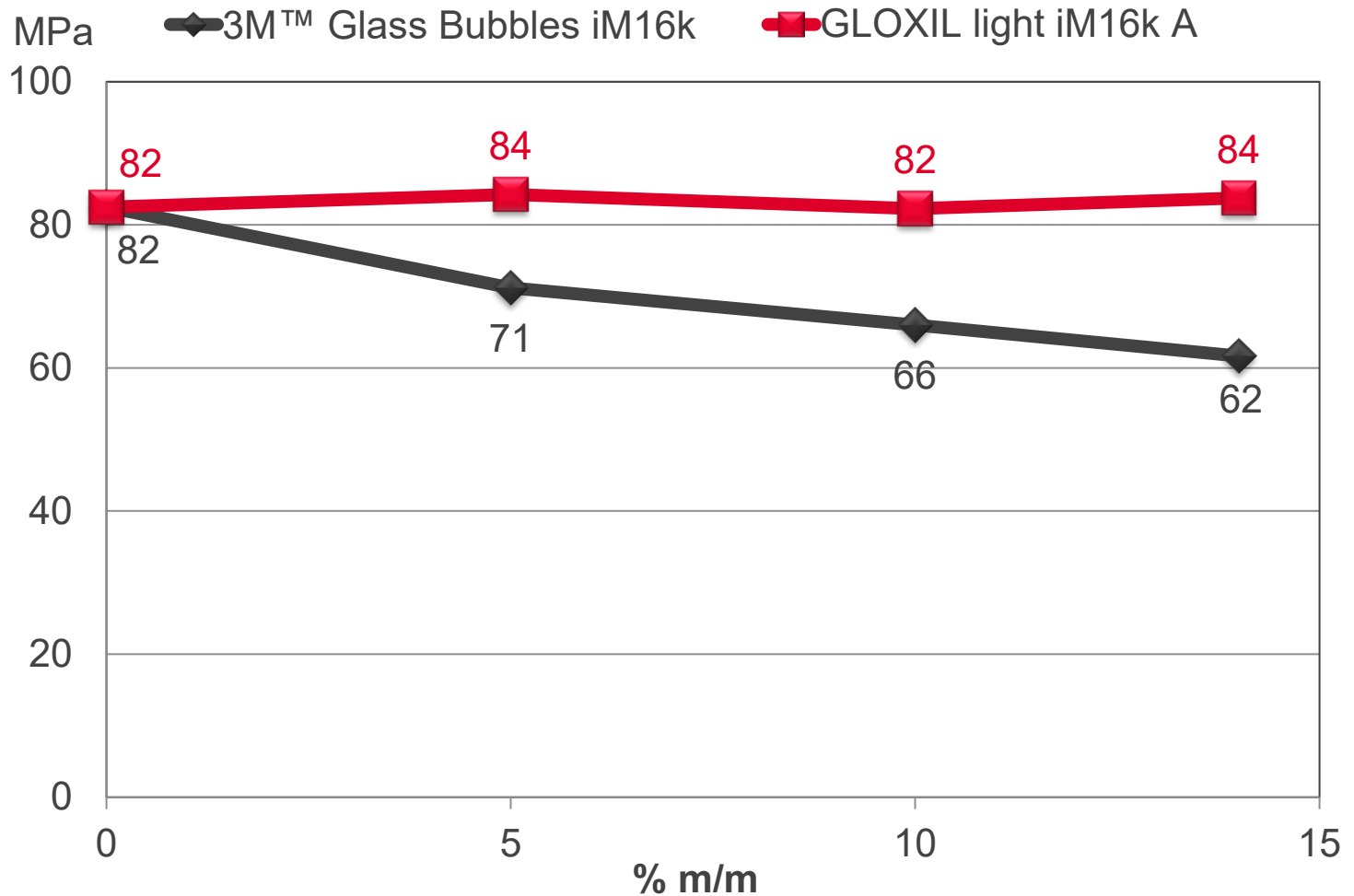
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Yield Strain

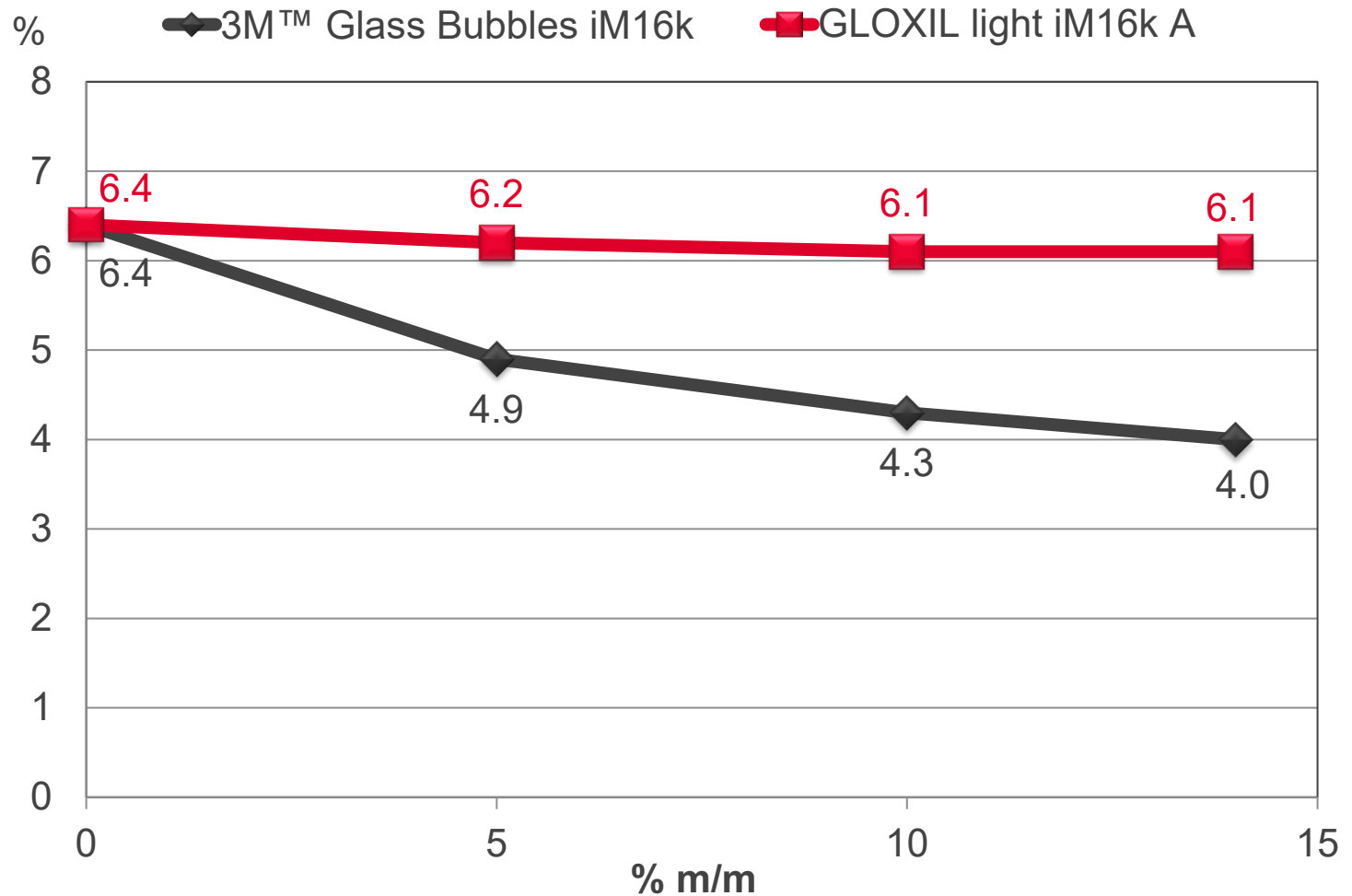
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Flexural Strength

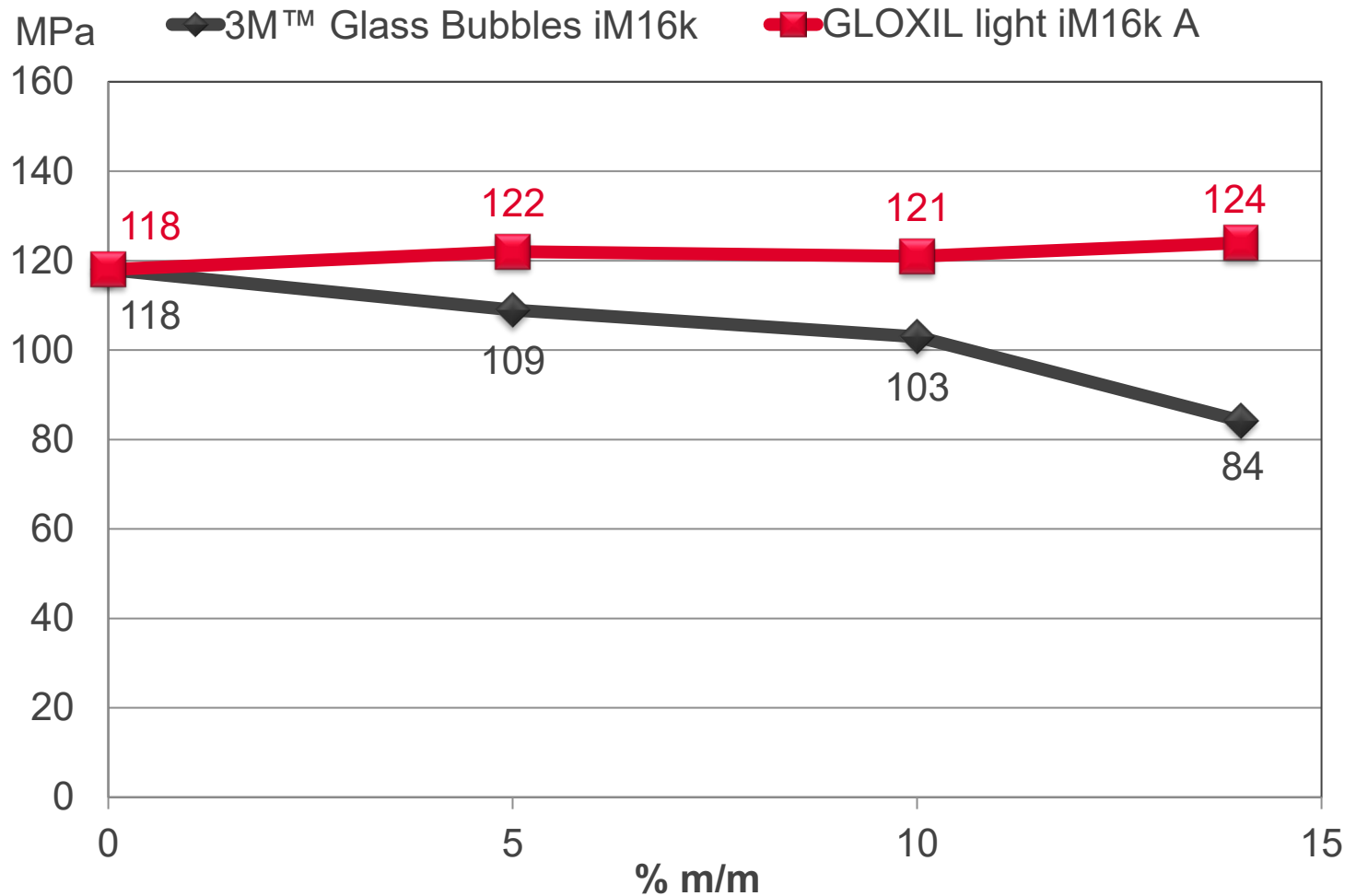
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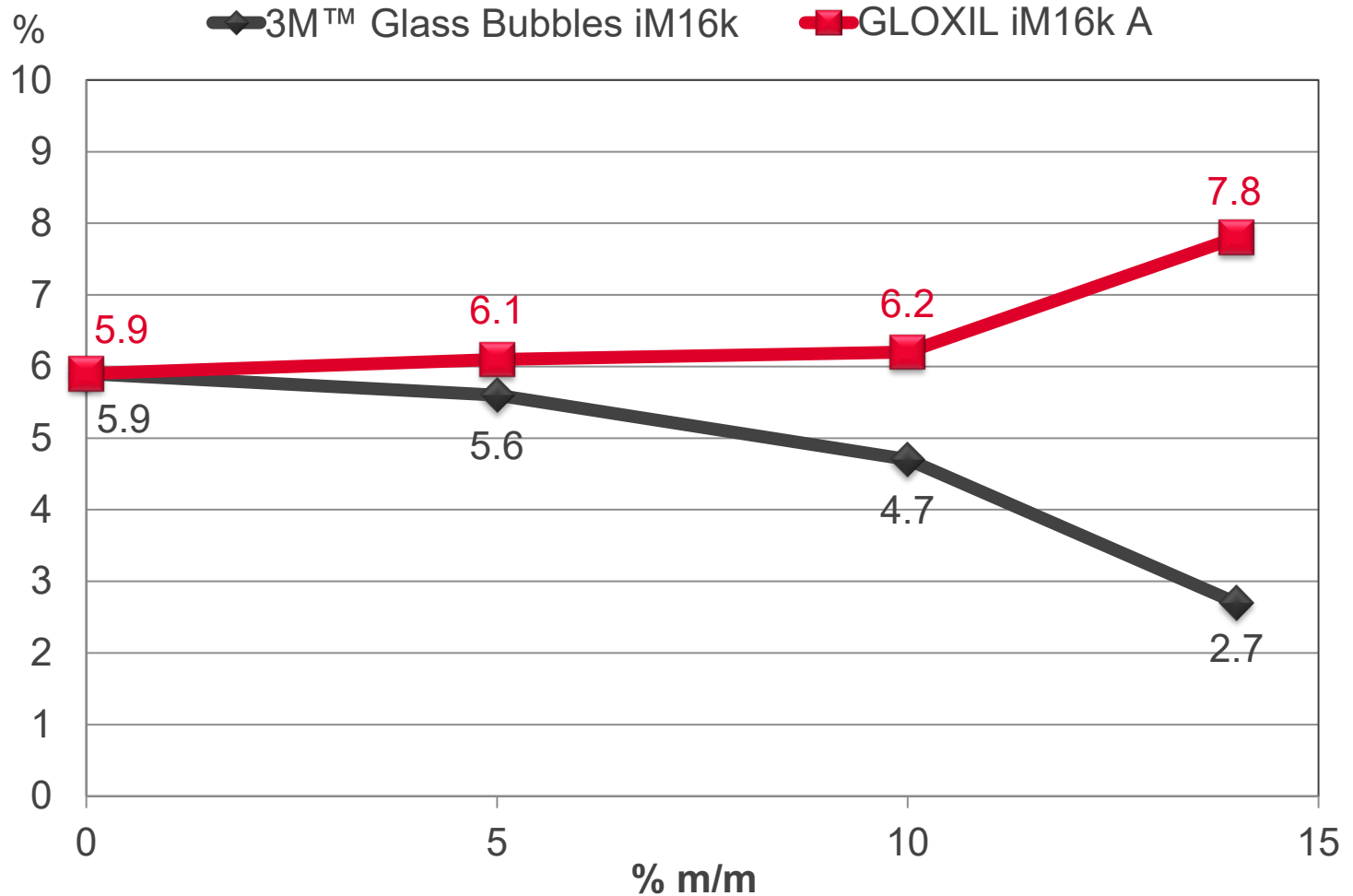
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Flexural strain

at flexural strength



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Impact Strength Charpy

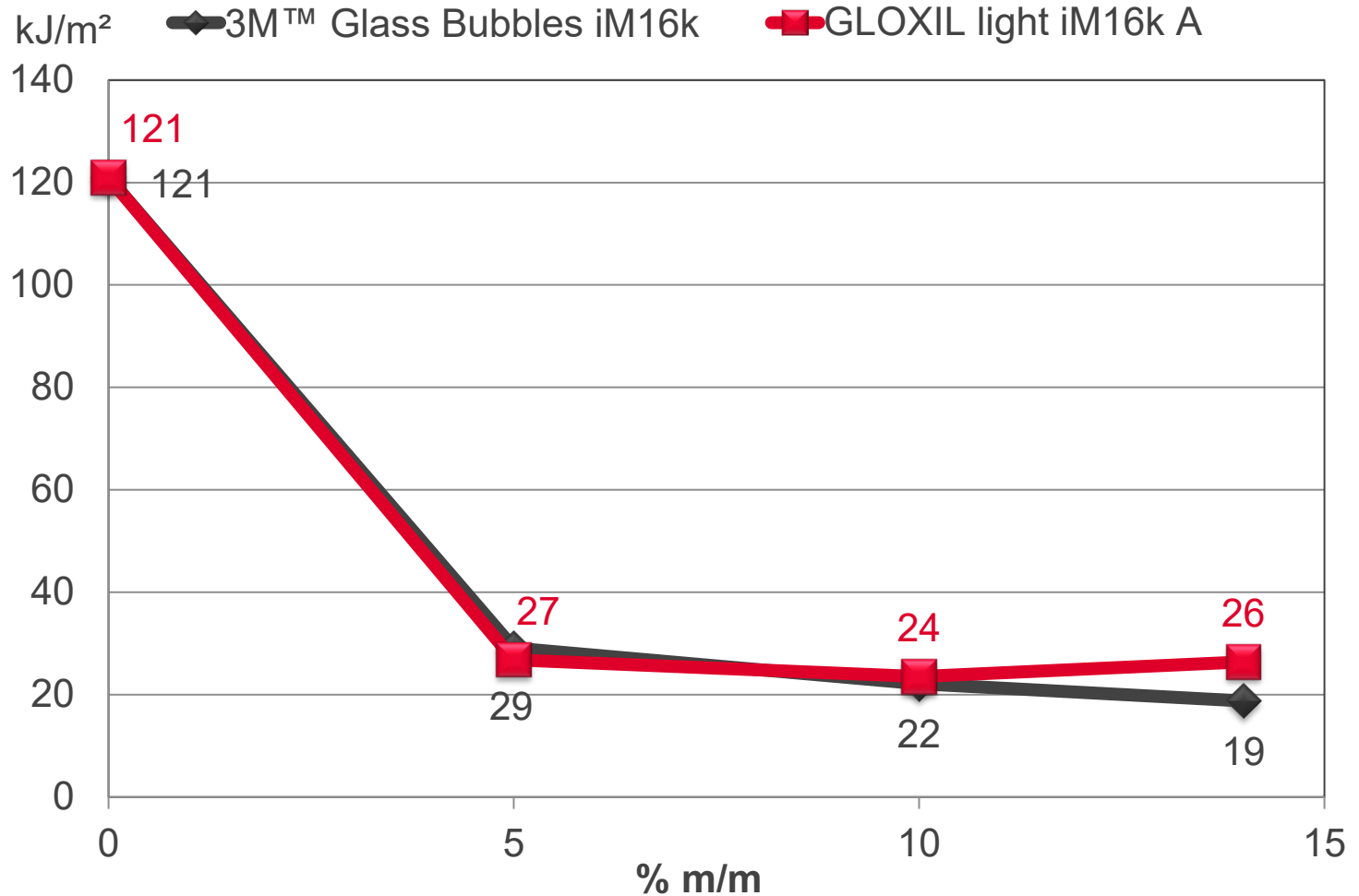
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Notched Impact Strength Charpy

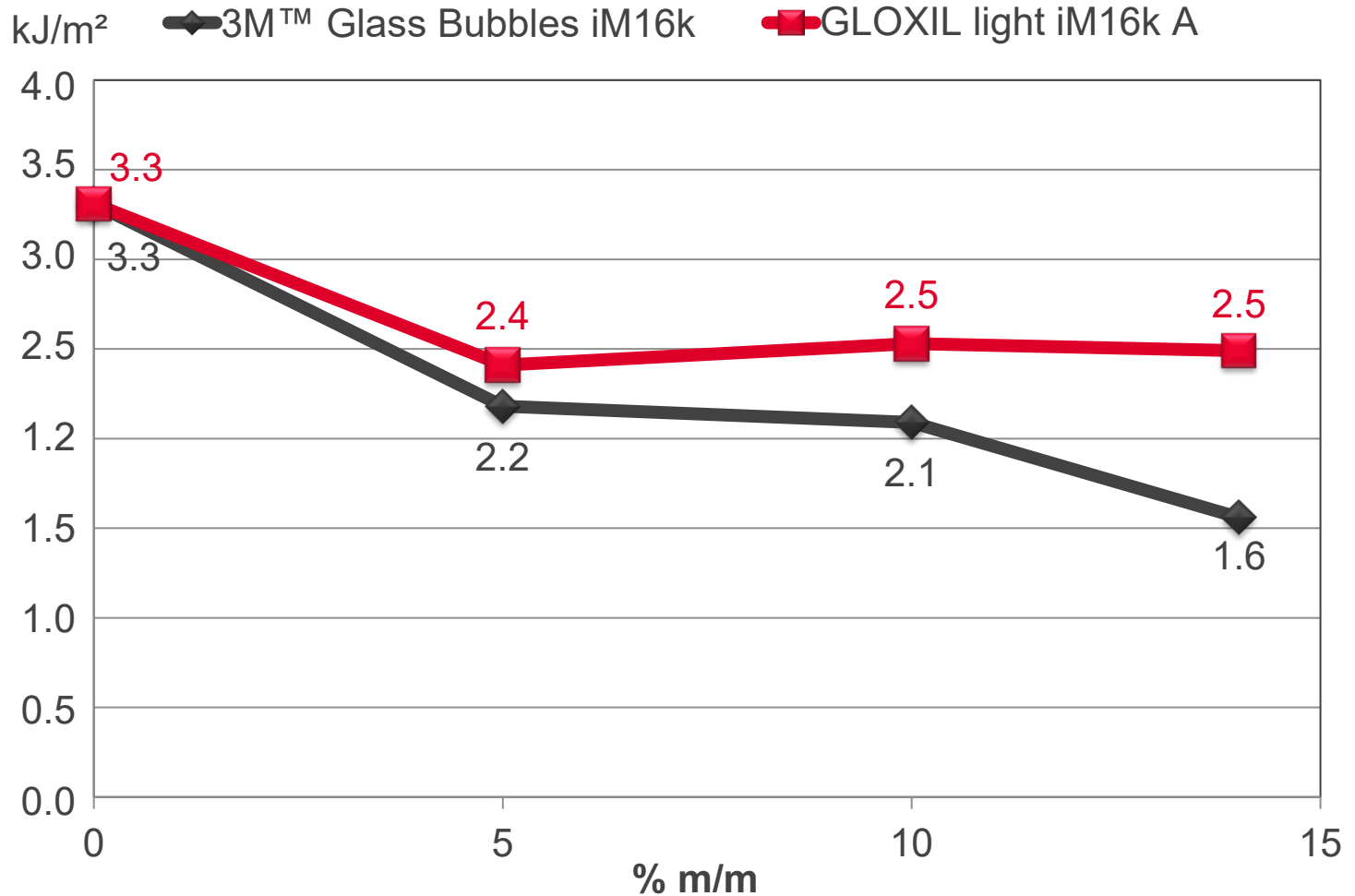
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GLOXIL light iM16k A shows in comparison to the untreated hollow glass spheres:

- Same density and thus weight saving potential
- Comparable increase in stiffness (tensile modulus and flexural modulus)
- + Significantly higher yield stress, largely independent of the filler content at the level of the unfilled PA6
- + Significantly higher yield strain, largely independent of the filler content at the level of unfilled PA6
- + Significantly higher flexural strength, with increasing filler content even higher than the unfilled PA6
- + Slightly higher impact strength
- + Slightly higher notched impact strength
- **Objective achieved:**
density / weight reduction and good mechanical properties
- + Expectation: improved scratch resistance



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More Results PA6 Glass Fibers + Glass Bubbles

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Objective:

Increase of filler content/stiffness without increase of density/weight and still good mechanical properties

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PA6 GF15
+ Glass Bubbles

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PA Compound Ultramid® B3K BASF Melt volume rate MVR 160 cm ³ /10 min (275 °C, 5 kg)			
Glass fibers	15 % (m/m) 8 % (v/v)	17 % (m/m) 8 % (v/v)	17 % (m/m) 8 % (v/v)
3M™ Glass Bubbles iM16k	---	4 % (m/m) 10 % (v/v)	---
GLOXIL light iM16k A	---	---	4 % (m/m) 10 % (v/v)
Total	100	100	100

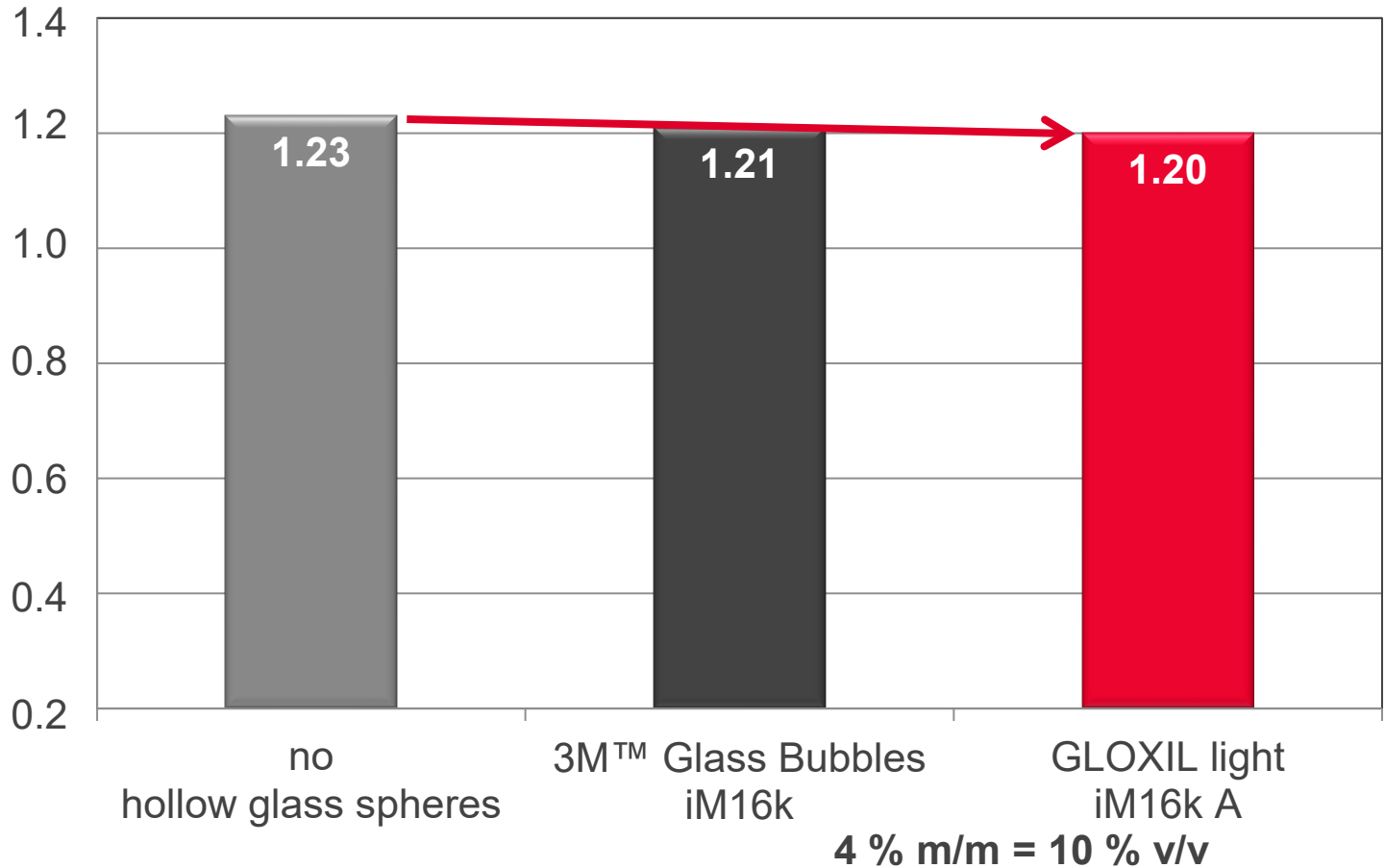
Data determined by 3M Advanced Materials Division, Special Additives Laboratory



Density

measured

g/cm³



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PA6 GF15
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Tensile Modulus

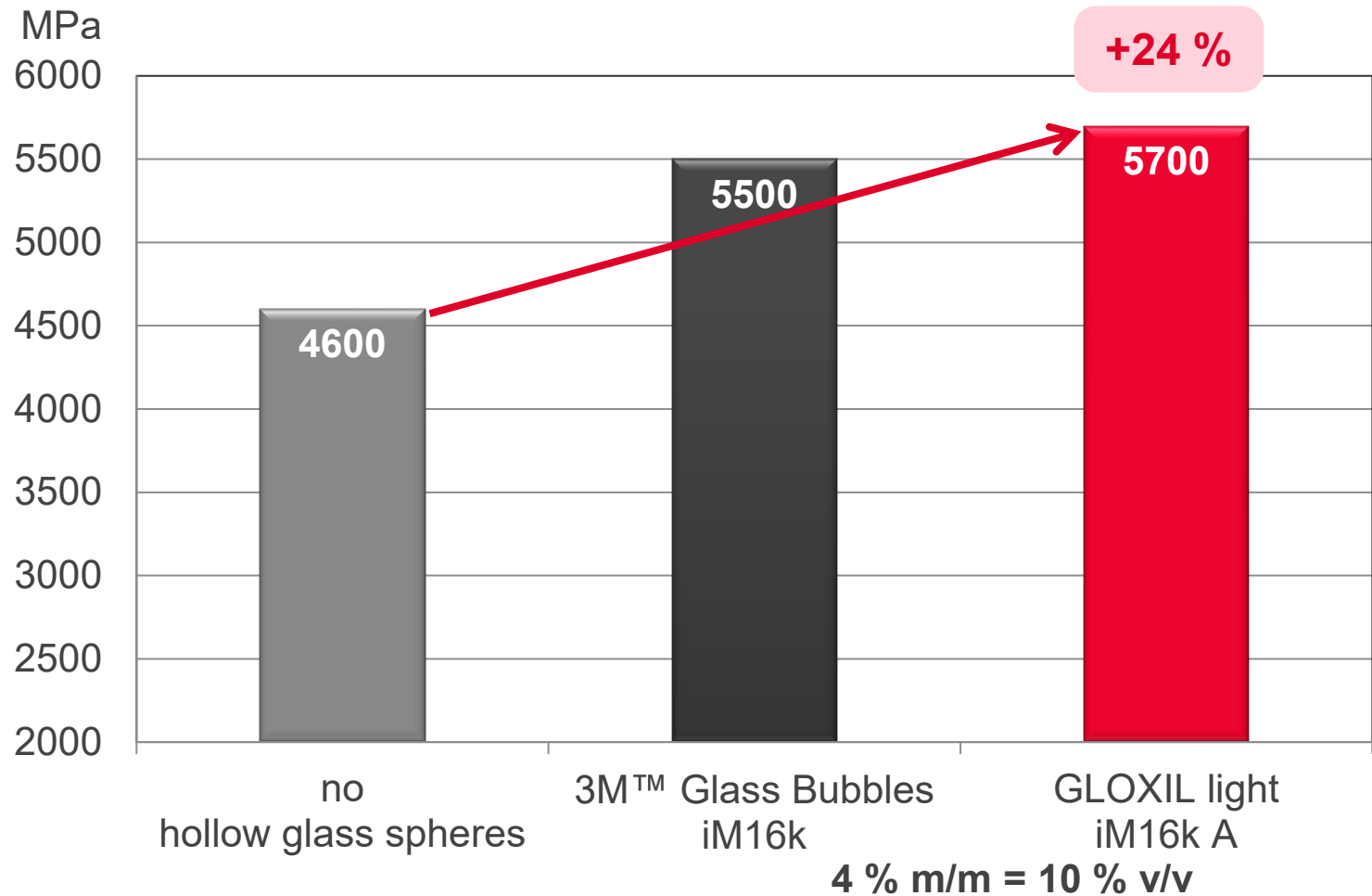
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Flexural Modulus

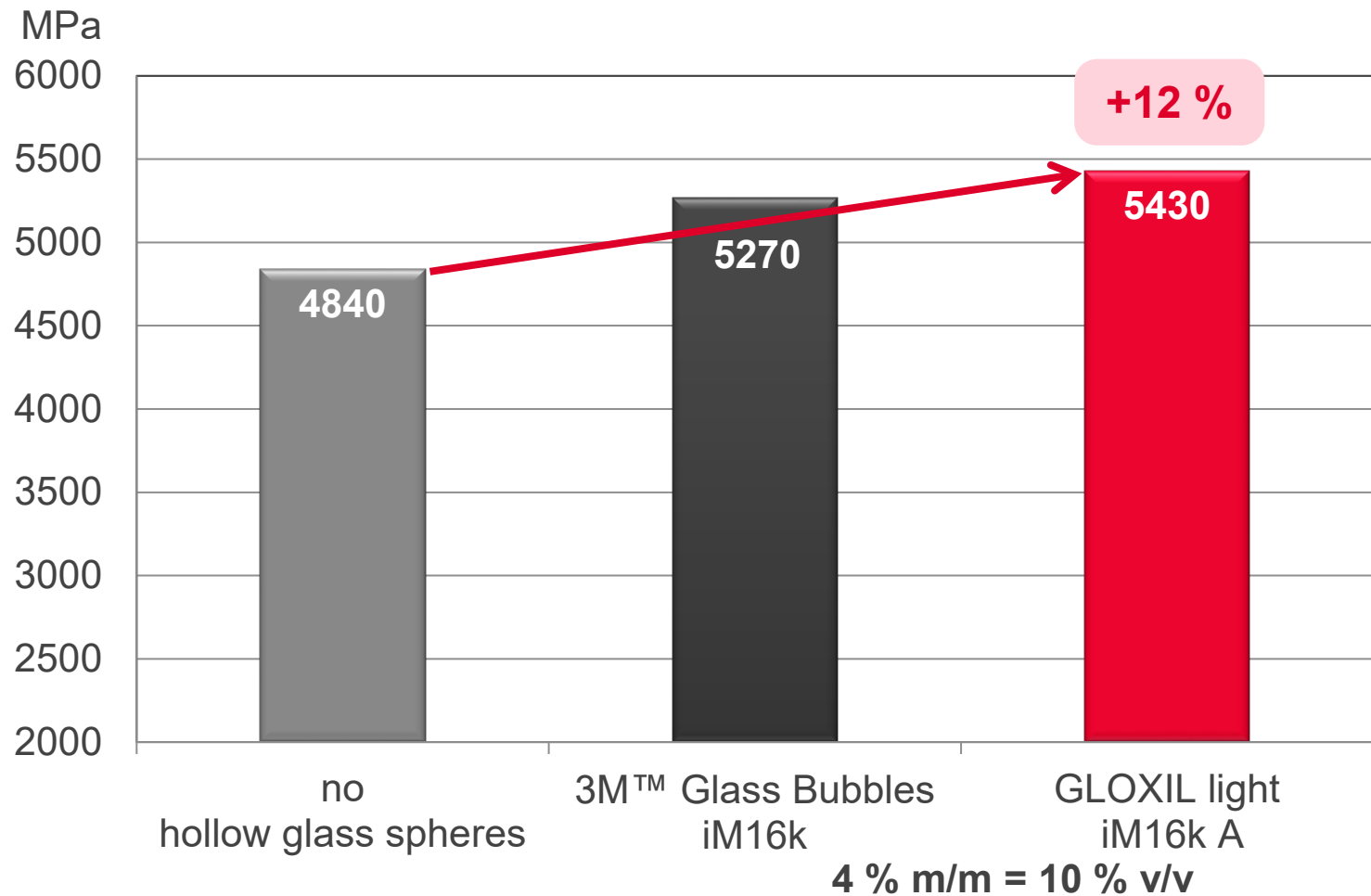
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Tensile Strength

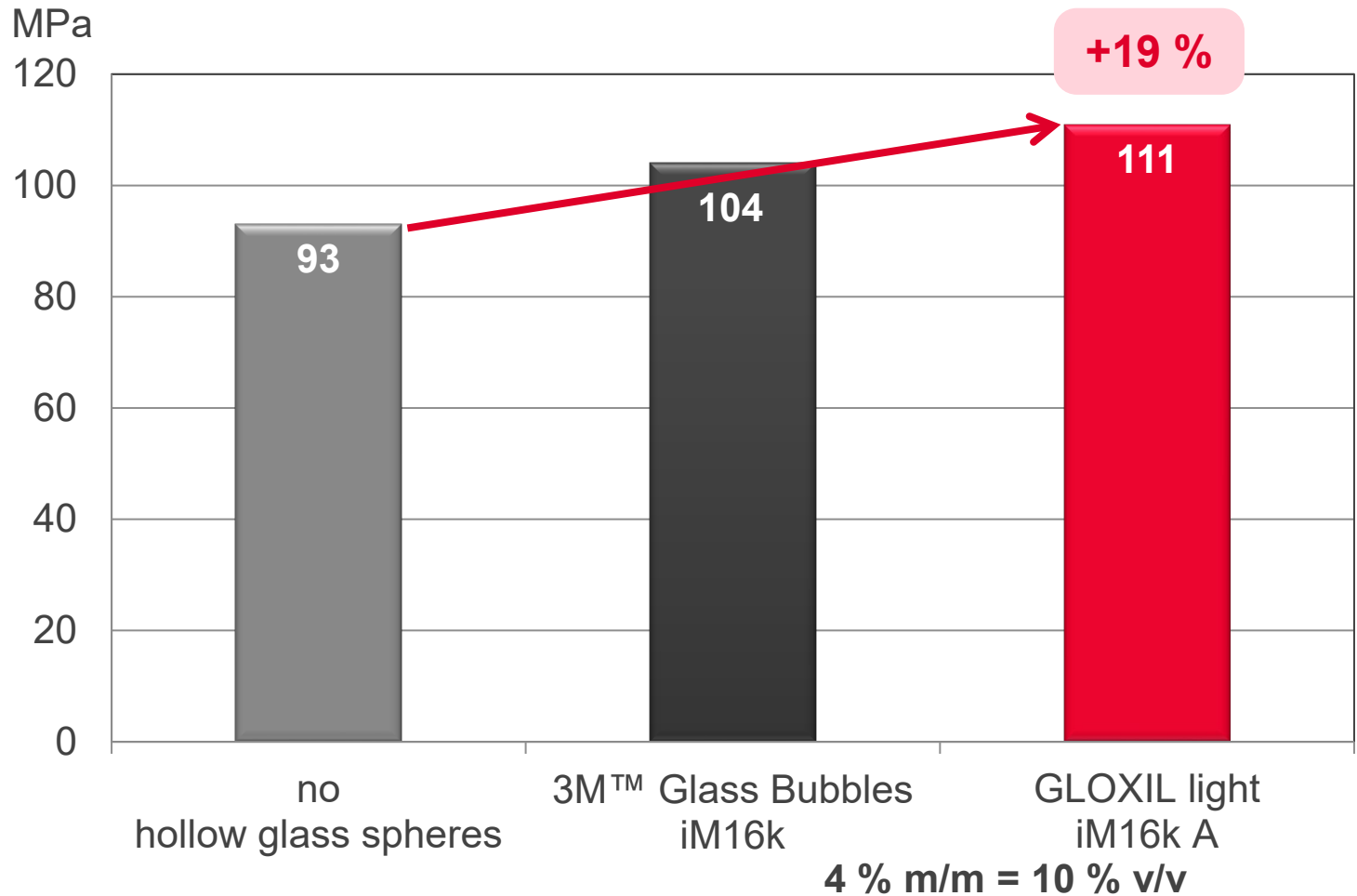
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Tensile Strain at Break

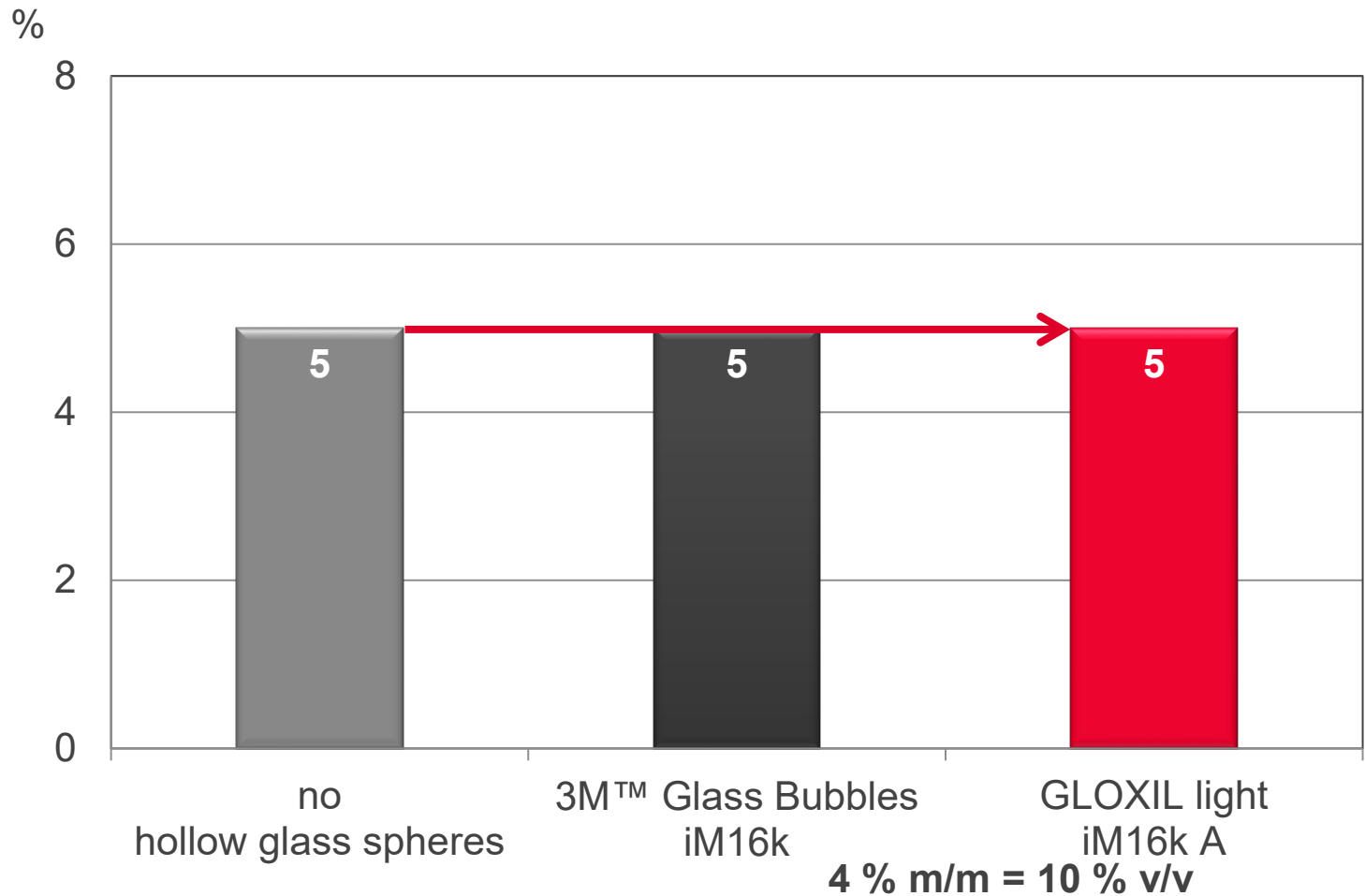
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Flexural Strength

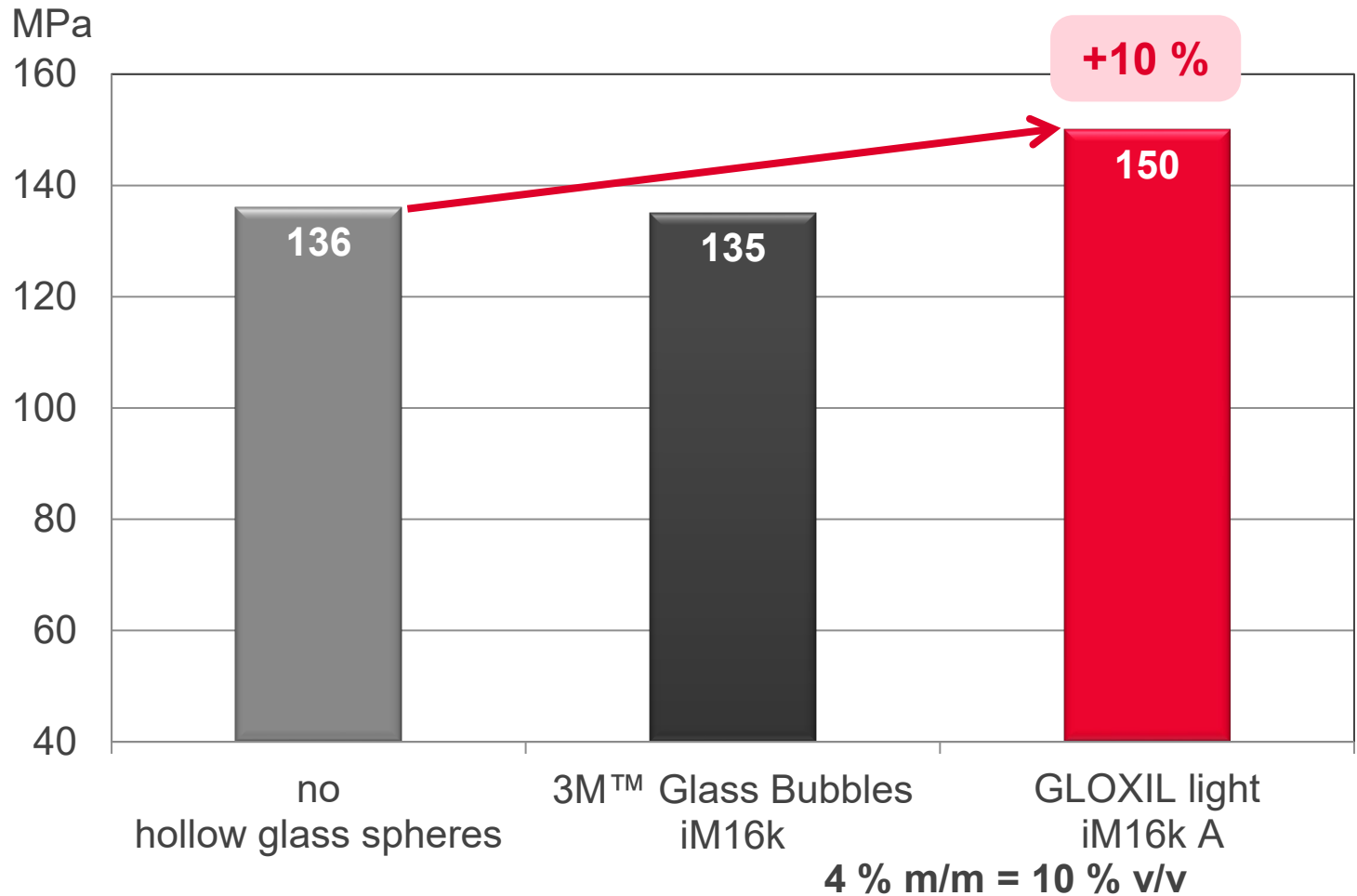
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Impact Strength Charpy

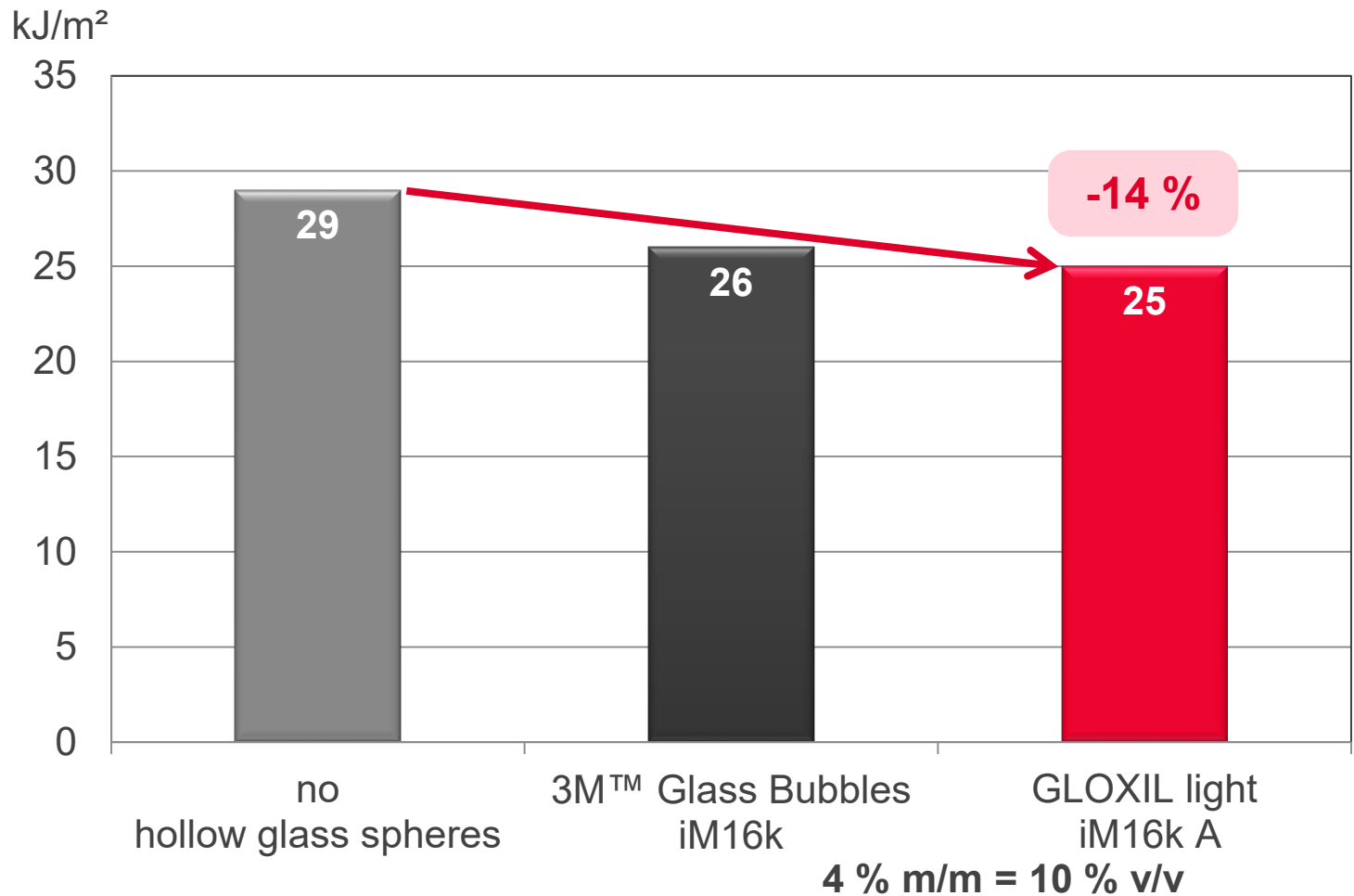
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Notched Impact Strength Charpy

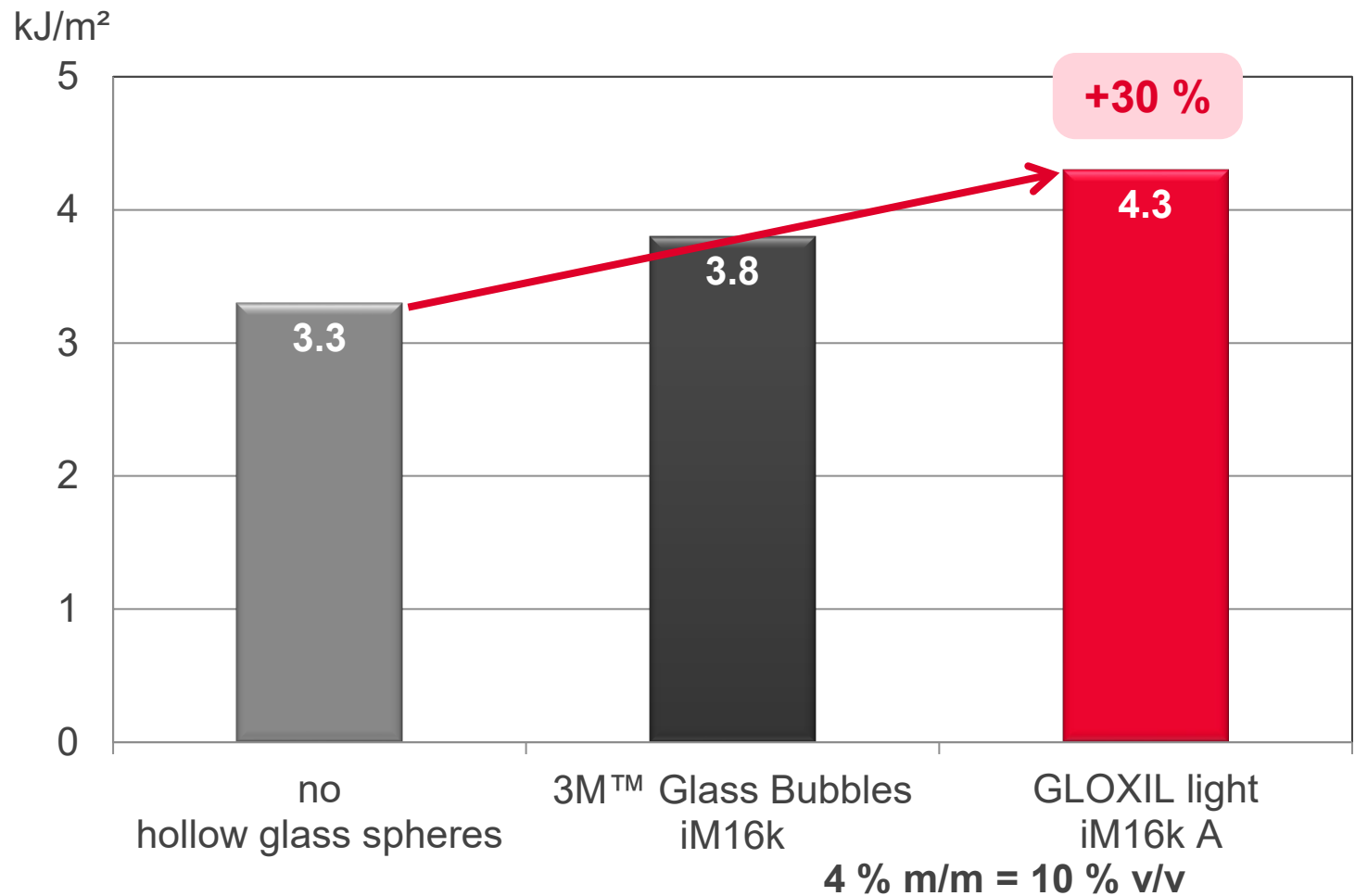
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PA6 GF15 + Glass Bubbles

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GLOXIL light iM16k A as an additive to PA6 GF 15 shows in comparison to PA6 GF15 without hollow glass spheres:

- Slightly lower impact strength
- Slightly reduced density and thus weight saving potential
- + Increase in stiffness (tensile modulus and flexural modulus)
- + Increase in tensile strength with unchanged tensile strain at break
- + Increase in flexural strength
- + Increase in notched impact strength
- Objective achieved: higher stiffness without increase in density/weight and good mechanical properties
- + Expectation: improved scratch resistance





PP Copolymer Compound Formulations

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Objective:

Density / weight reduction and still good mechanical properties

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PP-Copolymer

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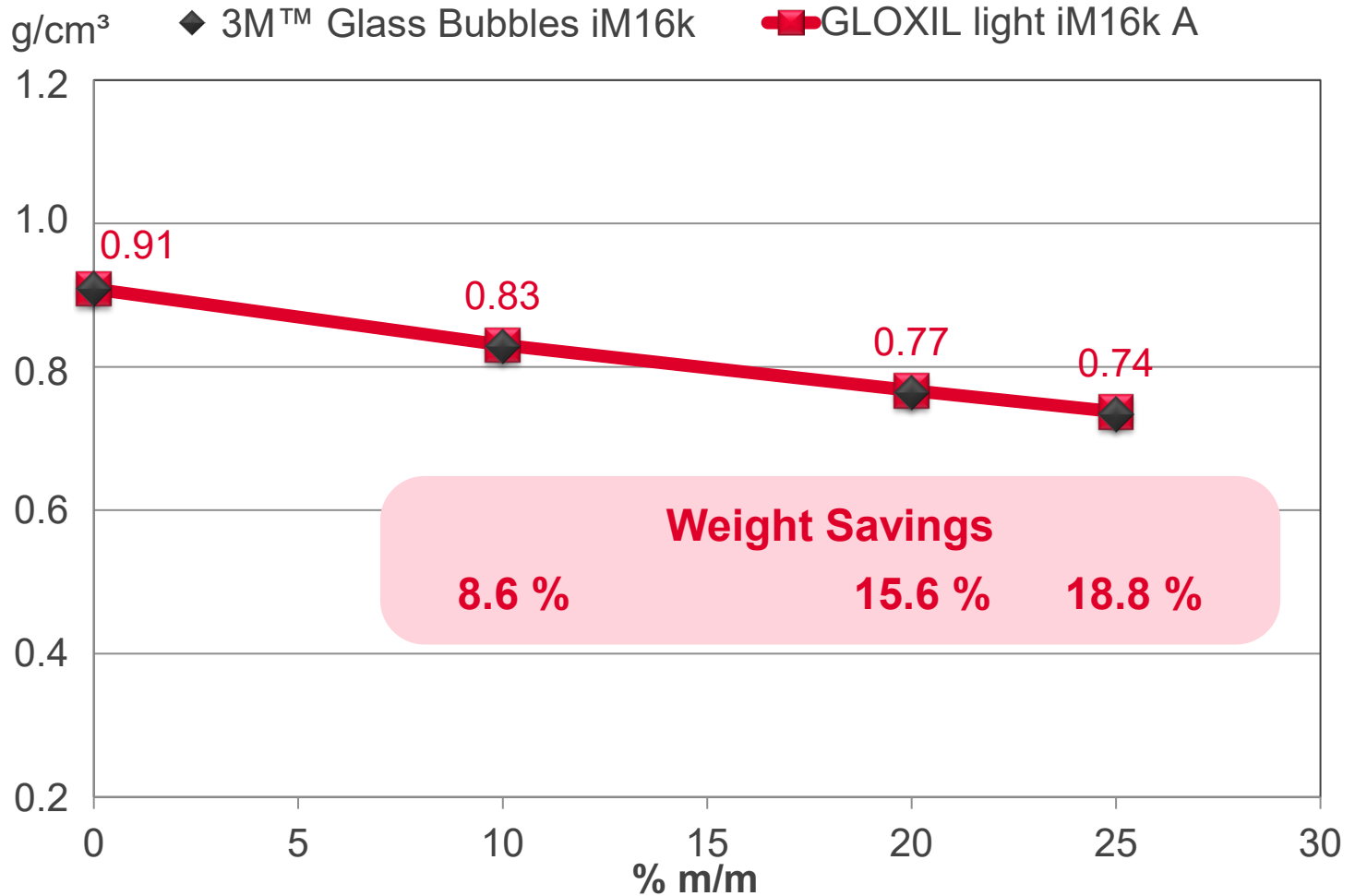
PP Compound Copolymer Bormod™ BF970MO Borealis MFR 20 g/10 min (230 °C, 2.16 kg)		
3M™ Glass Bubbles iM16k	0 to 25 % (m/m) 0 to 40 % (v/v)	---
Scona TPPP 2112 GA PP-g-MAH, approx. 1 % MAH, Byk	---	5 % (m/m)
GLOXIL light iM16k A	---	0 to 25 % (m/m) 0 to 40 % (v/v)
Total	100	100

Data determined by 3M Advanced Materials Division, Special Additives Laboratory



Density and Weight Reduction

measured; % m/m hollow glass spheres



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Tensile Modulus

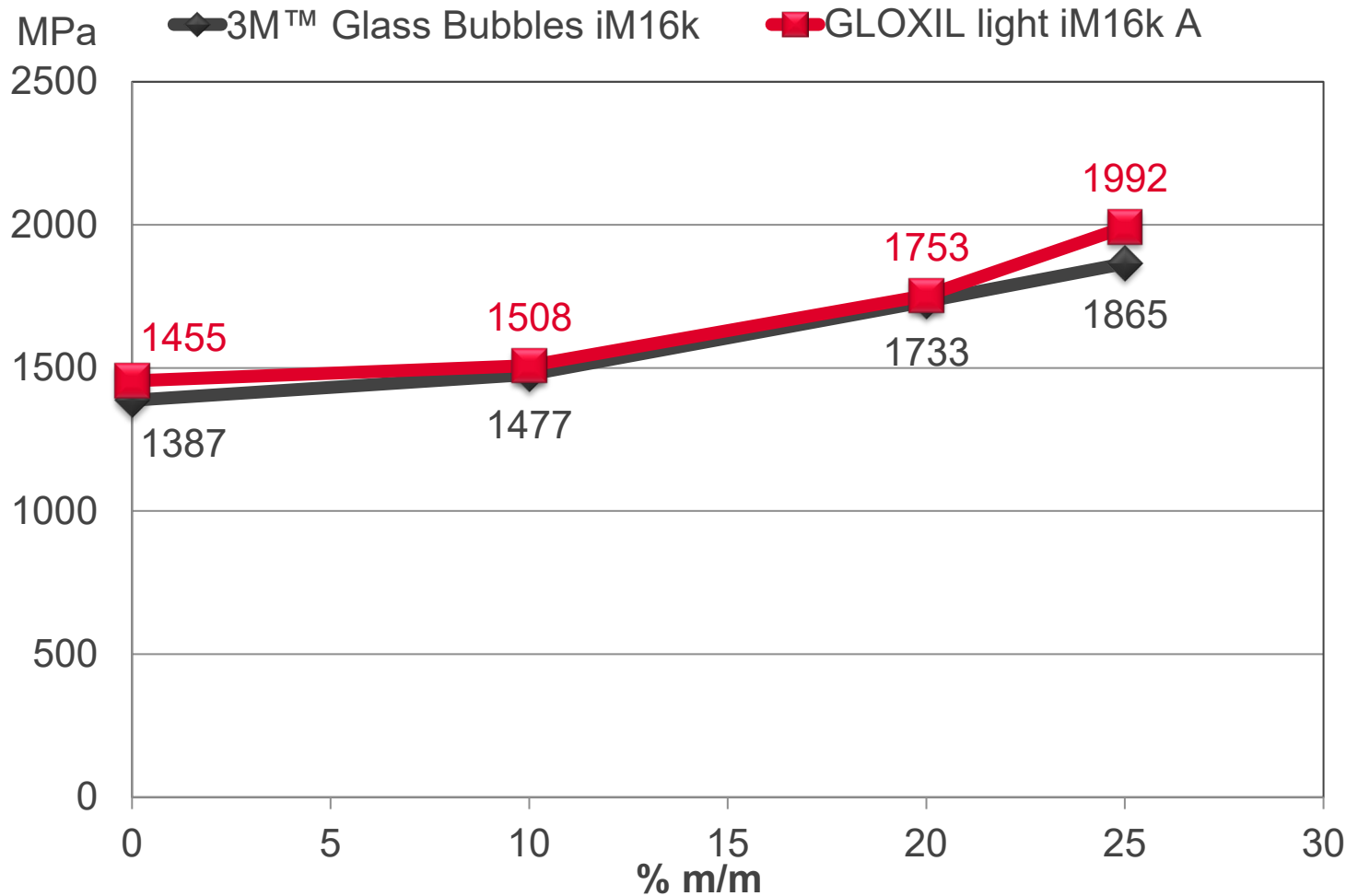
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Flexural Modulus

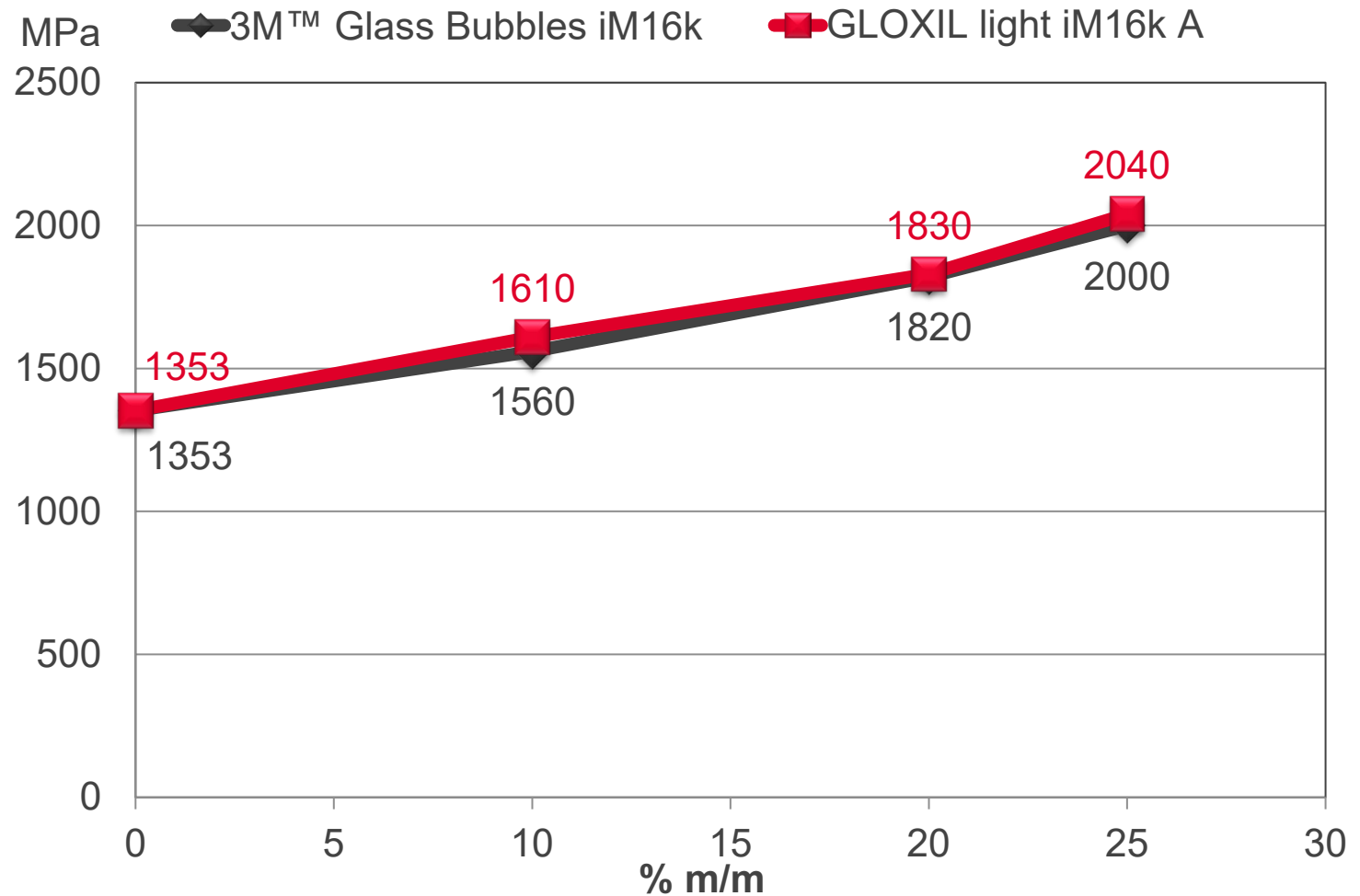
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Tensile Strength

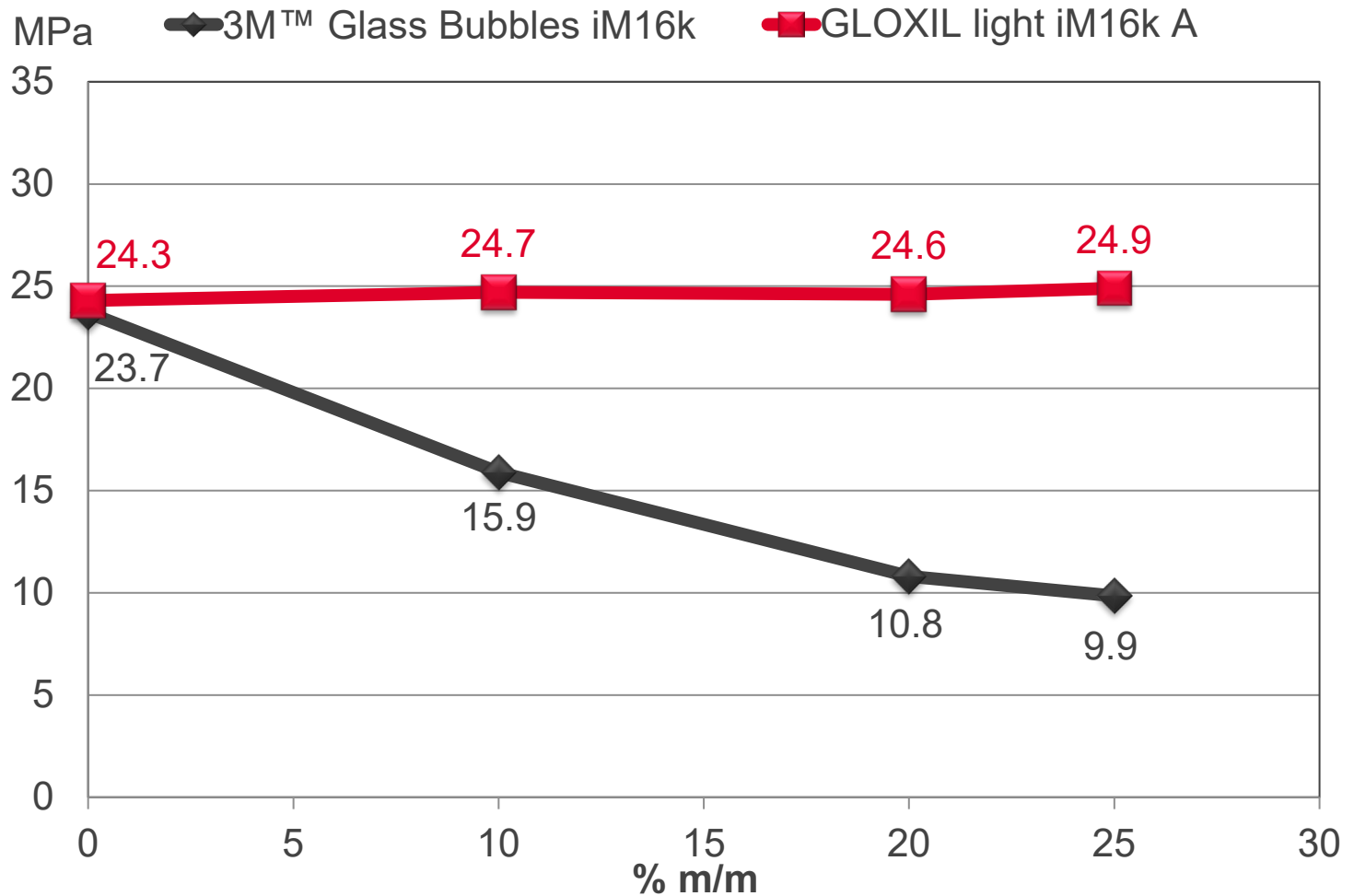
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Flexural Strength

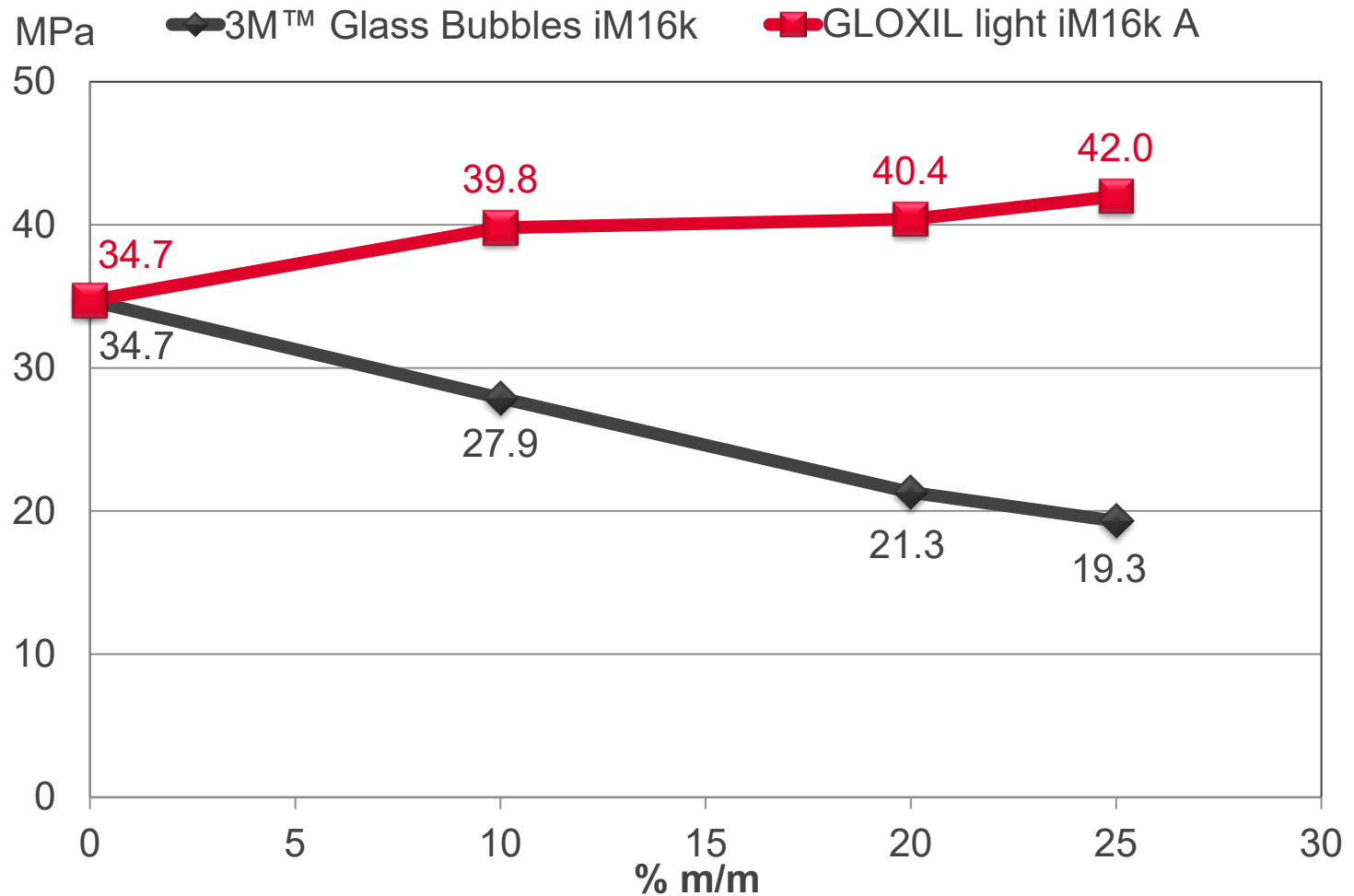
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Impact Strength Charpy

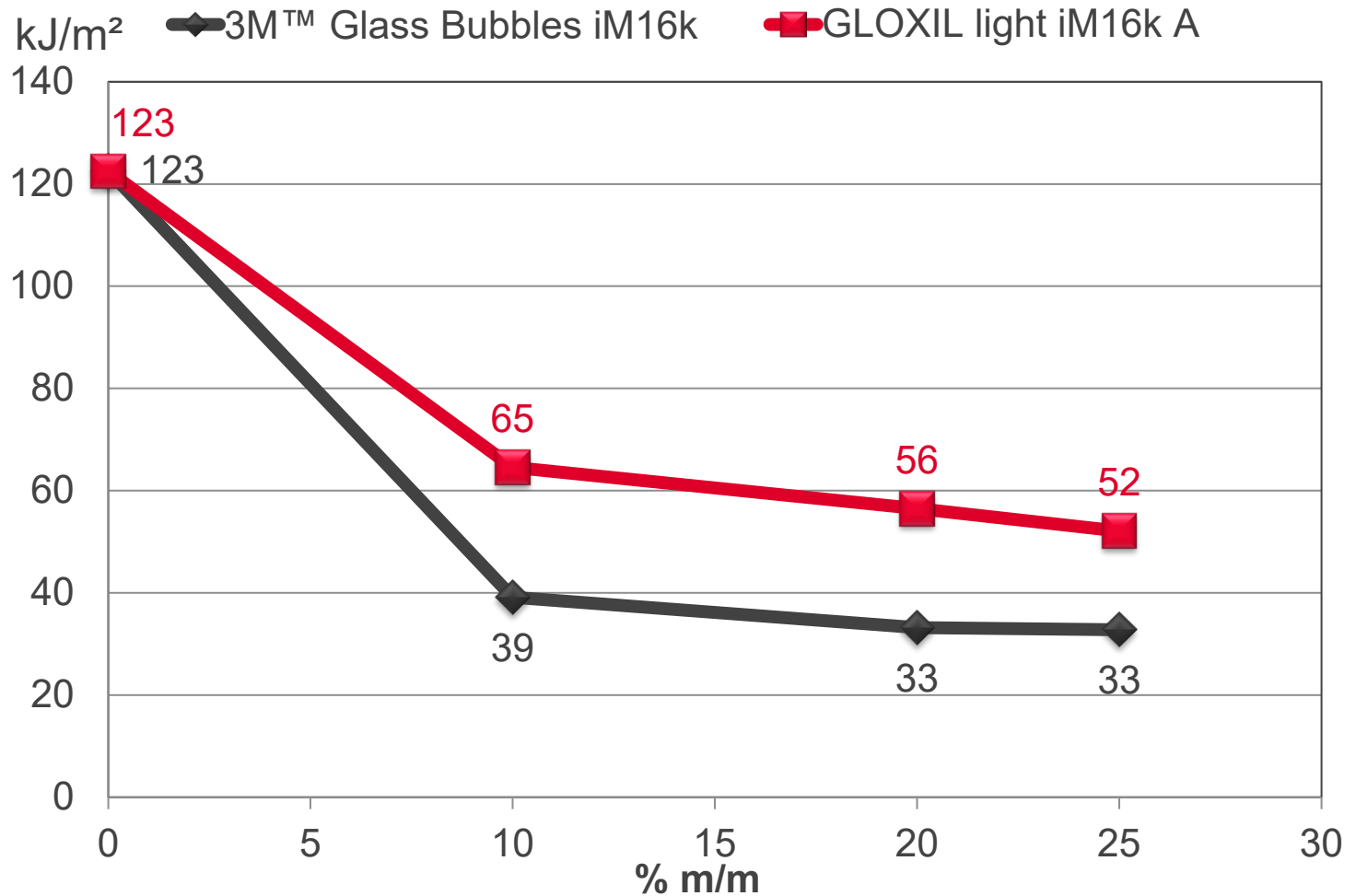
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Notched Impact Strength Charpy

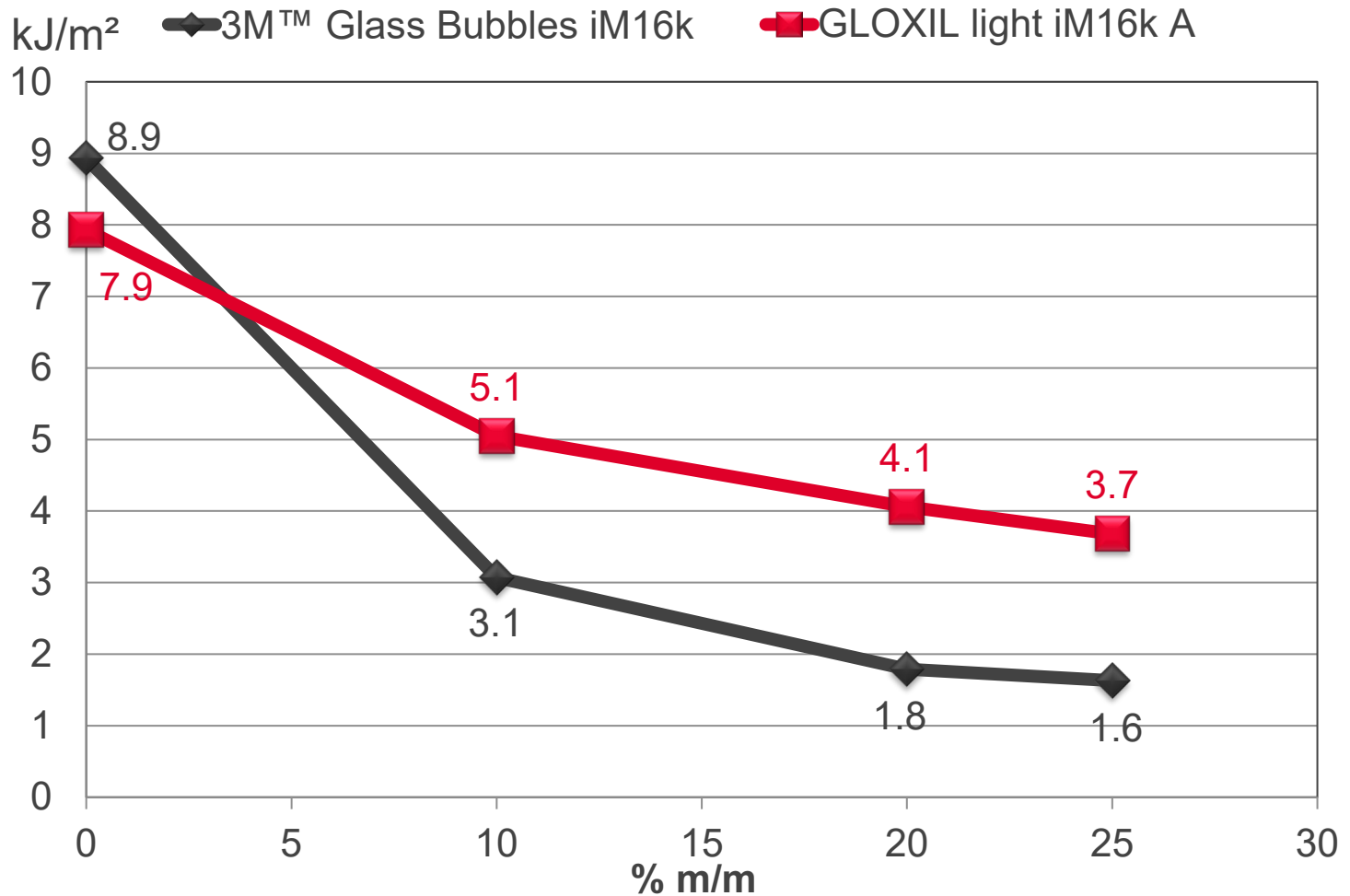
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PP Copolymer

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GLOXIL light iM16k A shows in comparison to the untreated hollow glass spheres:

- Same density and thus weight saving potential
- Comparable increase in stiffness (tensile and flexural modulus)
- + Significantly higher tensile strength, largely independent of the filler content at the level of the unfilled PP copolymer
- + Significantly higher flexural strength, with increasing filler content even higher than the unfilled PP copolymer
- + Higher impact strength
- + Higher notched impact strength
- **Objective achieved:**
density / weight reduction and good mechanical properties
- + Expectation: improved scratch resistance and reduced visibility of scratch marks

Note on efficient dosing of PP-g-MAH:

Concentration should be in the range of 10 to 15 % (m/m), based on the GLOXIL light iM16k A dosage (applies to MAH content in PP-g-MAH of approx. 1 %, for other contents the concentration should be adjusted accordingly)



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More Results PP Talc / Glass Bubbles



Objective:

Density / weight reduction and still good mechanical properties

PP Compound Copolymer Bormod™ BF970MO					
Borealis					
MFR 20 g/10 min (230 °C, 2.16 kg)					
Talc	20 % (m/m) 7 % (v/v)	10 % (m/m) 3 % (v/v)	10 % (m/m) 3 % (v/v)	10 % (m/m) 3 % (v/v)	---
Fusabond® P 613 PP-g-MAH 0.5 to 1 % MAH, Dow	---	6 % (m/m) 6 % (v/v)	6 % (m/m) 6 % (v/v)	6 % (m/m) 6 % (v/v)	5 % (m/m) 4 % (v/v)
3M™ Glass Bubbles iM16k	---	5 % (m/m) 10 % (v/v)	---	---	---
GLOXIL light iM16k A	---	---	5 % (m/m) 10 % (v/v)	5 % (m/m) 10 % (v/v)	10 % (m/m) 18 % (v/v)
Infuse™ 9000 Olefin Block Copolymer	---	---	---	10 % (m/m) 10 % (v/v)	---
Total	100	100	100	100	100

Data determined by 3M Advanced Materials Division, Special Additives Laboratory

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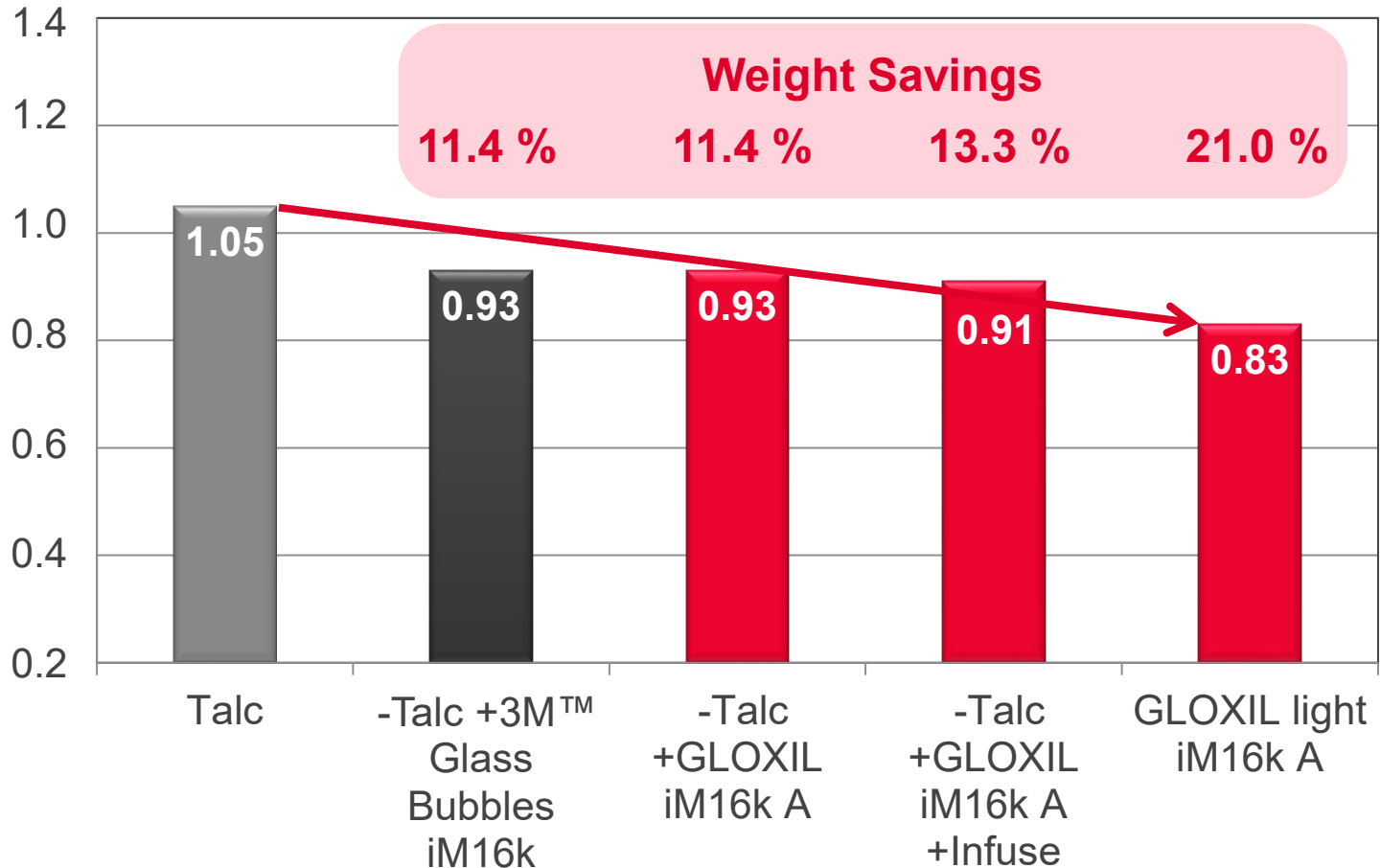
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Density and Weight Reduction

measured

g/cm³



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Tensile Modulus

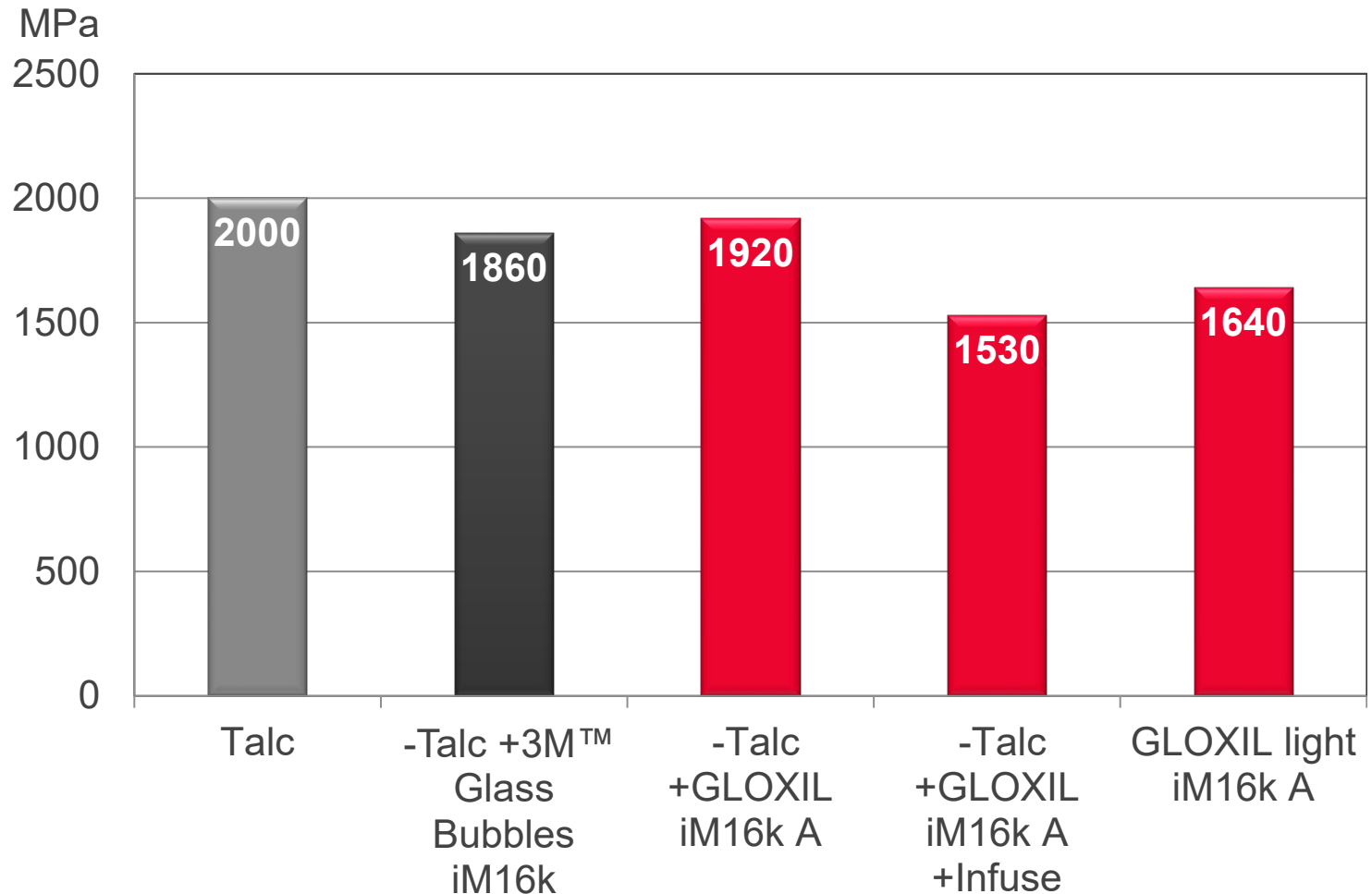
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Yield Stress

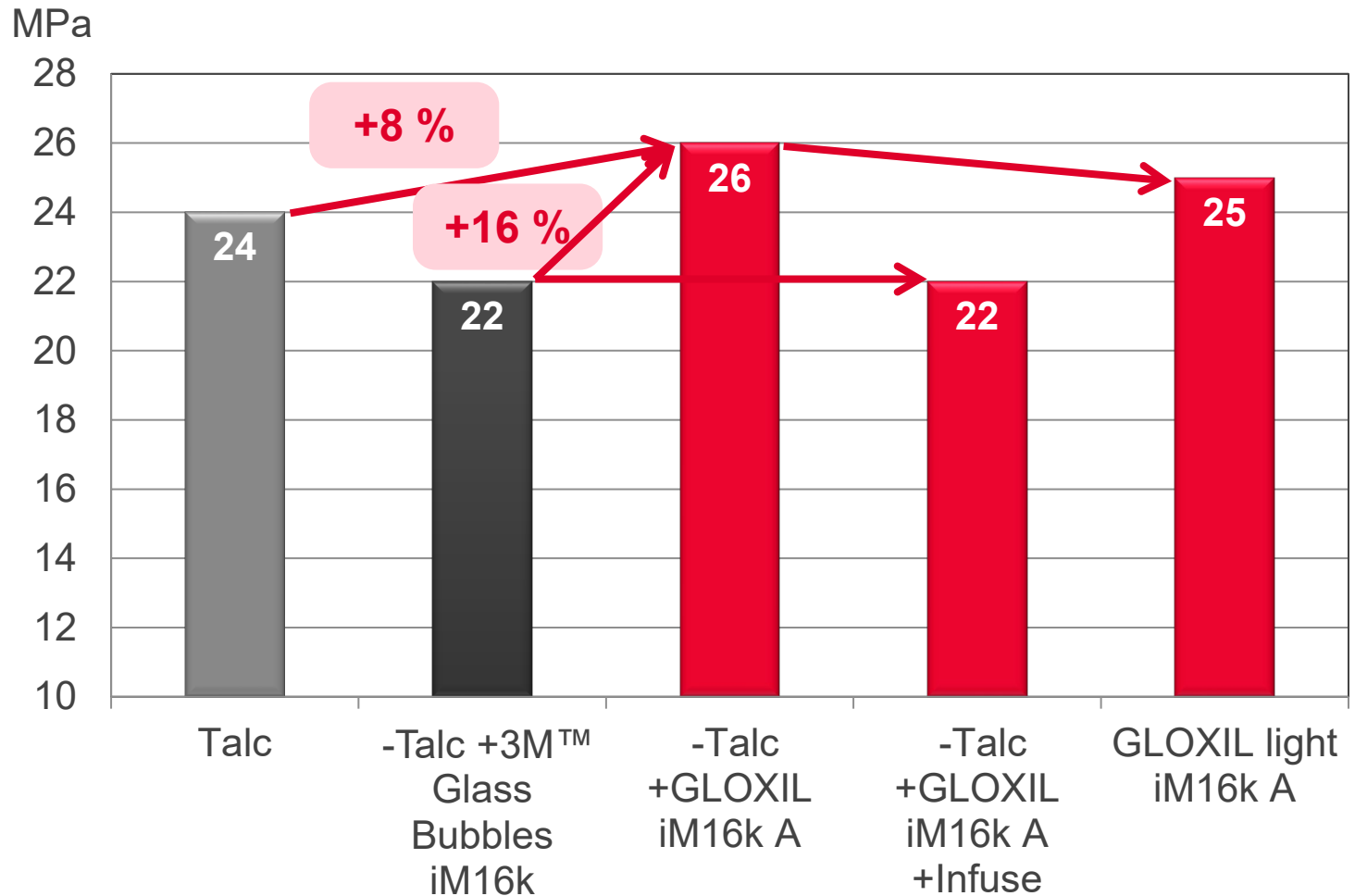
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Impact Strength Charpy

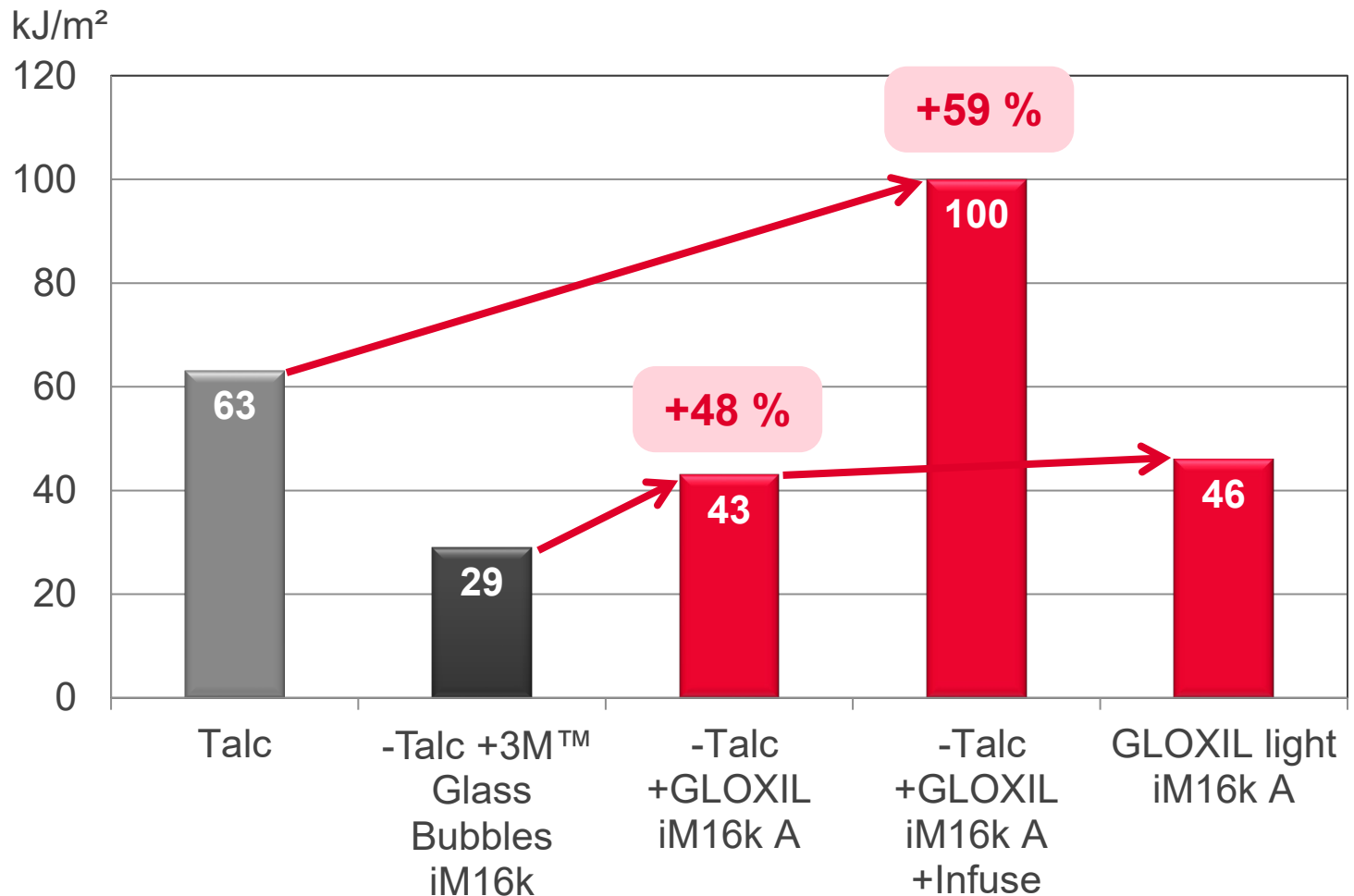
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Notched Impact Strength Charpy

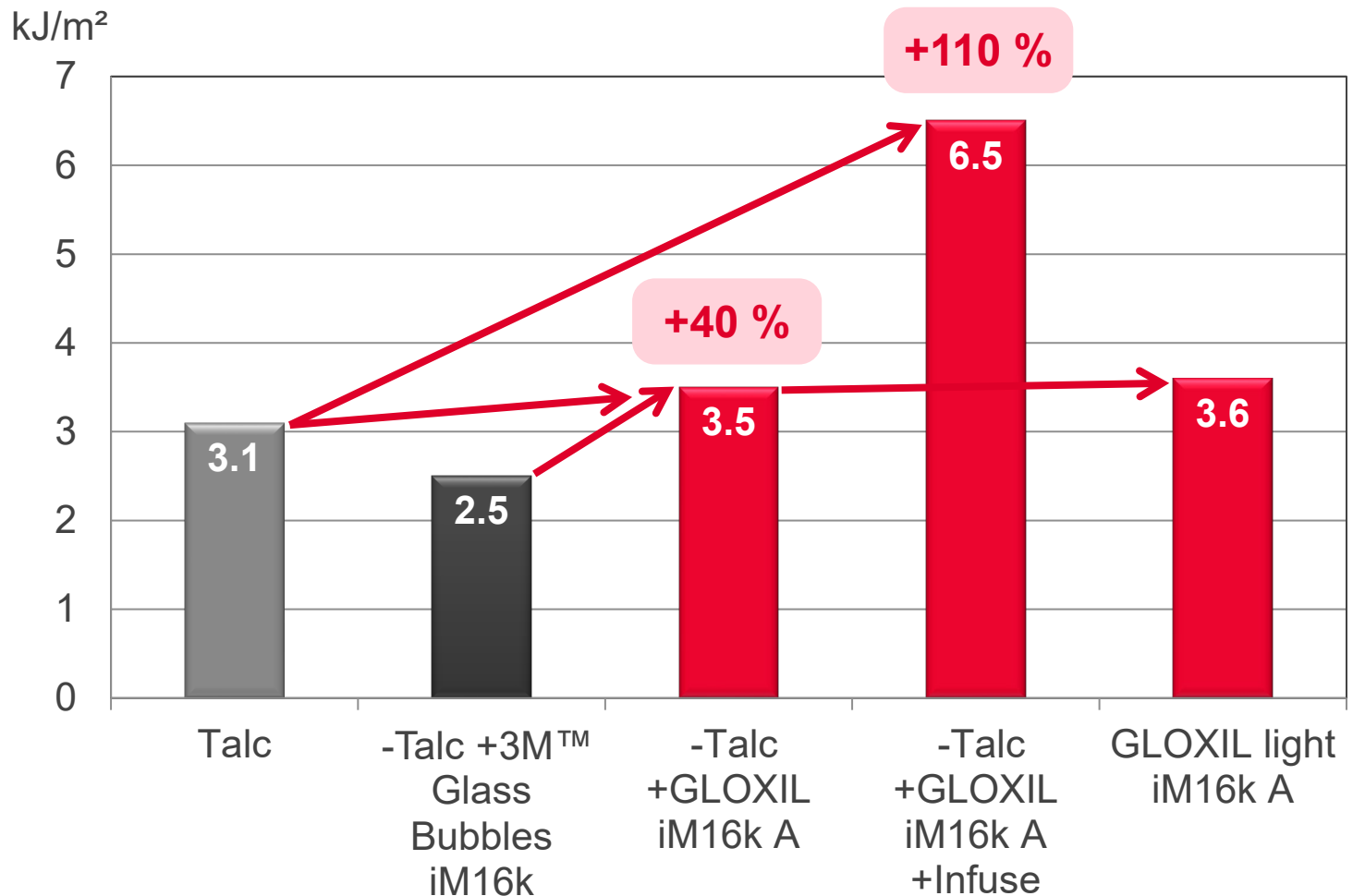
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Summary PP Copolymer Talc / Glass Bubbles

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GLOXIL light iM16k A shows as **partial and full replacement of talc** compared to PP Copo T20 without hollow glass spheres:

- Full replacement: slightly lower stiffness
- Partial replacement: comparable stiffness
- + Reduced density / weight saving potential up to 21 %
- + Increase in yield stress (and thus potential for introduction of impact modifier)
- + Hardly any loss of yield stress despite impact modifier
- + Comparable yield stress at full replacement
- + Increase in impact strength, especially with addition of impact modifier
- + Increase in notched impact strength, especially with addition of impact modifier
- + Comparable notched impact strength at full replacement
- **Objective achieved:**
density / weight reduction and good mechanical properties
- + Expectation: improved scratch resistance



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Summary Overall

GLOXIL light iM16k A shows in comparison to the untreated hollow glass spheres:

- Same density and thus weight saving potential
- Comparable increase in stiffness (tensile and flexural modulus)
- + Significantly higher yield stress or tensile strength, largely independent of the filler content at the level of the unfilled polymer
- + Significantly higher flexural strength, with increasing filler content in some cases even higher than the unfilled polymer
- + Higher impact strength
- + Higher notched impact strength
- + Various possibilities for compound modification with e.g. impact modifiers without loss of other properties
- + Expectation: improved scratch resistance



We supply material for good ideas!

HOFFMANN MINERAL GmbH
Muenchener Straße 75
DE-86633 Neuburg (Donau)

Phone: +49 8431 53-0
Internet: www.hoffmann-mineral.de
E-mail: info@hoffmann-mineral.com

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