The Ultimate in Slip and Stability for Polyolefins

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- Introduction
- Enhanced stability slip in films
- Benefits for automotive anti-scratch
- Improved organoleptics in closure applications

Slip or friction reducing additives

- Slip additives have been used in polyolefins for over 50 years to reduce friction films, aid mould release and facilitate the application and removal of closures

- Many materials have been proposed and used but mono-unsaturated fatty acid amides have become the de facto standard for high slip applications

- The most commonly used additives today are oleamide and erucamide which are monounsaturated primary amide with a carbon chain length of 18 and 22 respectively

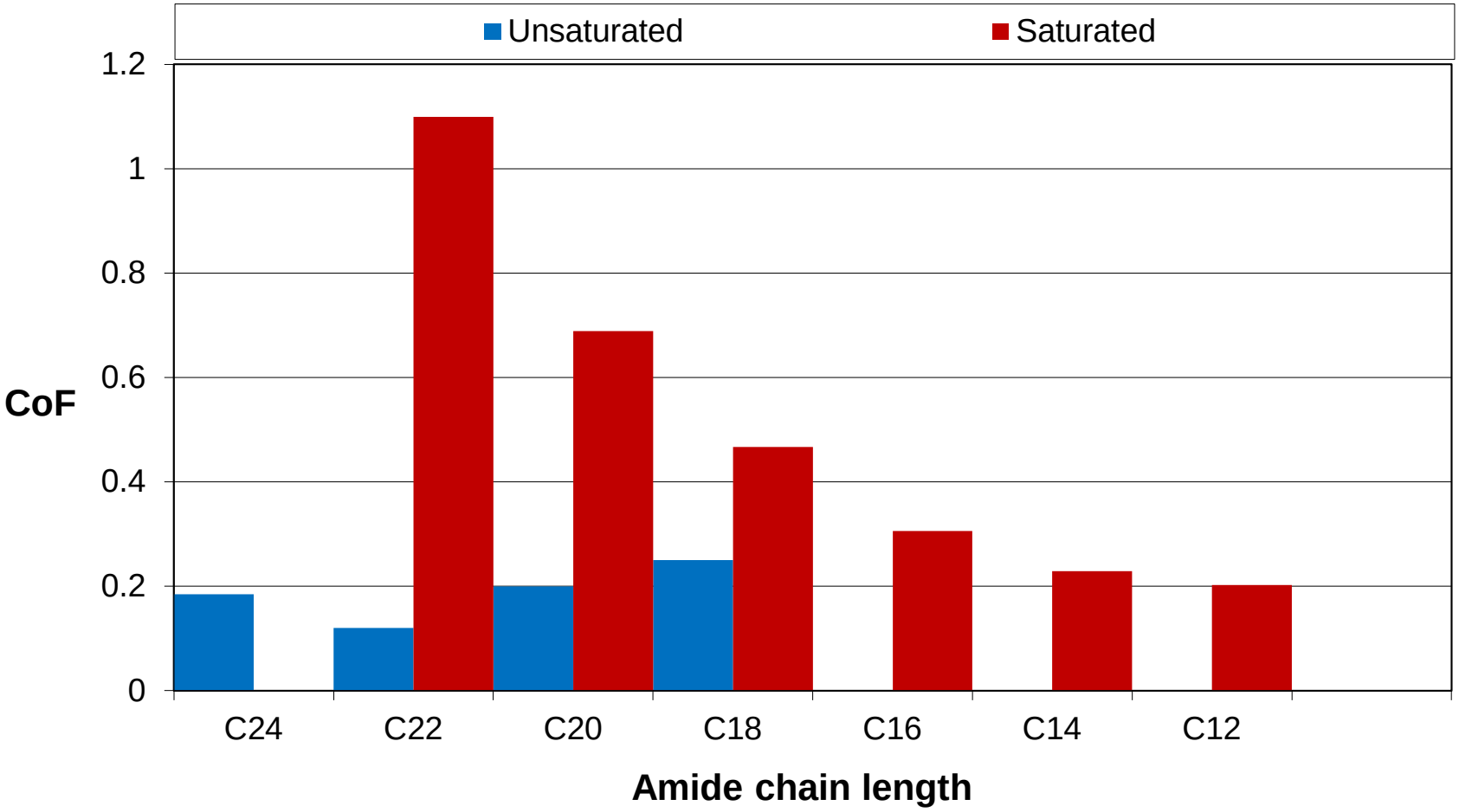
- These materials are highly effective slip agents, at modest addition levels have acceptable stability and volatility for most polyolefin processing.

Unsaturated or saturated amides?

- The best high slip additives are mono-unsaturated primary fatty acid amides in the C18 – C24 range
- They combine reasonable stability and volatility characteristics with low coefficient of friction at low addition levels (typically CoF <0.2 at 500 – 2000 ppm)
- However, typically 90% of the material still has one double bond which will oxidise 10 times faster than the related saturated amide
- High UV, high ambient temperatures or presence of oxidising species such as ozone or peroxides make unsaturation undesirable
- Saturated amides have poor slip properties due to slower migration and more crystalline surface morphology

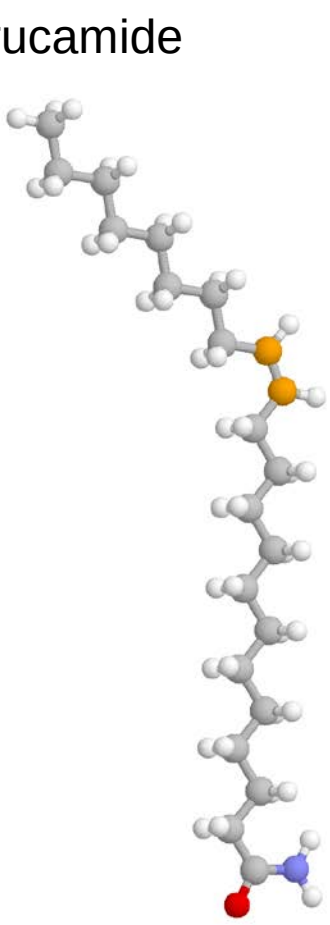
CoF of saturated and unsaturated amides

500 ppm in LDPE, 40µm blown film after 14 days, amide of varying carbon chain length



Un-saturates and saturates

erucamide

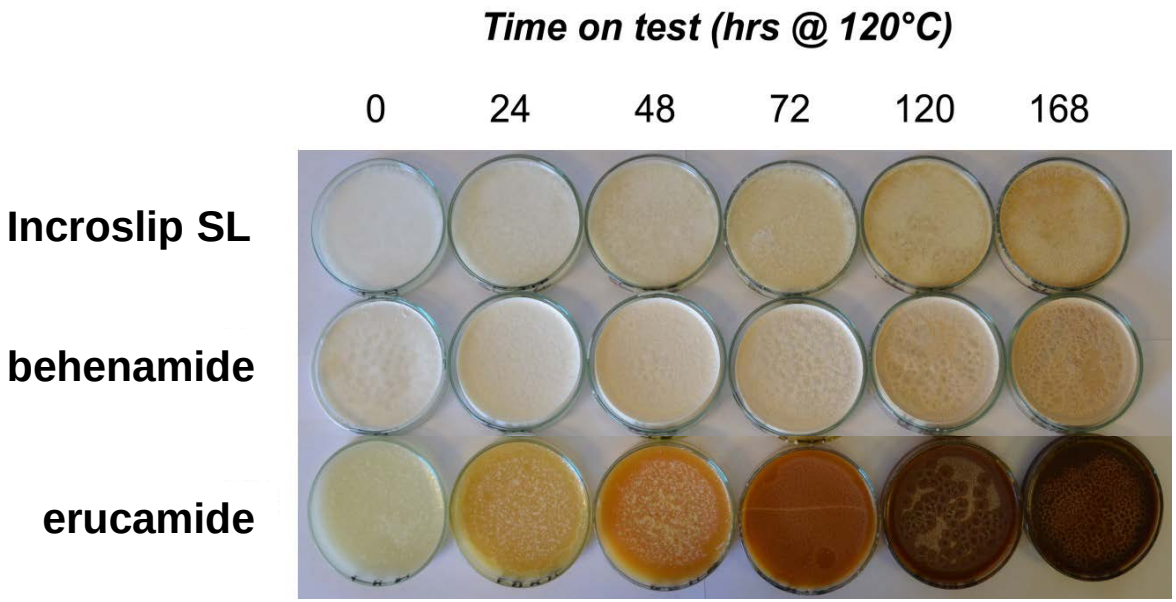


behenamide

- Erucamide: iodine value 75-85, melting point ~80˚C, translucent in the solid state, deforms under pressure, waxy feel.
- Behenamide: iodine value 1-3, melting point ~112˚C, opaque in the solid state, hard and resists deformation under pressure.
- In polyolefins erucamide migrates quickly, covers the surface, has a planar layer like structure on the polymer surface. Behenamide migrates slowly, does not cover the surface so well and appears to have a more crystalline 3 dimensional structure
- The double bond in erucamide results in poorer oxidative stability than with behenamide. Mono-unsaturates always have small quantities of polyunsaturates which are more unstable.

Colour stability

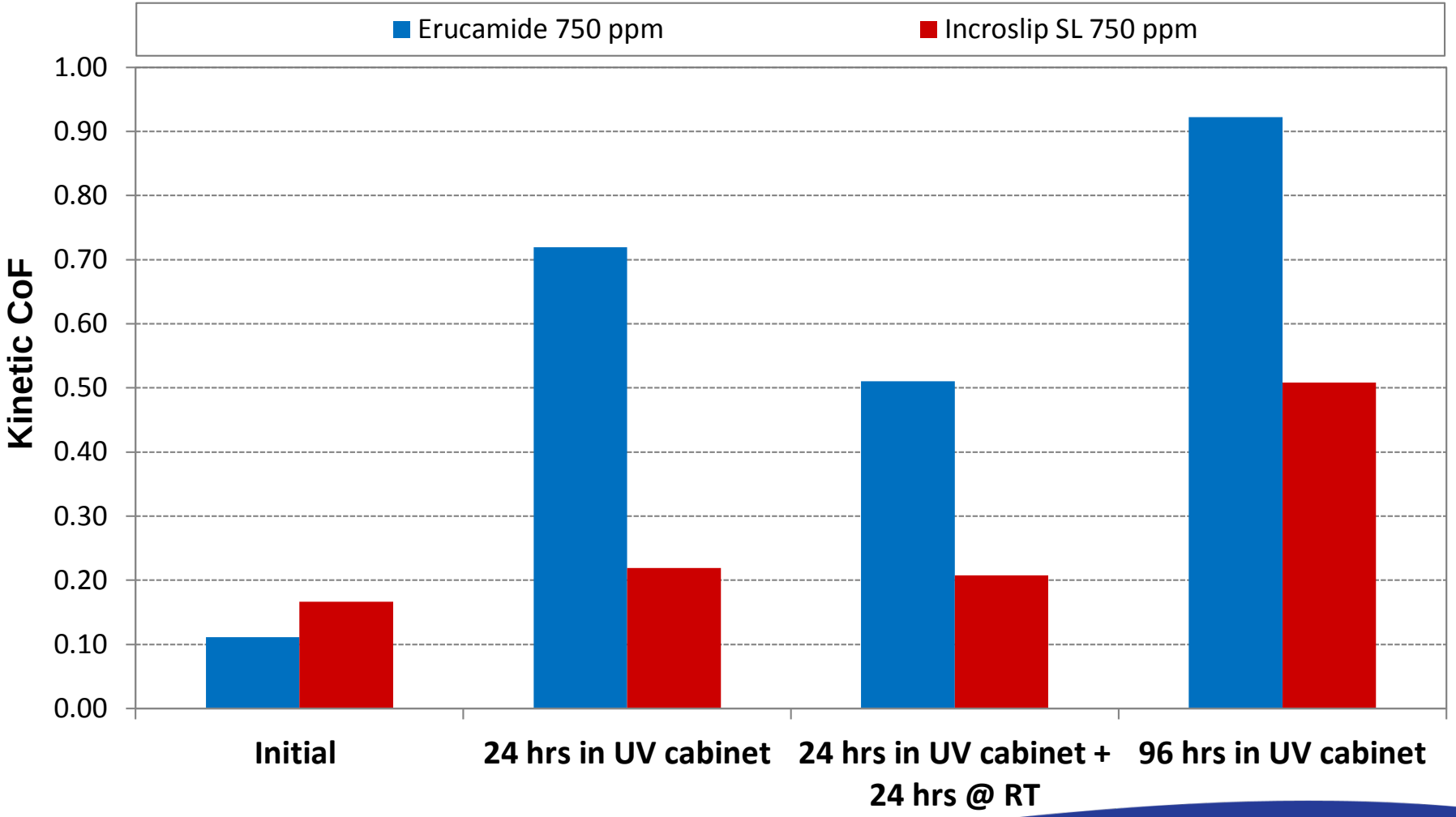
Why do you want a product with good colour stability?



- ✓ *Less yellowing indicates less oxidation*
- ✓ *Lower colour of finished films*
- ✓ *Fewer oxidative bi-products*
- ✓ *Less demand on anti-oxidants in system?*

Kinetic CoF of erucamide and Incroslip SL in LDPE

Before and After Accelerated Aging in the UV Cabinet*



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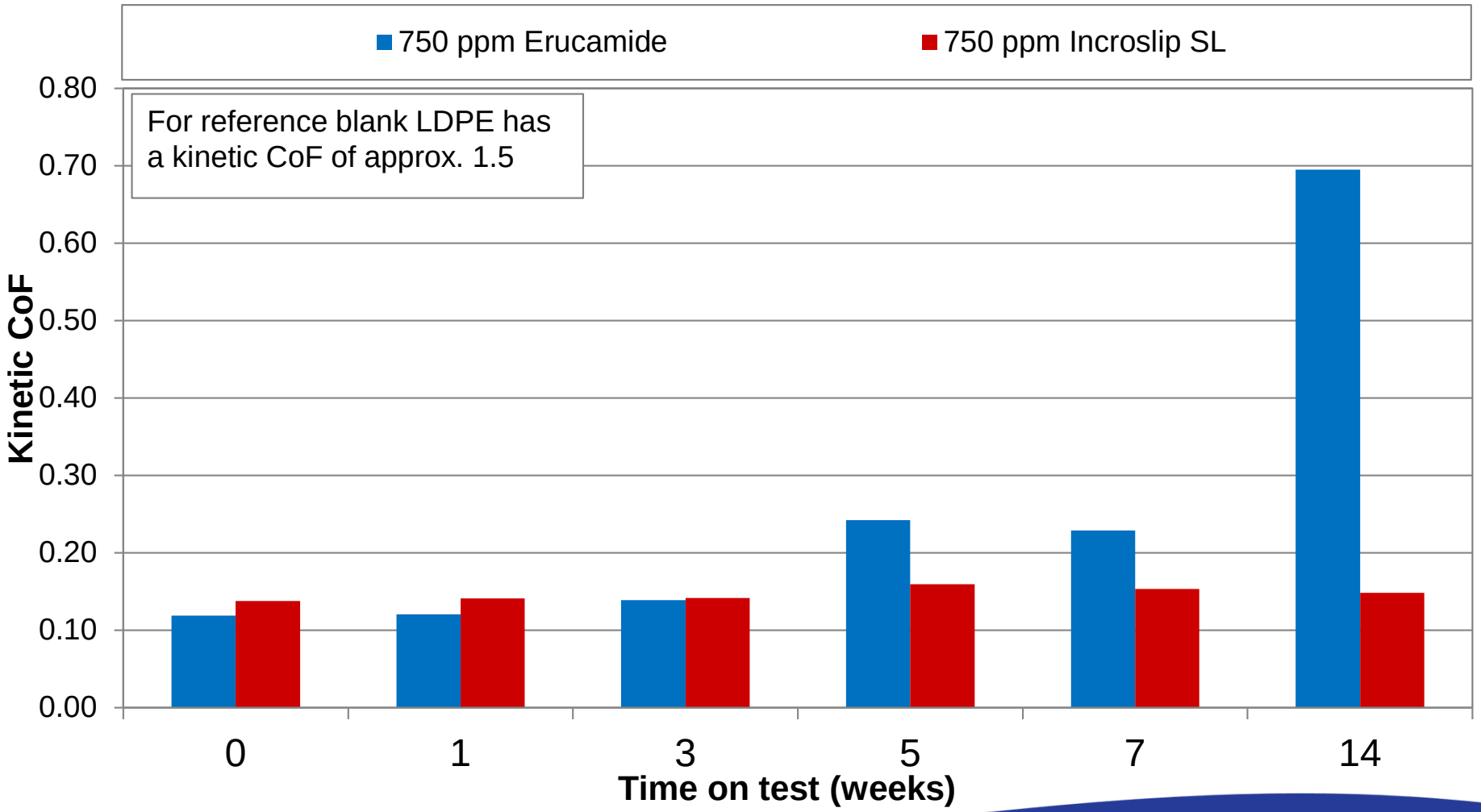
*24 hours in UV cabinet represents approximately 12 days in natural sunlight

Kinetic CoF of film 35 µm LDPE blown film

Samples That Have Been Exposed to Natural UV Through a Window



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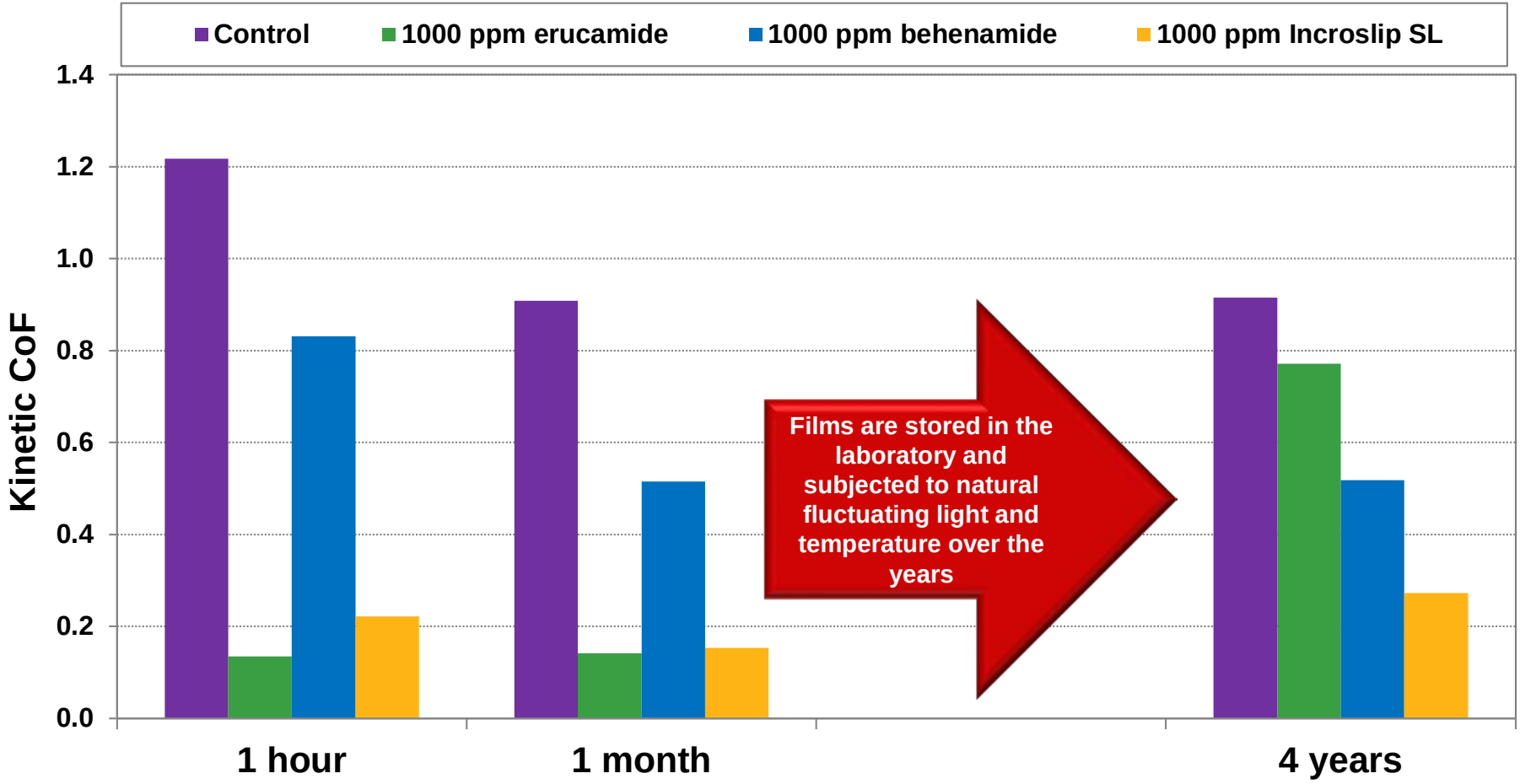
LDPE slip performance after extended storage

Films storage in rolls at ambient temperature under standard fluorescent tube illumination. Additives Natural silica 1000 ppm, slip 1000 ppm



All samples contain 1000 ppm natural silica

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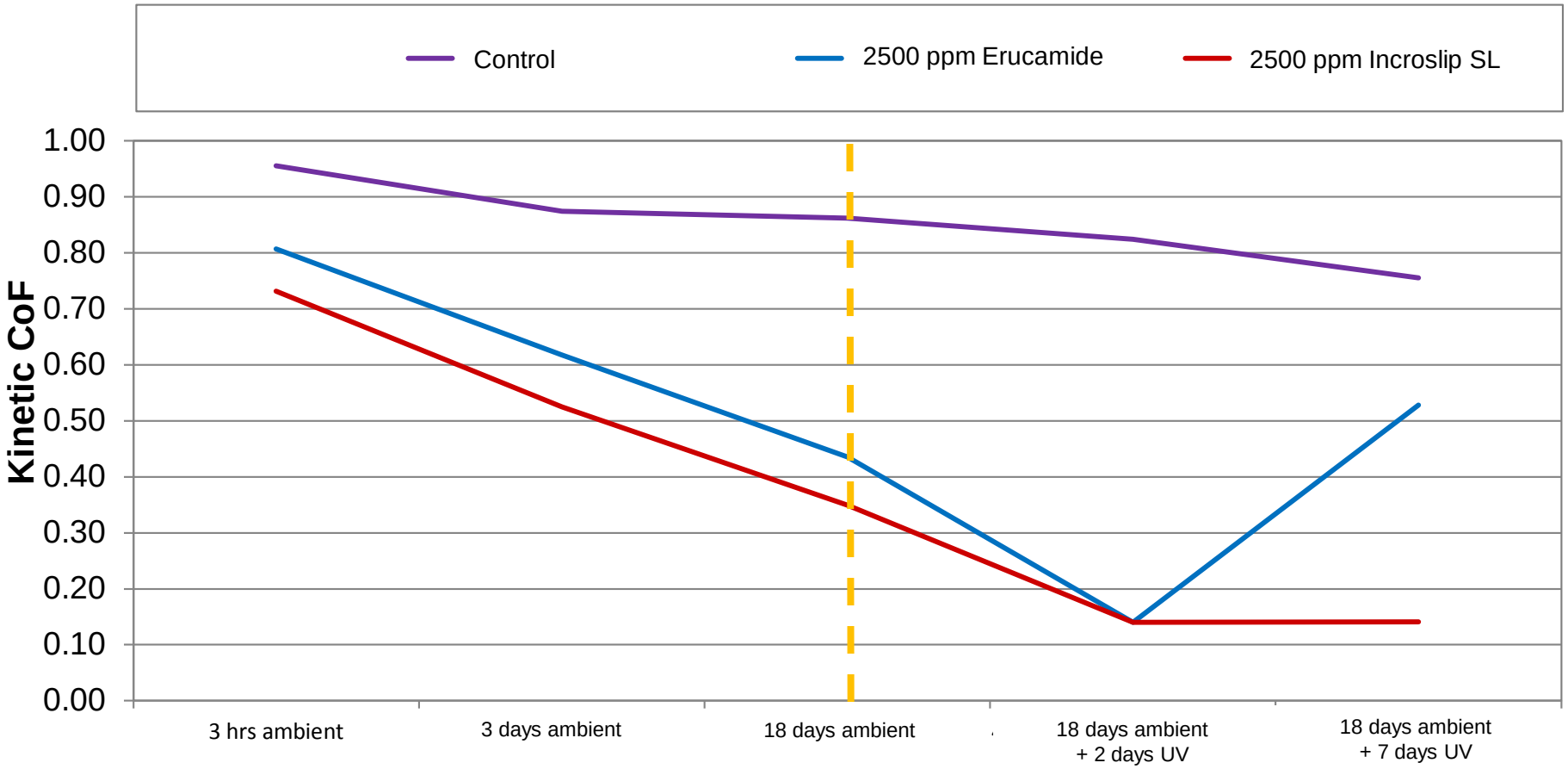
Kinetic CoF of hPP conditioned in UV cabinet* (After 432 Hours Under Ambient Conditions)



*UV cabinet is maintained at 50ºC/all films contain 2000ppm synthetic silica

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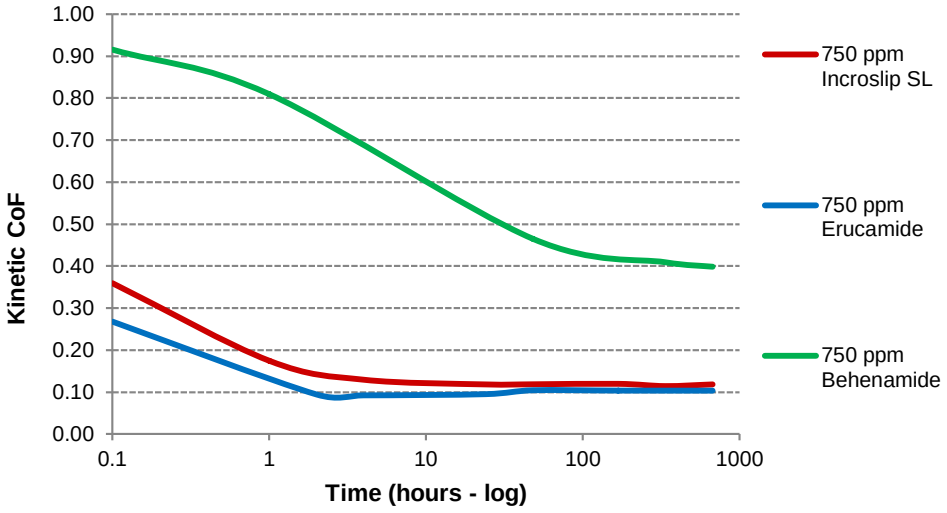
Conclusions

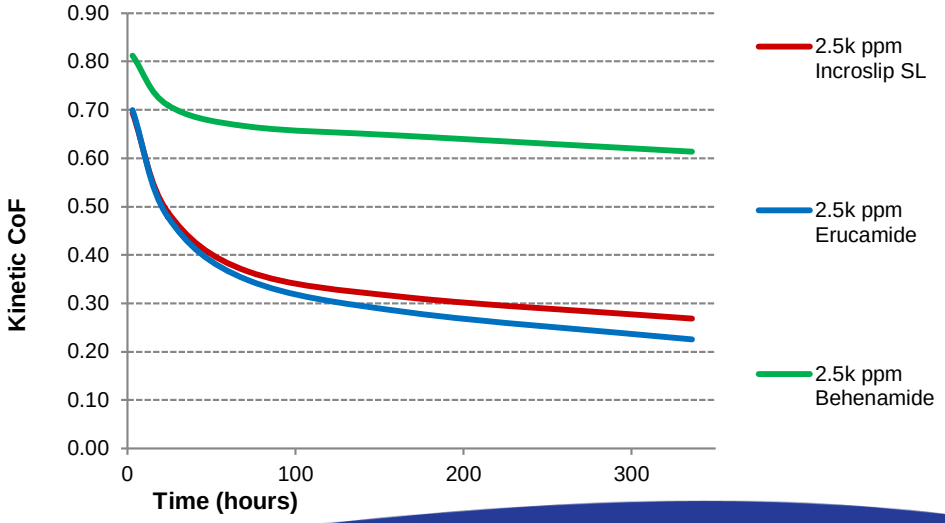
- Under UV Erucamide loses significant performance
- Under UV Incroslip SL maintains its CoF level

Of course under normal conditions Incroslip SL has the same frictional properties as erucamide

Same CoF as ER - Kinetic CoF of Incroslip SL vs. Erucamide and Behenamide at 750 ppm in LDPE (35 µm film, All Contain 1k ppm Natural Silica)



Kinetic CoF of Incroslip SL vs. Erucamide and Behenamide at 2500 ppm in hPP (50 µm film, All Contain 2k ppm Synthetic Silica)



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Technical requirements for film

	Traditional slip additives	Incroslip SL
Process consistently	✓	✓
Wind on and off reels	✓	✓
Ease of in use application (secondary processing)	✓	✓
Low odour		✓
Low visible bloom		✓
Good colour		✓
Low stickiness		✓
Maintain CoF in all conditions		✓

Injection Molding Plastics for Automotive Applications

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What can you do to improve performance in automotive plastics?

- Anti-scratch
- Reduce stickiness
- Low visible bloom
- Mold release
- Superior organoleptic

Let's discuss the data to support this

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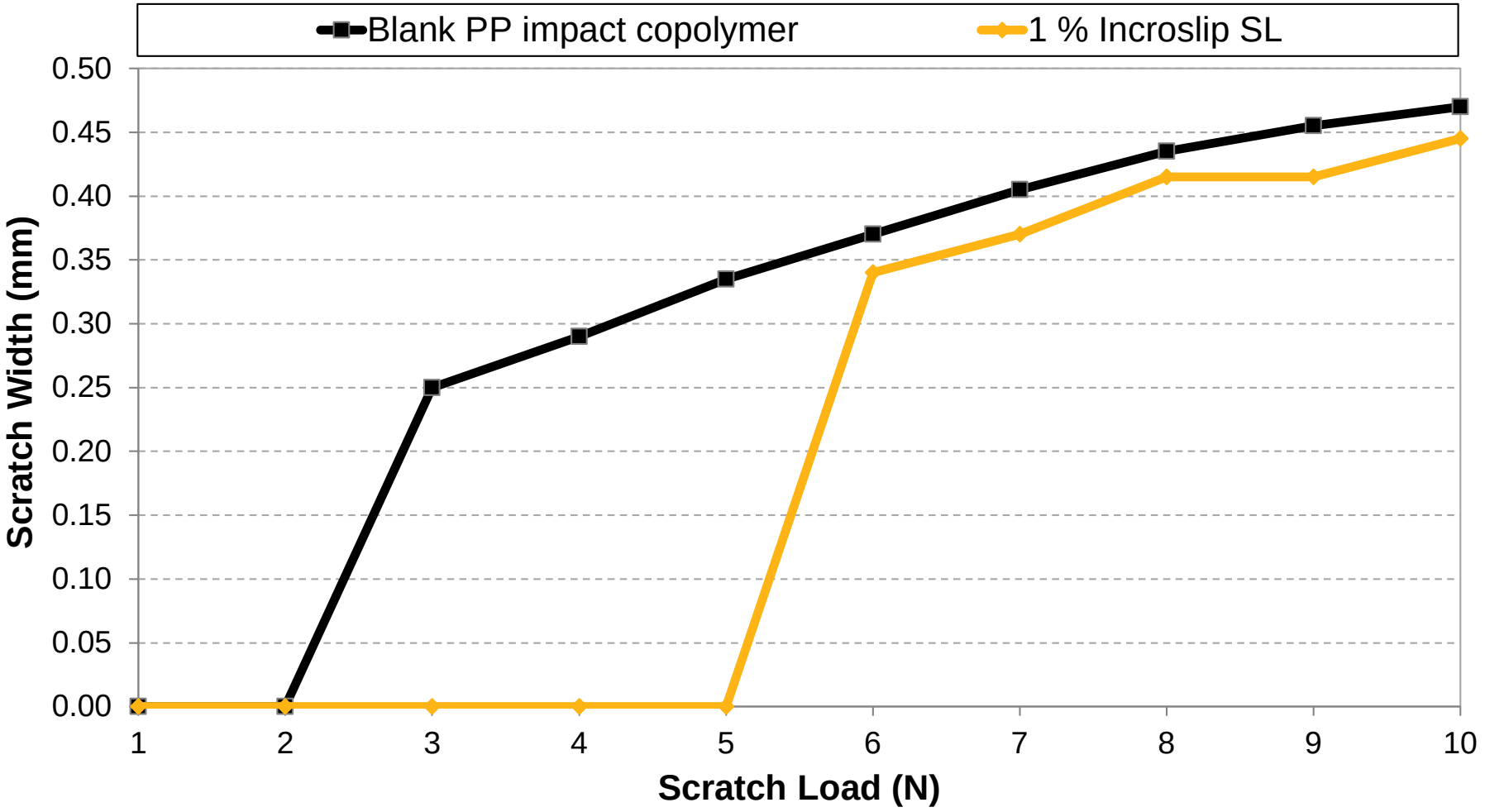
Reducing scratch width with Incroslip SL



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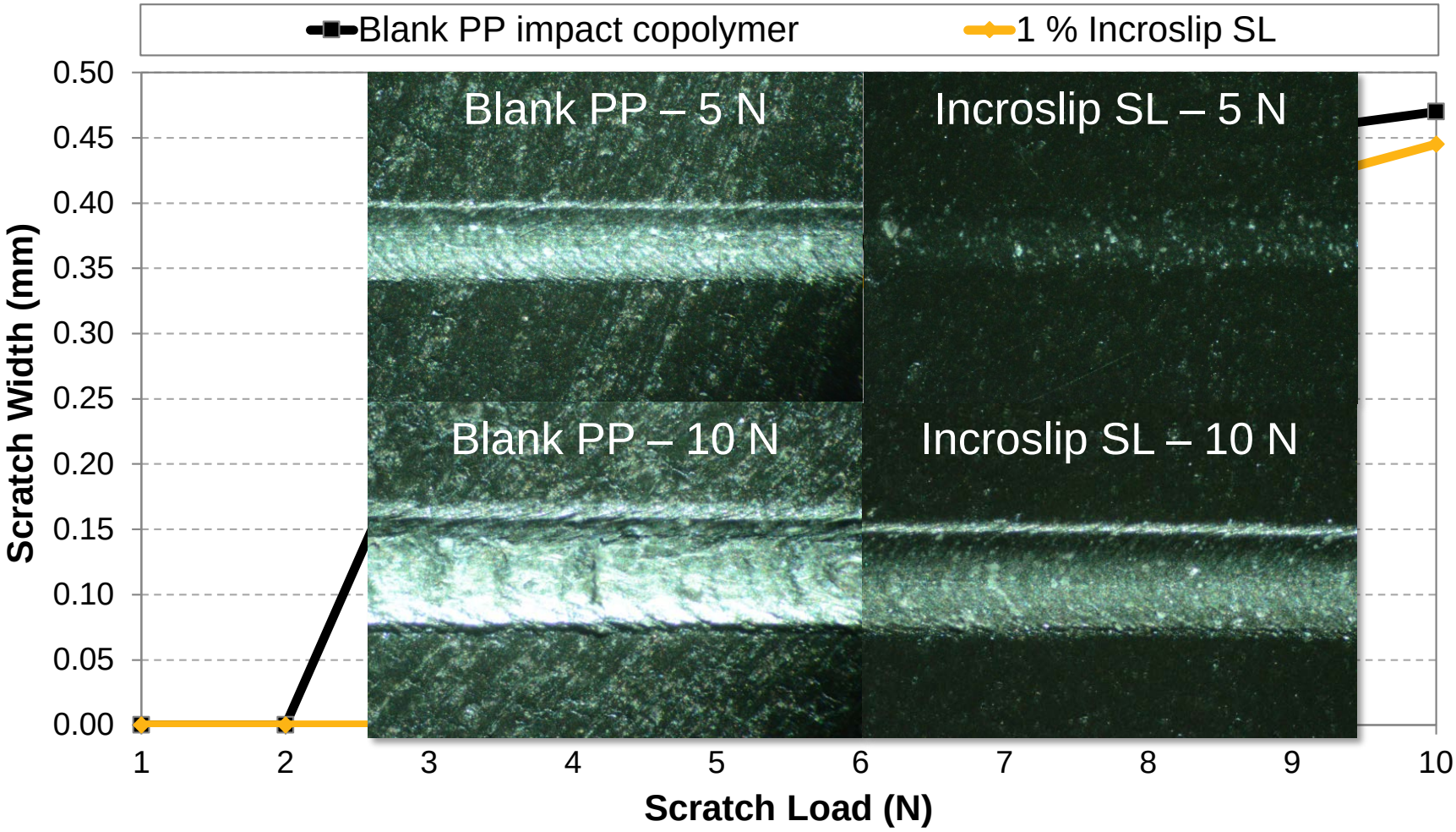
Reducing scratch width with Incroslip SL



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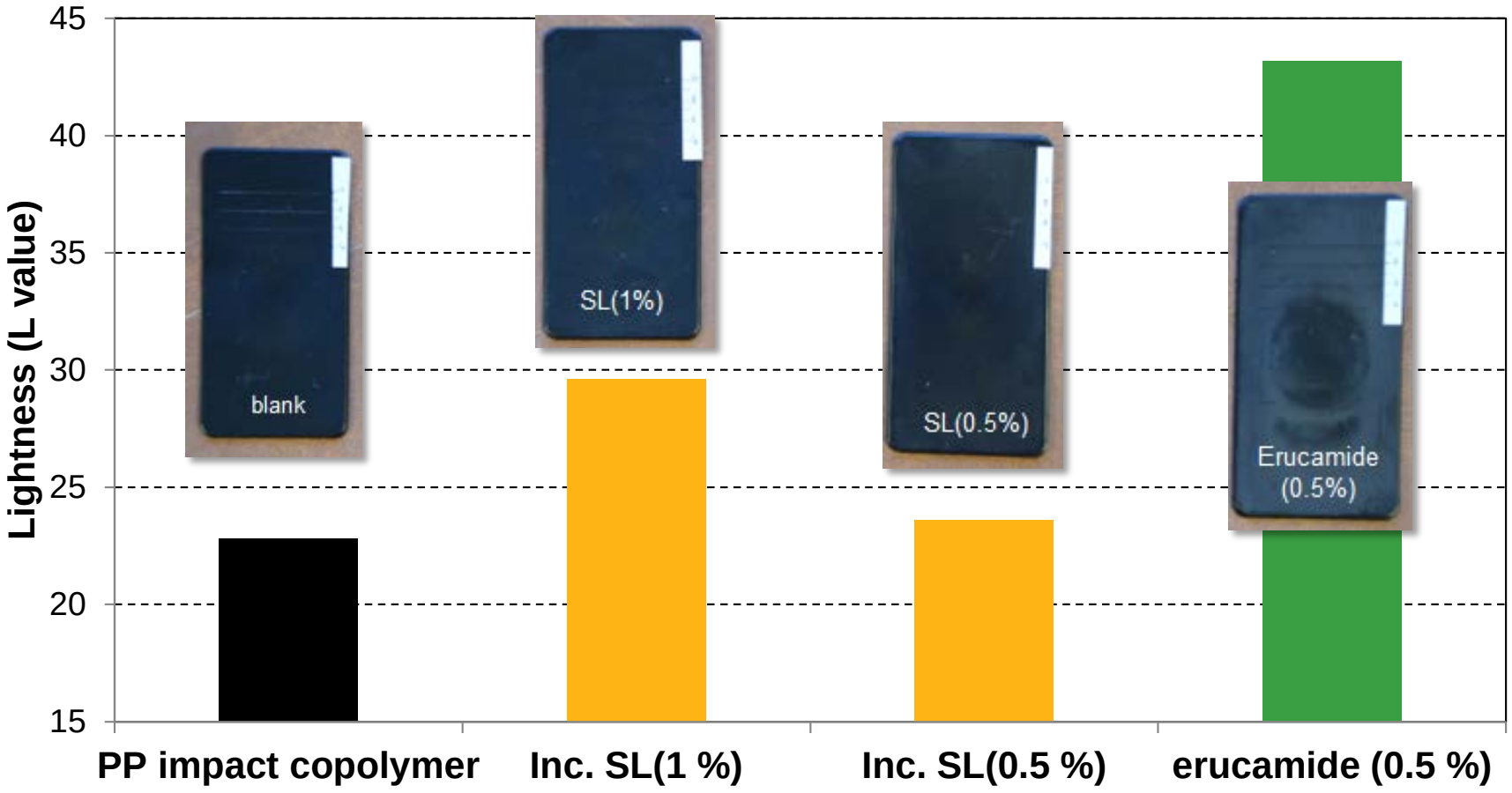
Reducing visible bloom with Incroslip SL



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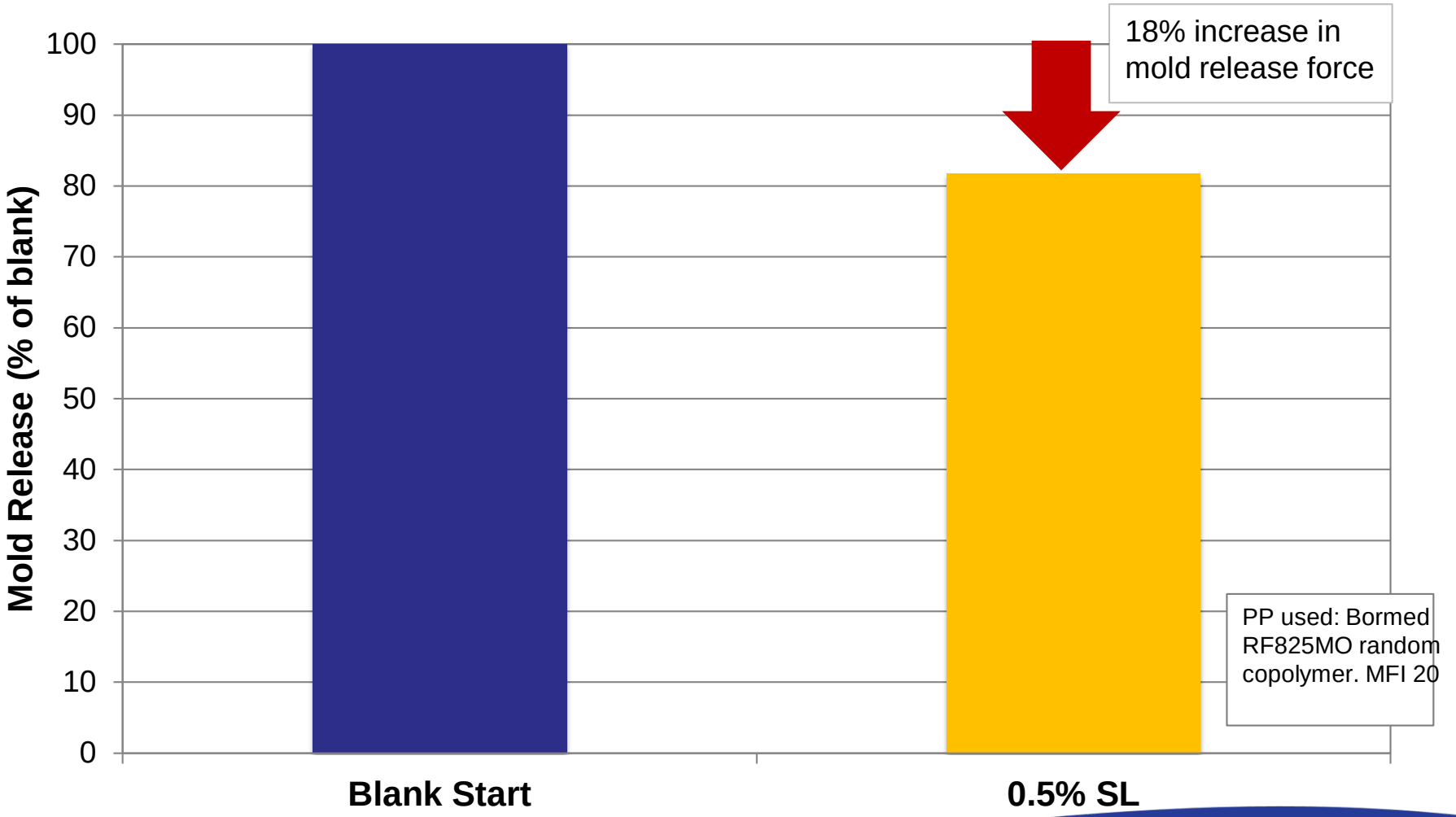
Mold release force of Incroslip SL

As a percent of blank PP after the residual forces have been subtracted



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Requirements for automotive molding

	Traditional Slip Additives	Incroslip SL
Cycle consistency	✓	✓
Process efficiency	✓	✓
Mold release	✓	✓
In use application (assembly/anti-squeak)	✓	✓
Low odour		✓
Scratch resistance	✓	✓
Low visible bloom		✓
Good and consistent colour		✓

Injection Molding - Packaging

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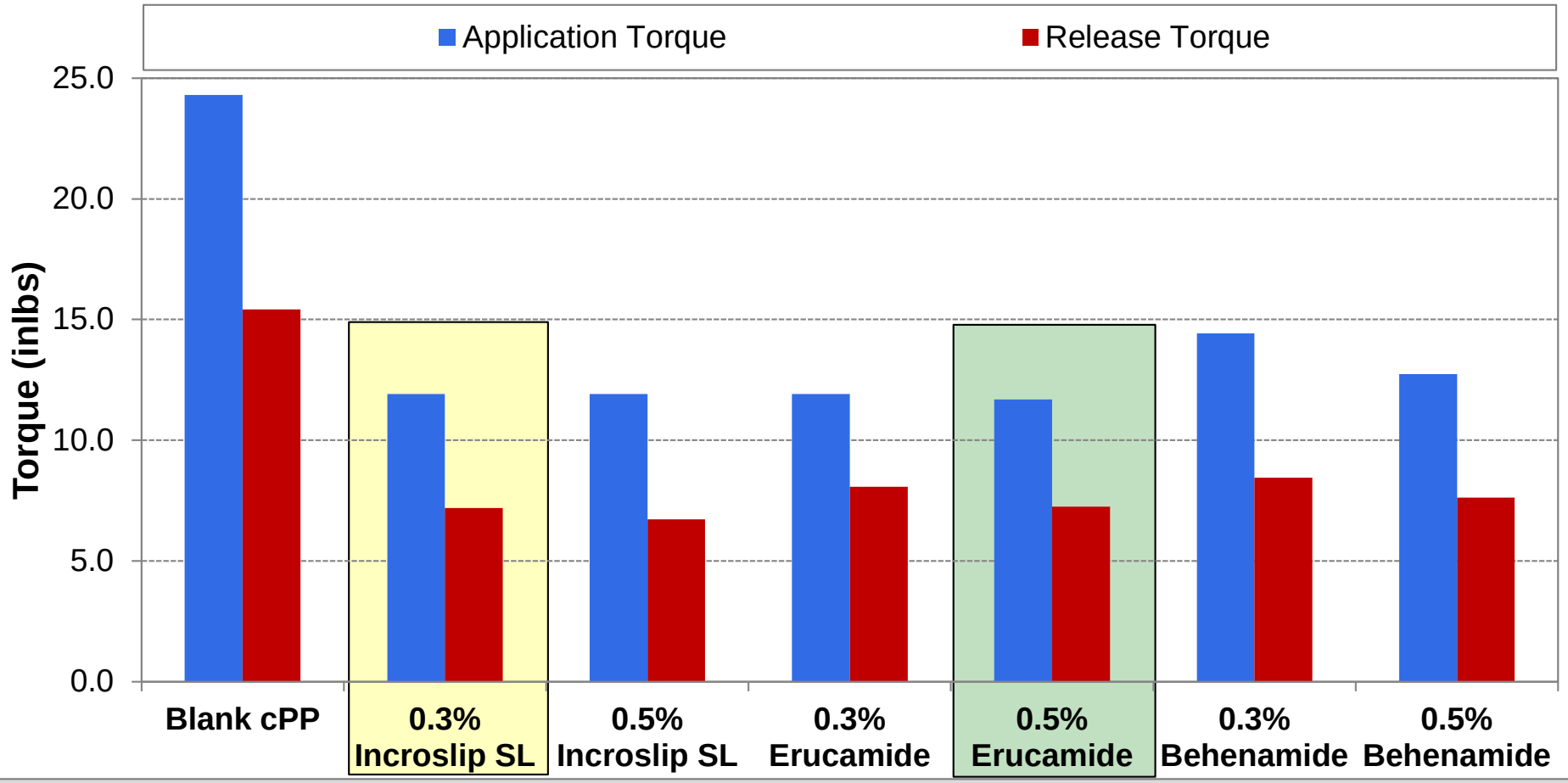
Torque release

Application and release forces of cPP closures on PET preforms (180° application)



0.3% Incroslip SL has a **better** release torque than 0.5% Erucamide

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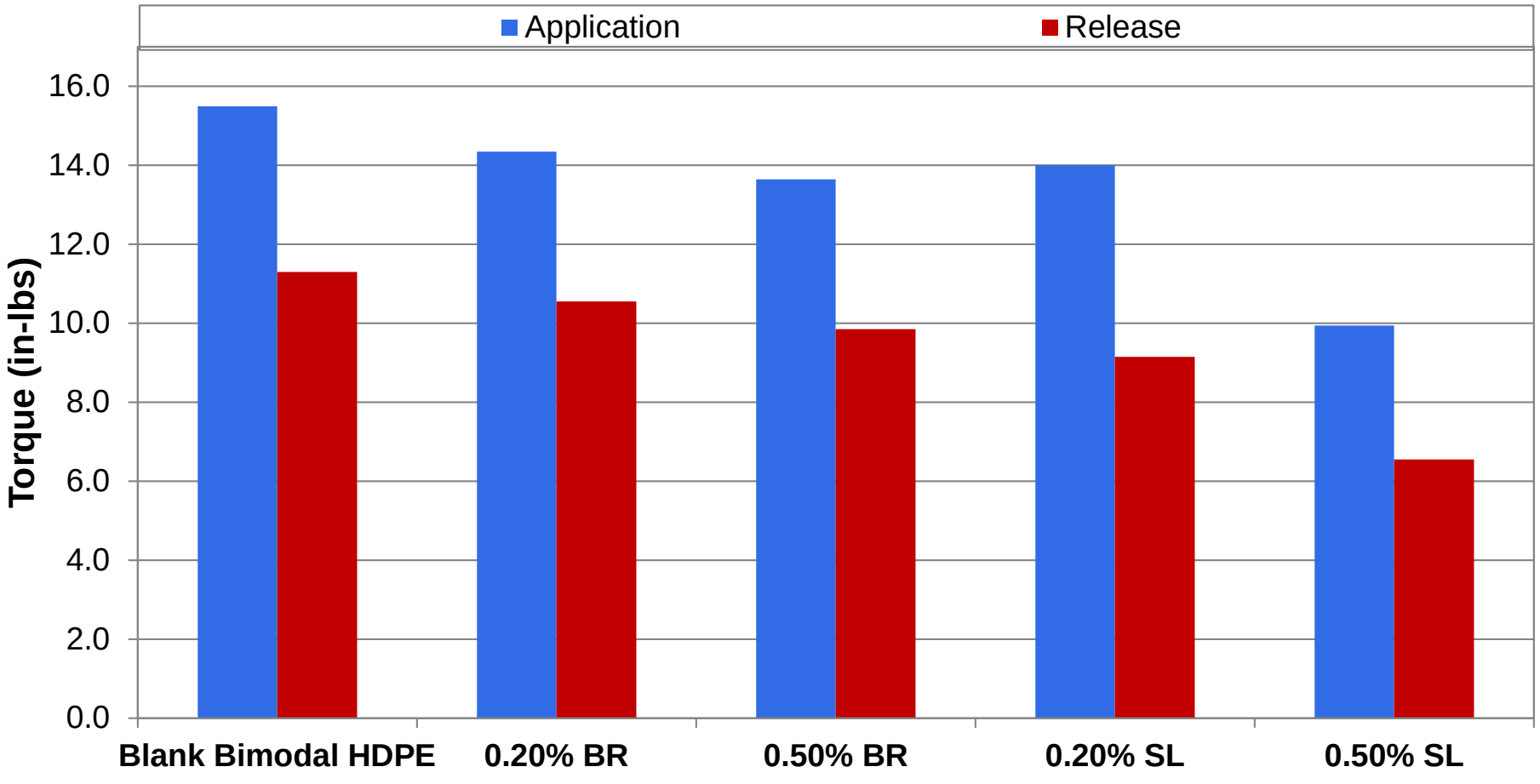
Torque release

Application and release forces of bimodal HDPE caps on PET preforms (90° application)



0.5% Incroslip SL gives an application torque release of 10 inch / lbs

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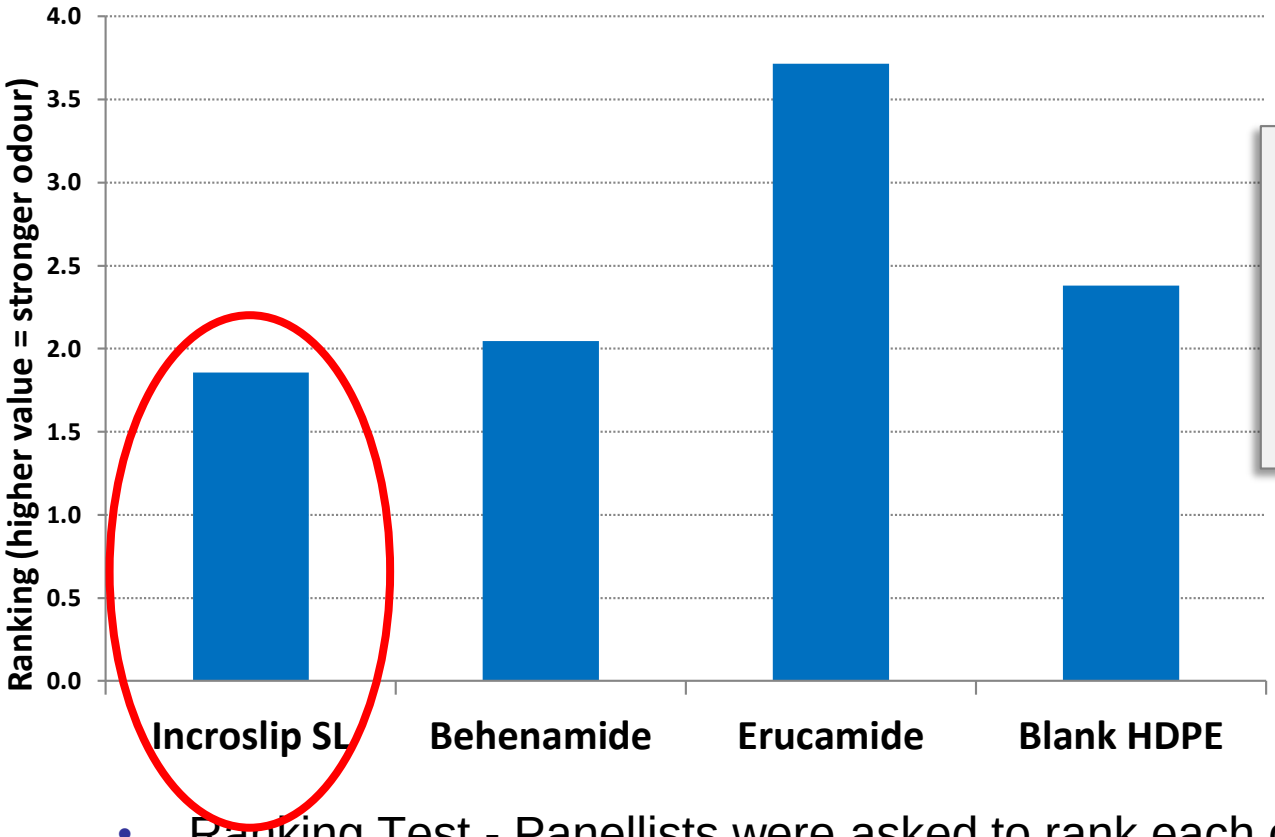
Odour Tests

Differences between Incroslip SL, erucamide & behenamide in HDPE compounds at 2000 ppm



Incroslip SL has the lowest odour when tested in a formulation

- Ranking Test - Panellists were asked to rank each of the four samples (blank, Incroslip SL, Erucamide & Behenamide) in order of least odour to most odour (1 = least odour, 4 = most odour)

Samples were aged in UV cabinet for 48 hours and sealed with lids.

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What is Needed in Packaging?

	Traditional Slip Additive	Incroslip SL
Torque release	✓	✓
Mold release	✓	✓
Low odour		✓
Low taste		✓
Stable under sterilisation	Some	✓
Scratch resistance	✓	✓
Low visible bloom		✓
Good and consistent colour		✓

Summary

- Traditional slip additives can breakdown and create problems for the end customers
- Incroslip SL does not breakdown and therefore will continue to deliver the performance you require
- Some of superior performance characteristics are:
  - Low influence on odour/colour
  - Low oxidation
  - CoF not influenced by oxidative degradation (stable slip)
  - Low visible bloom on storage
  - Improved scratch resistance
  - Mold release agent
  - Incroslip SL has better torque release than Erucamide in hPP
  - Incroslip SL does deliver torque release in HDPE but at higher levels

Thank you for listening!

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