

Additive Approaches to Improving Scratch and Mar Resistance In Automotive Polyolefins

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Abstract

The need for improved scratch and mar resistance for TPO's and other polyolefins used in automotive applications is well known. Incumbent technologies for antiscratch effect in automotive polyolefins have been briefly reviewed and an overview of the current test methods used throughout the world is presented. New additive technology solutions for scratch and mar resistance is introduced along with its performance test data.

Introduction

CIBA is a major supplier of plastic additives for automotive industry. Developmental work has been undertaken to further improve scratch and mar properties of automotive polyolefins. Comparative performance of the new developmental product indicates superior results. Problems such as exudation, stickiness, poor adhesion/paintability, and lack of permanence have been overcome.

It can be used for both interior and exterior applications.

Current Situation: Incumbent technologies

Improving the scratch resistance of PP and TPO remains a key unmet need in the automotive industry. (See Ref.1-4). Current technologies applied include:

1. Slip additives (e.g. erucamide)
2. Special fillers (e.g. wollastonite, nanoclays)
3. Siloxane additives
4. Substitute other polymers (e.g. PVC) for PP and TPO
5. Laminates
6. Coatings

None of the current solutions is completely satisfactory to the industry!

1. Slip additives

These additives act by lubricating the surface to provide an antiscratch effect, and also reduce scratch whitening. However, several disadvantages related to uncontrolled migration:

- Exudation on the surface of parts
- Stickiness after aging/weathering can be an issue
- Fogging (critical for interior applications)
- Poor paintability (partial paint applications & touch up)
- Poor adhesion (parts may be attached using adhesives)
- Effect is not permanent
- Weatherability is poor
- Stronger antiscratch effect is desired.

2. Special fillers

One of the most commonly used filler is Wollastonite. It provides better scratch resistance to TPO and PP vs. talc. However, Wollastonite has some limitations, e.g.,

- Higher cost vs. talc
- Difficult to incorporate during compounding due to high aspect ratio (must be fed downstream)
- Several grades of wollastonite-filled materials are available.

The other commonly used filler is based on Nanoclays. It also provides improved scratch resistance vs. talc but suffers from following limitations:

- Very high cost
- Not yet a mature and commercially viable technology
- Adopted in some low volume platforms to test.

3. Siloxane additives

Like the slip additives, these additives act by lubricating the surface to provide an antiscratch effect, and reduce scratch whitening. However, they require higher loading levels and have a higher effect price (>10x) vs. slip additives. Although, these additives are less migratory than slips, but still suffers from some of the same disadvantages:

- Poor paintability (partial paint applications & touch up)
- Poor adhesion (parts may be attached using adhesives)
- Effect is not permanent
- Stronger antiscratch effect is desired
- Not commercially successful to date.

4. Polymer substitution

Plastics such as PVC, PC/ABS, and ionomer have superior scratch resistance vs. PP and TPO. These products generally higher cost and have inferior weatherability vs. PP and TPO. PC/ABS can only be used in interior applications without painting! Furthermore, PVC is under environmental pressure due to problems with contamination of recycled components.

5. Laminates

Ionomer laminates and PVDF paint films eliminate conventional painting and provide excellent scratch resistance. But this solution imparts higher cost vs. molded-in-color PP and TPO. In-mold lamination process is complex, labor intensive, and has high scrap rates.

6. Coatings

This approach is considered to be the state of the art! Excellent scratch and mar resistance can be obtained with broad range of colors and visual effects. Furthermore, coatings can provide other effects:

- Gloss control
- Soft touch for interiors
- Chemical resistance (auto fluids, sunscreen, insect repellents, etc.)

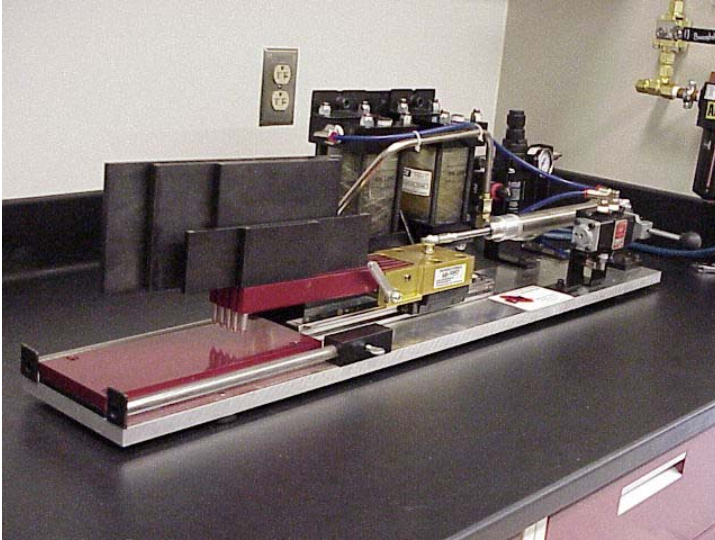
Coating are expensive, but equipment for painting already exists at OEM's and Tier 1's.

Negative effect on impact strength is a potential issue for some exterior applications (e.g. bumper fascia).

Overview of test methods

1. Ford 5- Finger Scratch Test

This test method is most commonly used test method in both Europe and North America. It was designed specifically to test plastic materials and to allow for quantifying either scratch or mar type damage. The Ford 5-finger test method is very adaptable to modification for higher loads or different radius scratch pins. The method is well suited as a tool to draw comparisons of damage resistance of different materials.



Visual inspection guidelines for using the Ford 5- Finger scratch test are given in the table (1) below.

Table (1)

Rating	Scratch Width	Whitening
1 (best)	<0.2 mm wide, almost invisible	None
2	0.2-0.3 mm wide, slight deformation, visible at close range	None
3	0.3-0.4 mm wide, clearly visible	Slight whitening in places
4	0.4-0.5 mm wide	Visible whitening over entire scratch
5 (worst)	>0.5 mm wide	White over entire scratch and sometimes accompanied by debris

2. Pencil Hardness Test

The test was originally designed for evaluation of coatings. The available pencil hardness for use with the gage is specified from softest to hardest.

– 6B, 5B, 4B, 3B, 2B, B, HB, F, H, 2H, 3H, 4H, 5H, 6H, 7H, 8H, 9H.

The test is conducted by applying the hardness gage to the part starting with highest hardness lead. If the surface is scratched, the next softest lead is applied until the lead, which crushes and does not scratch the surface is found. This lead type then becomes the pencil hardness value for the material.

3. Chrysler Crocking/ Ford Crocking

Both tests are mar-type damage resistance test. The Chrysler method consists of two devices, a crock meter, which applies marring action to the test piece, and a 20 degree gloss meter, which is used to compare before-and-after gloss levels of the test piece. In Chrysler test, the marring is accomplished by applying a thin film of ordinary household abrasive cleanser (Bon-Ami is the standard) to the test piece followed by placement in the crock-meter. The Ford test uses a polishing paper instead of the abrasive cleanser. The crock-meter, using a 9N normal load and a 16 mm diameter dowel, then applies 10 back and forth repetitions of rubbing a wool cloth across the test piece. The before and after 20 degree gloss readings are used to calculate mar resistance as a percentage retention of gloss. Results between Chrysler and Ford tests should not be compared.

New Developmental Product performance

New product is based on CIBA proprietary technology, it provides excellent scratch resistance to TPO and PP. Results indicate improved permanence of the effect. New developmental product provides solution to problems related to additive migration:

- Reduced exudation
- No stickiness after weathering
- Paintable

Benefits include ease of use:

- No special equipment (and added capital cost) required
- Potential exists for direct dosing during molding.

Experimental

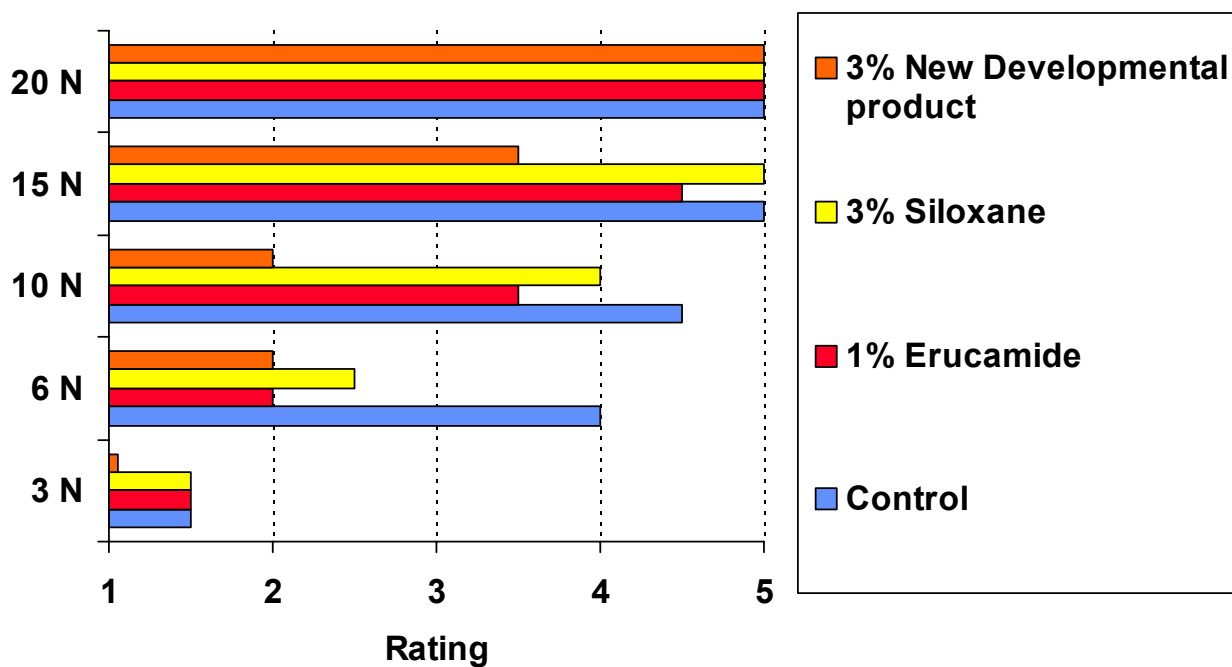
Substrate used was impact PP copolymer, containing talc and carbon black. Compounding was performed on a Leistritz twin-screw extruder. Injection Molding was done using a BOY50M Machine.

The following tests were conducted:

- Five finger scratch test
- Accelerated weathering
- High- speed impact
- Notched izod impact
- Contact angle

Figure (1) shows results obtained in 5-finger scratch test.

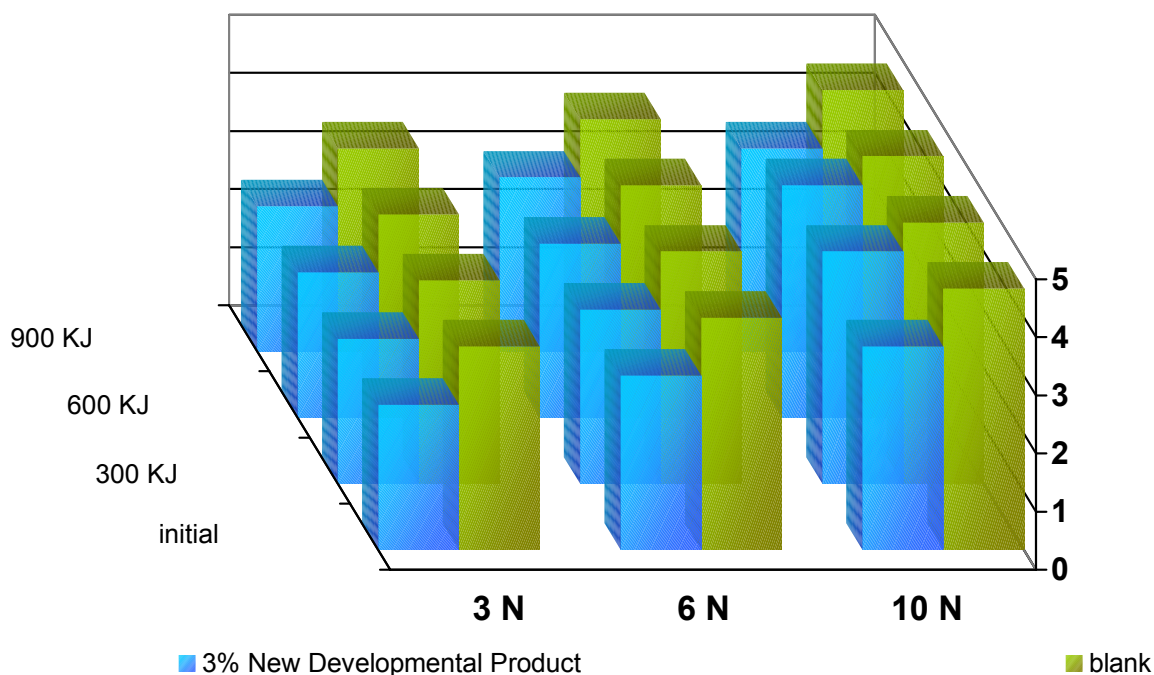
Figure (1)



The 5-finger scratch test results indicate that the new developmental product performs better than siloxane and erucamide up to 15 N. On the new developmental product, accelerated weathering data (using SAE J 1885 – NAFTA interior automotive protocol, 89°C black panel temperature, dry conditions) was also collected and is shown in Figure (2). Parts containing new additive still showed improved scratch resistance v/s the control after 900-kJ/m² exposure.

Figure (2)

Scratch test results after artificial weathering



Notched Izod impact test and High-speed impact test data obtained are given in Figure(s) (3) and (4) respectively. Both of these tests indicate no negative effect due to the use of the additives in comparison to the control. This may be due to efficient dispersability of the fillers in the polymer used.

Figure (3)
Notched Izod Impact Test Results

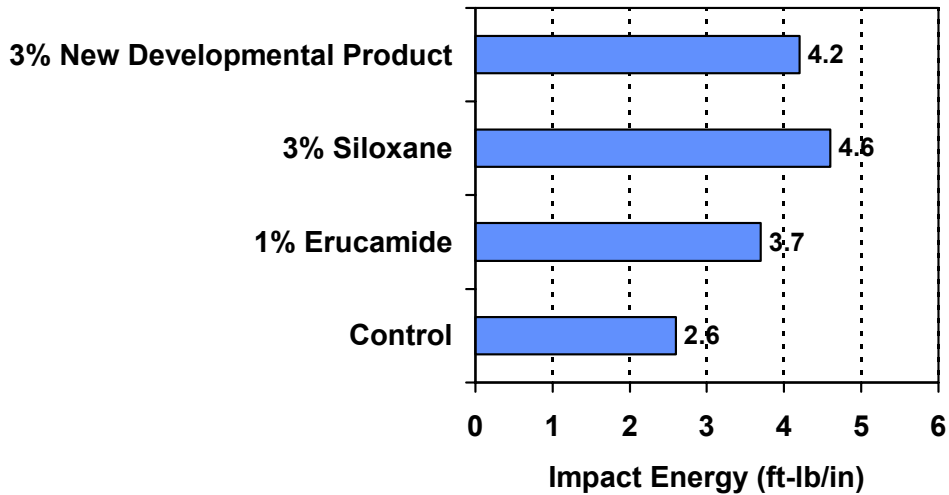
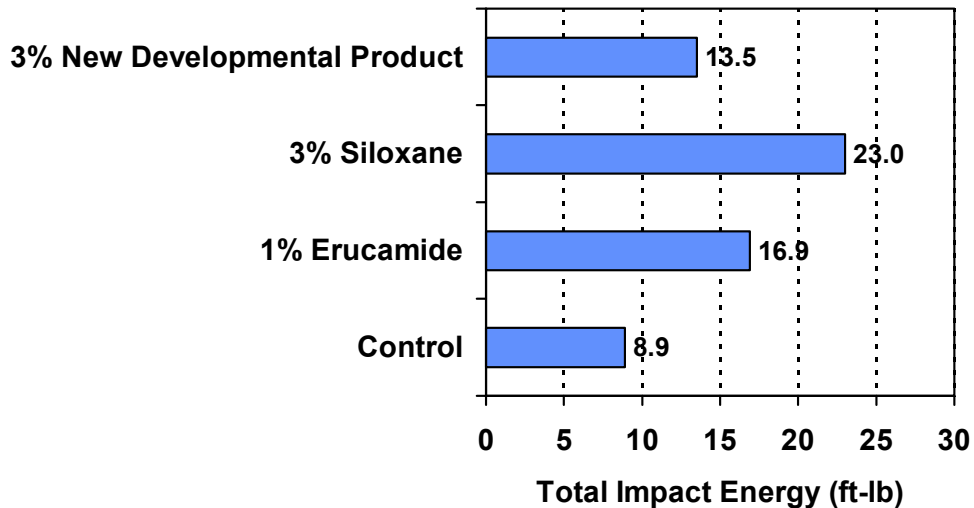


Figure (4) High Speed Impact Test Results



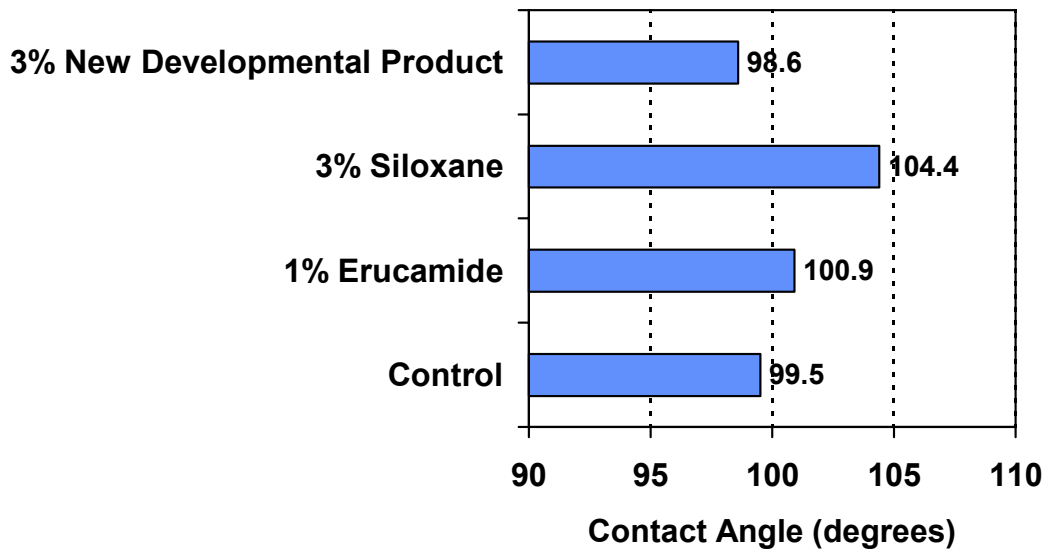
Paintability was also tested (Ref. 5). Paintability is needed to enable the manufacture of two-tone parts. The test plaques were painted using a standard water-borne urethane/acrylic coating and rated for wettability. New developmental product gave superior results vs. the standard scratch resistant grade. The painted plaques were also subjected to a paint adhesion test after thermal shock, the plaques containing new developmental product exhibiting excellent adhesion.

Table (2) below summarize the paintability results obtained.
 Table (2)

Formulation	Wettability Rating (10 best → 1 worst)
Control: Standard scratch resistant grade	4
Control: without scratch additives	10
2% New Developmental Additive	10
3% New Developmental Additive	9

Finally, contact angle test results (using ASTM D 724) of the samples tested are given in Figure (5).

Figure (5) Contact Angle Test Results



As the contact angle is a measure of wettability, lower contact angle is desirable. The new developmental product indicates good wettability in comparison to the control.

Key application areas suggested for the new CIBA developmental product are:

- Instrument panels: To eliminate migration issues associated with slip additives
- Interior trim
- Exterior trim: For examples: Body side moldings, wheel flares, and cladding
- Bumper fascia: The product meets weatherability requirements and has permanence of effect.

Conclusions

Addition of new CIBA developmental product at 3% loading improves the scratch resistance of the tested polymer. The scratch resistant improvement is visible in the range from 3 N to 15 N. In talc filled PP Copolymer, the new developmental product gives better competitive performance. For paintability, new developmental product gave superior results vs. the standard scratch resistant grade. New product demonstrates permanence of performance upon weathering. No negative effect on physical properties such as impact.

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