NEW NANO-SILICA POLYETHER UV CURABLE RESINS FOR AUTOMOTIVE APPLICATIONS

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SAE INTERNATIONAL

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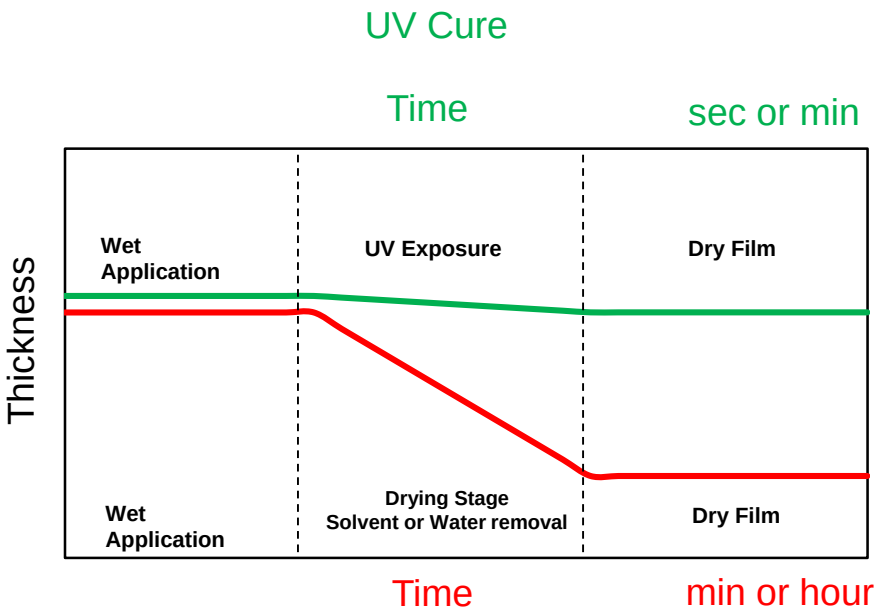
We create chemistry

UV Curable Coatings



Advantages

- ❑ 100% solid system → lowest VOC consumption
- ❑ Low energy consumption for curing process
- ❑ Very short curing time → enables direct handling of cured substrate (sanding, packaging, …)
- ❑ Less space required than conventional coatings
- ❑ Best economical / ecological relation

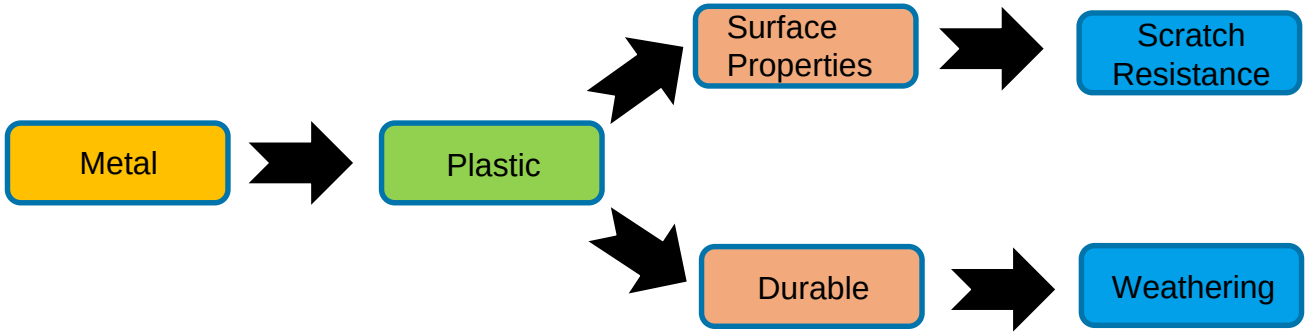
UV Curing in Automotive Coating

Headlight & Tail light

Refinish

Interior

Trend in Automotive Market



Scratches can be caused by……

Coating failures can also be caused by ……

To Improve Scratch and Weather Resistance

Improve Scratch Resistance

Crosslinking	Shrinkage and Brittleness
Nanoparticles	Transparency, Large Surface Area
Inorganic Fillers	High Viscosity, Loss of Transparency

Mohs Hardness	Material
1	Talc
2	Calcium
4	Iron
7	**Silica**
9	Alumina

Inexpensive
Commonly used
Hard
Similar RI to resins

Improve UV Durability

UV Absorbers (UVA) + HALS → Synergistic Effect

BASF Nano-Silica Product

Physical Properties	BASF Product	Competitor Product
Chemistry	Polyether acrylate containing **50% nano-silica**	Aliphatic urethane acrylate nanocomposite
Viscosity (cps) @ 25 ^{o}C	**1,500**	9,500
Functionality	1.5	3

BASF Product

- **Sprayable** with incorporating small amount reactive diluents
- Use with **other radiation-curable resins** to formulate UV coatings

Formulations

	Experimental Formulations	Silica+/ TMPTA	Silica-/ TMPTA	Silica+/ HDDA	Silica-/ HDDA	PO/ TMPTA	Competitor/ TMPTA	Competitor/ HDDA
Oligomer	BASF PO Acrylate Nano-Silica	46.9	31.3	46.9	31.3			
	BASF Aliphatic Urethane Acrylate	15.6	31.3	15.6	31.3			
	BASF PO Acrylate					62.5		
	Competitor						62.5	62.5
Monomer	TMPTA	30	30			30	30	
	HDDA			30	30			30

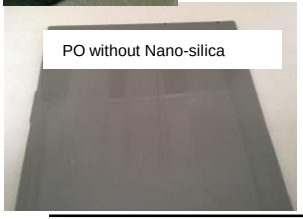
Additive Package Used in Formulations

UVA	2
HALS	1
Photoinitiator	4
Leveling agent	0.5

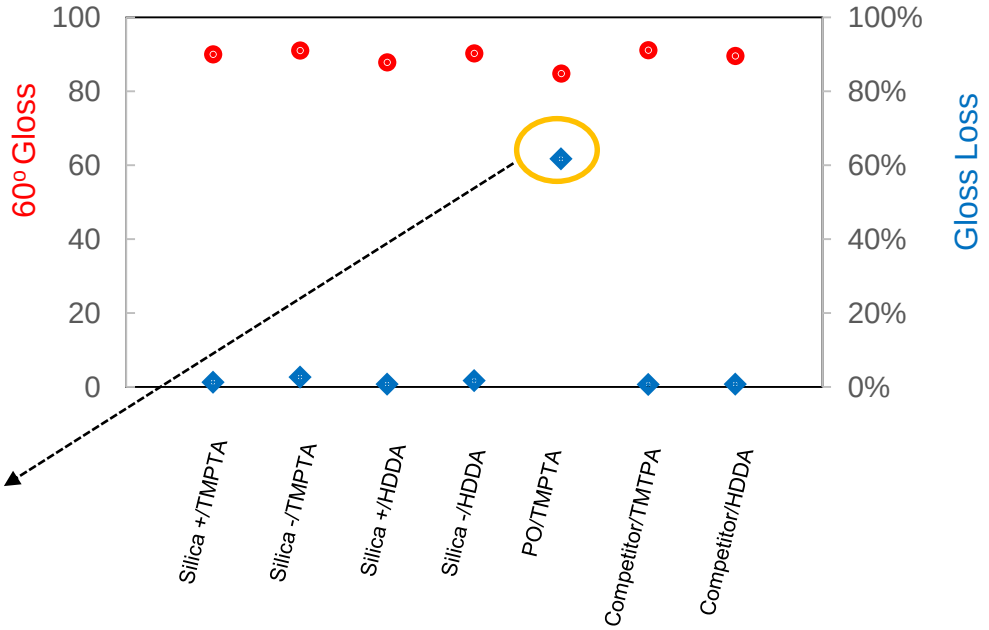
- Weathering, scratch resistance, adhesion were evaluated
- Cured by 120 W/cm Gallium-Indium doped Hg lamp
- Substrate: Polycarbonate

Scratch Resistance

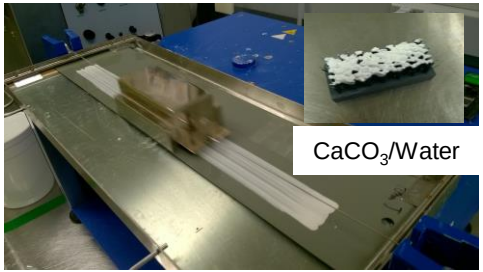
Dry Scratch Resistance



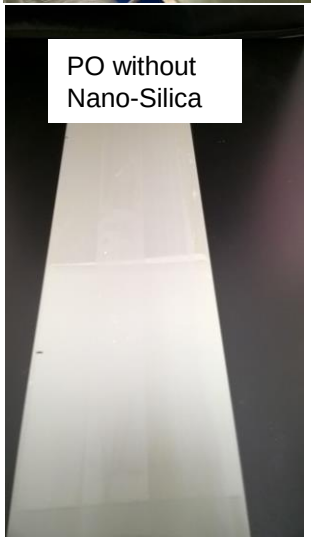
- Substrate: Polycarbonate
- Coating Thickness: 0.8 mil
- New Ford test method to evaluate micro-scratching resistance

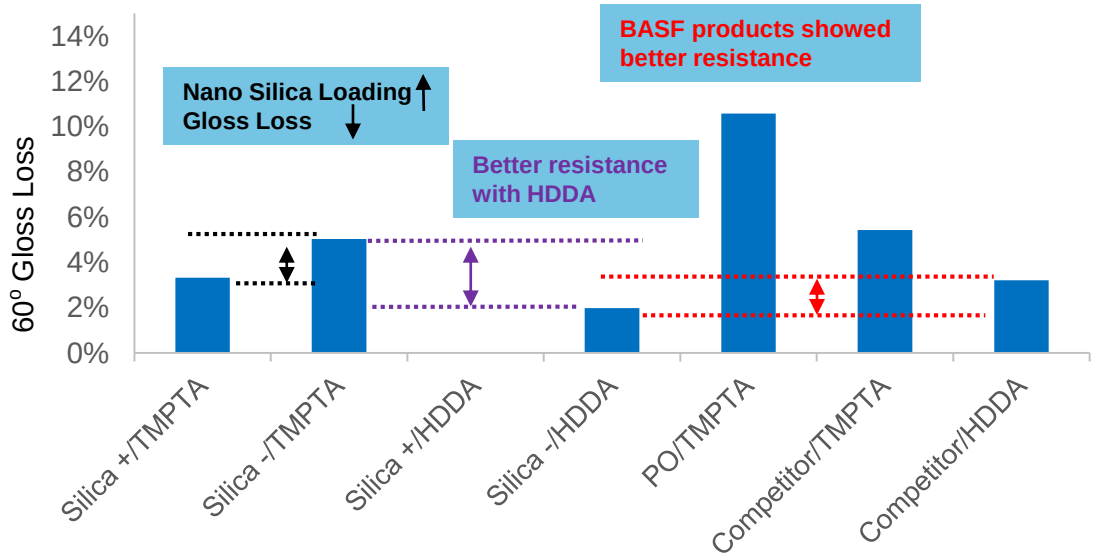


Wet Scratch Resistance (Erichsen Car Wash)

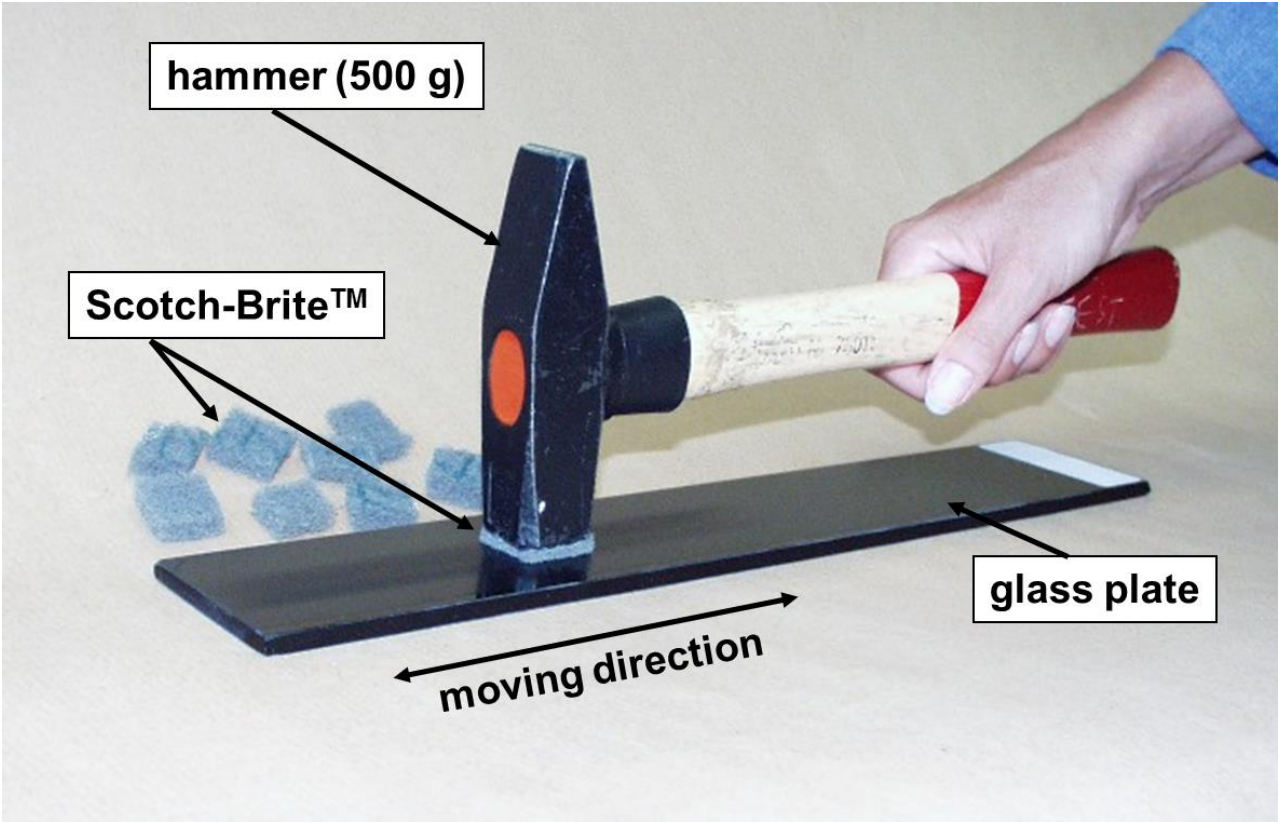


- Substrate: Baked Cold Roll Steel
- Coating Thickness: 1.5 mil
- Cycle: 200 times
- Method obtained from BASF Coating group



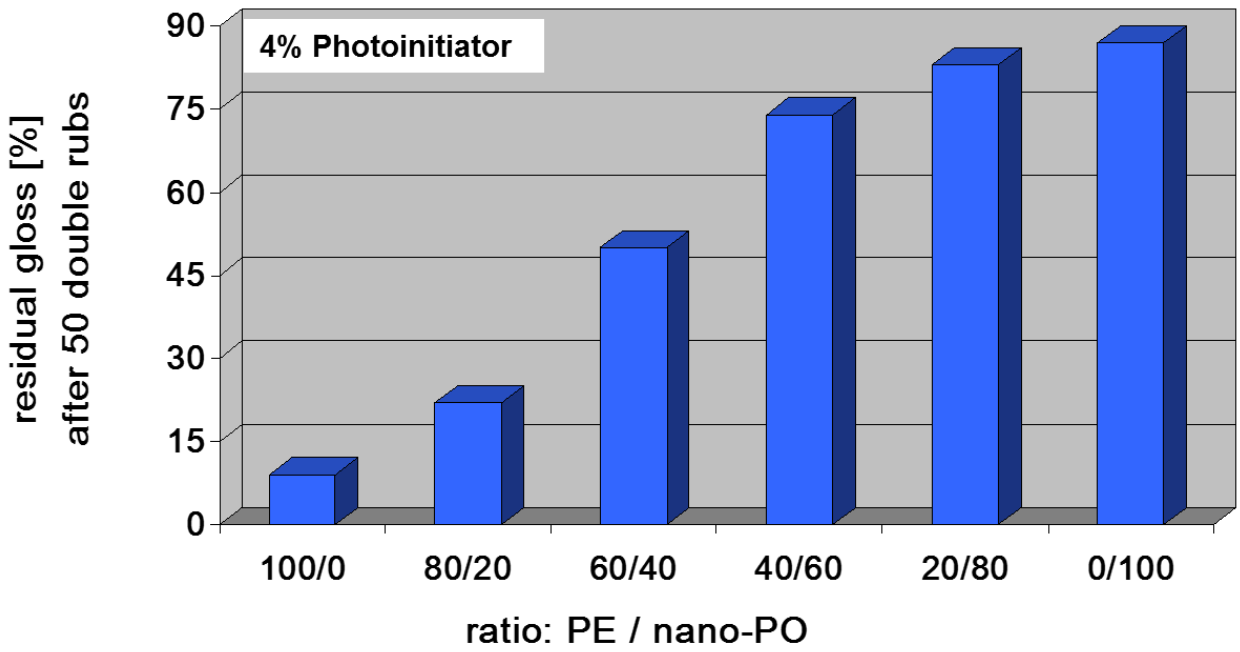


Scratch Resistance: Hammer Test



Influence of Nano Scaled Silica

Hammer (500g) / Scotch-Brite™ Test



Weathering Resistance

Weathering Resistance

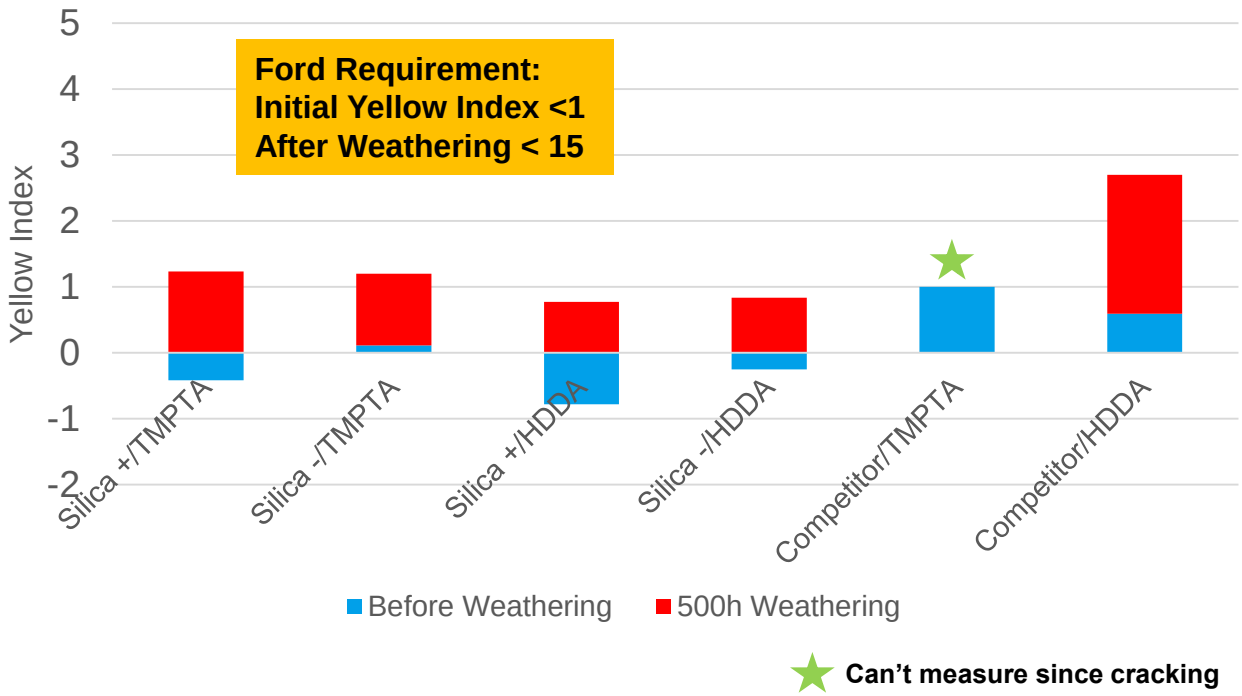
- **Xenon Testing –** SAE J2527 (previously SAE J1960 or CAM 180)
- **Substrates**

1. Polycarbonate (Grey)
2. Polycarbonate (Clear)

- **Extended UV filters (Quartz/Boro) –** significant short wavelength UV exposure.
- **Cycles –** 60 mins Dark + Spray → 40 mins light → 20 mins light + Spray → 1 hour light
- Followed Ford Weathering Specification for exterior coating.

Weathering Resistance

Yellow Index defined by ASTM 1925



Weathering Resistance

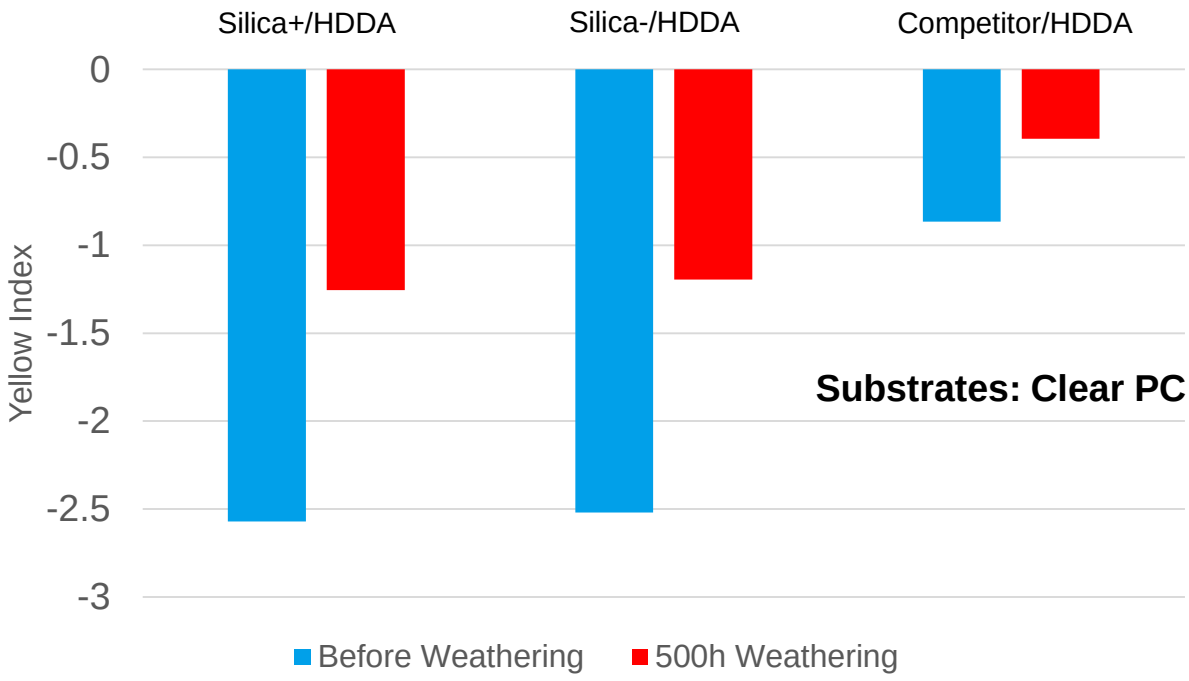
Formulation	Visual
Silica +/TMPTA	Cracking
Silica -/TMPTA	Good
Silica +/HDDA	Good
Silica -/HDDA	Good
Competitor/TMPTA	Cracking
Competitor/HDDA	Cracking

Same Formulation coated on Clear PC

- Pigmented PC absorbed light and transferred to heat, which caused the cracking of higher crosslinking density coatings.
- Coating on Clear PC substrates didn't show any cracks.

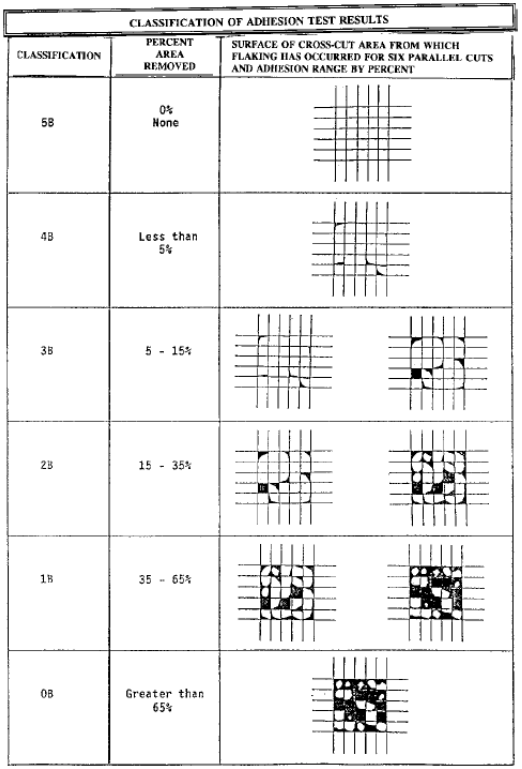
Weathering Resistance

- All coated Clear PC samples had Yellow index< 1.
- **All samples are still under weathering.**



Other Properties

Adhesion to Polycarbonate



CLASSIFICATION OF ADHESION TEST RESULTS

CLASSIFICATION	PERCENT AREA REMOVED	SURFACE OF CROSS-CUT AREA FROM WHICH FLAKING HAS OCCURRED FOR SIX PARALLEL CUTS AND ADHESION RANGE BY PERCENT
5B	0% None	
4B	Less than 5%	
3B	5 - 15%	
2B	15 - 35%	
1B	35 - 65%	
0B	Greater than 65%	

Adhesion Test ASTM D 3359 Method B

- Substrate: Polycarbonate
- Coating thickness: 0.8 mil
- Ford Specification for exterior coating: **4B or above**

Formulation	Result
Silica +/TMPTA	3B
Silica -/TMPTA	5B
Silica +/HDDA	5B
Silica -/HDDA	5B
PO/TMPTA	5B
Competitor/TMPTA	0B
Competitor/HDDA	5B

- Better adhesion with HDDA
- Nano-silica slightly affected the adhesion
- BASF products had better adhesion than competitor products

Taber Abrasion

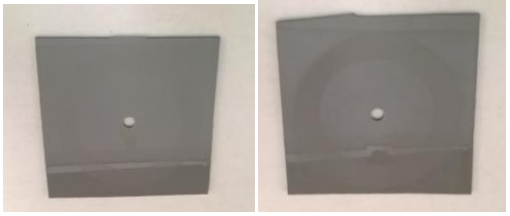
Test Method

- Substrate: Polycarbonate
- Coating thickness: 1.2 mil
- Ford specification: 500 g loading, 300 Cycle, CS-10 abraser

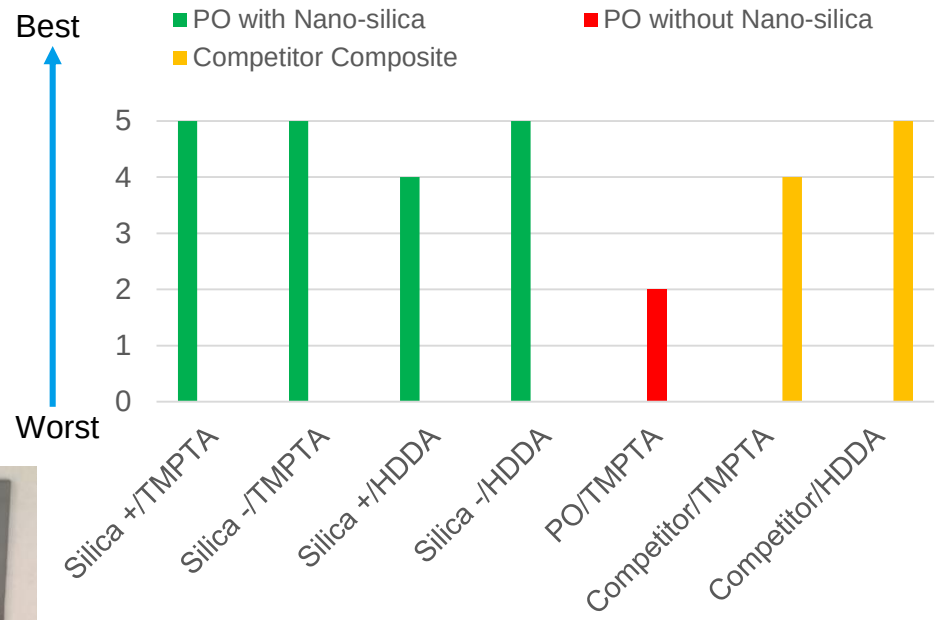
Result

- Coating weight loss < 0.5%
- Evaluate the coating surface by mar

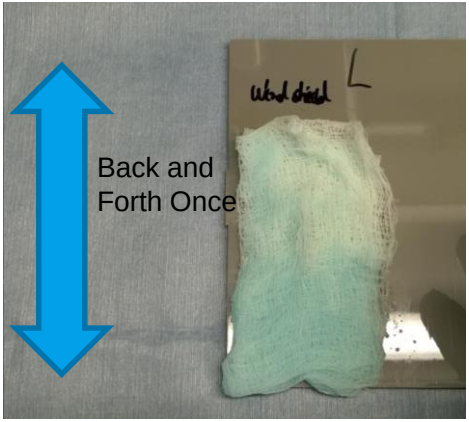
Silica +/HDDA **PO/TMPTA**



Visual Evaluation



Chemical Resistance



Test Fluids: Motor Oil, Tar Remover, Windshield Washer Fluid, Antifreeze based on Ford specification

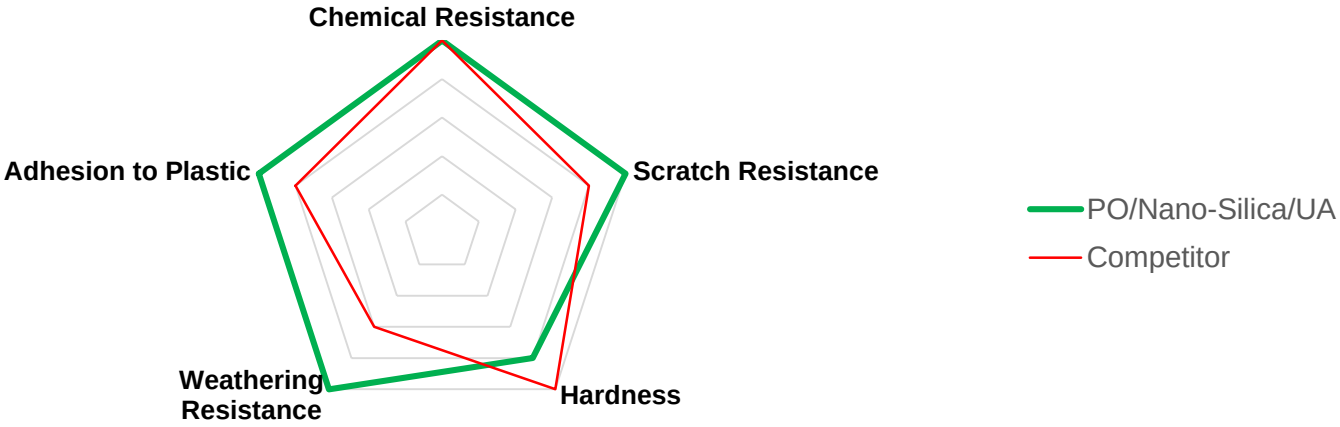
Visual Evaluation Worst 1 → 5 Best

	Motor Oil	Tar Remover	Windshield Fluid	Antifreeze
Silica +/TMPTA	5	5	5	5
Silica -/TMPTA	5	5	5	5
Silica +/HDDA	5	5	5	5
Silica -/HDDA	5	5	5	5
PO/TMPTA	4	3	3	3
Competitor/TMPTA	5	5	5	5
Competitor/HDDA	5	5	5	5

- Most of the sample showed good chemical resistance
- No Crackings, Gloss loss, Stain were observed

Summary

- BASF Nano-sized silica products
  - Scratch resistance improved with incorporating small amount of Nano-Silica Resin
  - Low viscosity, good for spray application
- Formulation with HDDA had better adhesion, weathering resistance
- Formulation with TMPTA had better hardness
- A good fit for Automotive interior and exterior applications



Acknowledgement

We would like to thank

Dan Waldon, David Law and Sean Riley

BASF Corporation, 24710 W. Eleven Mile Road, Southfield, MI 48033

for sharing the test methods and test equipment.

Thank you for your attention!

Questions?

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