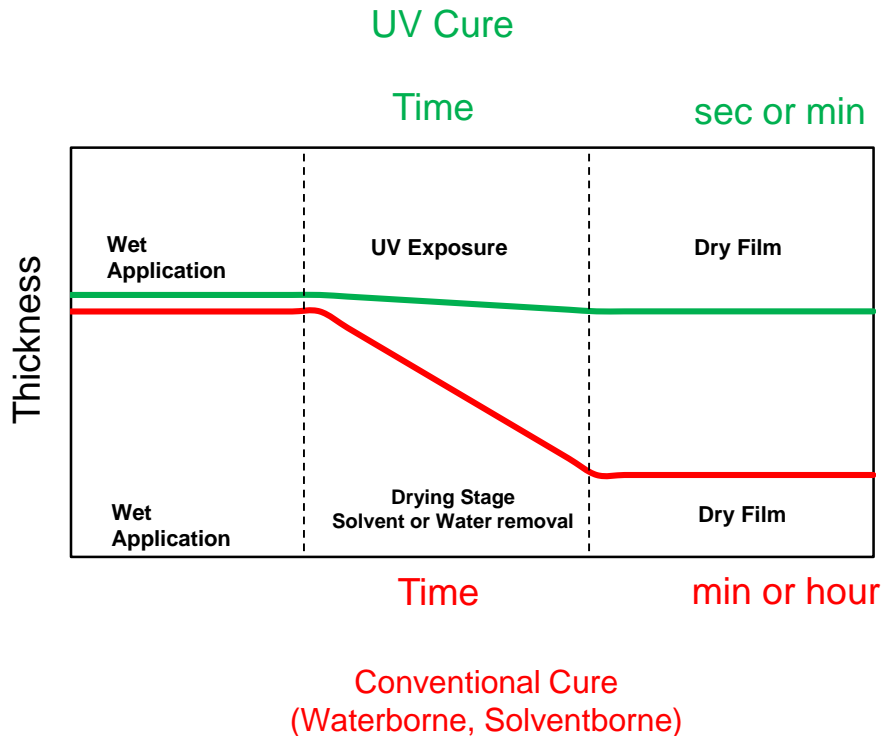


# NEW NANO-SILICA POLYETHER UV CURABLE RESINS FOR AUTOMOTIVE APPLICATIONS

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# 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



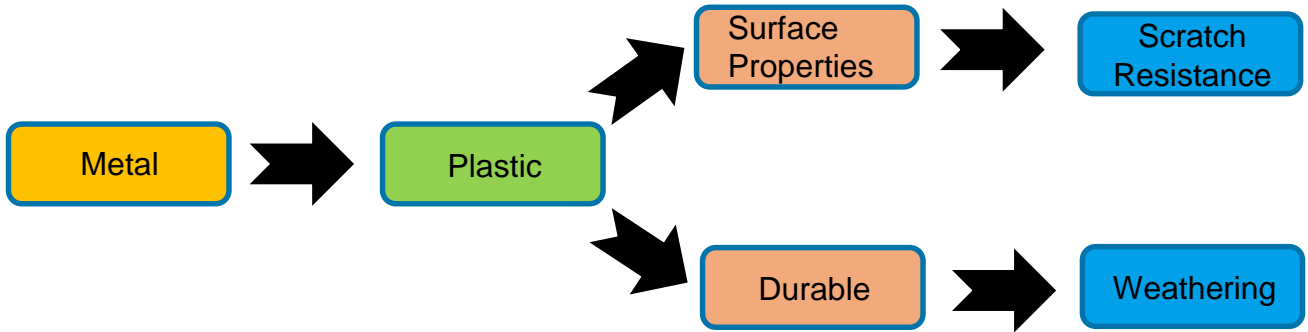
Refinish



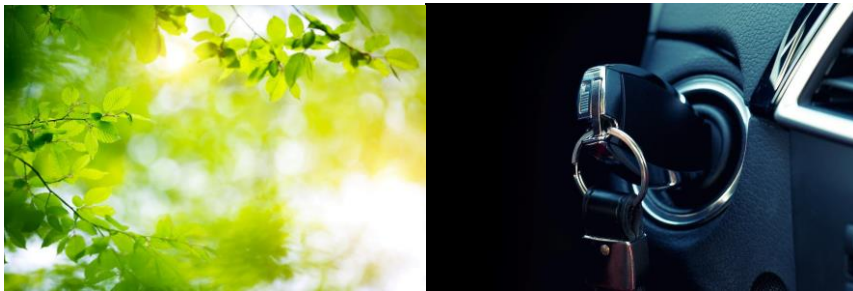
Interior



# 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	<b>Silica</b>
9	Alumina

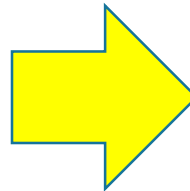
Inexpensive  
Commonly used  
Hard  
Similar RI to resins

## Improve UV Durability

UV Absorbers (UVA)



HALS



Synergistic Effect

# BASF Nano-Silica Product

Physical Properties	BASF Product	Competitor Product
Chemistry	Polyether acrylate containing <b>50% nano-silica</b>	Aliphatic urethane acrylate nanocomposite
Viscosity (cps) @ 25 °C	<b>1,500</b>	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 Competitor					62.5	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

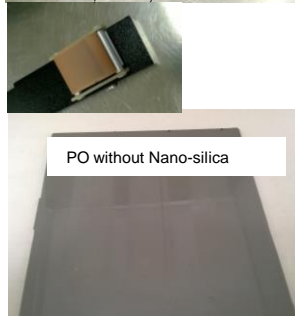
# Scratch Resistance



# Dry Scratch Resistance

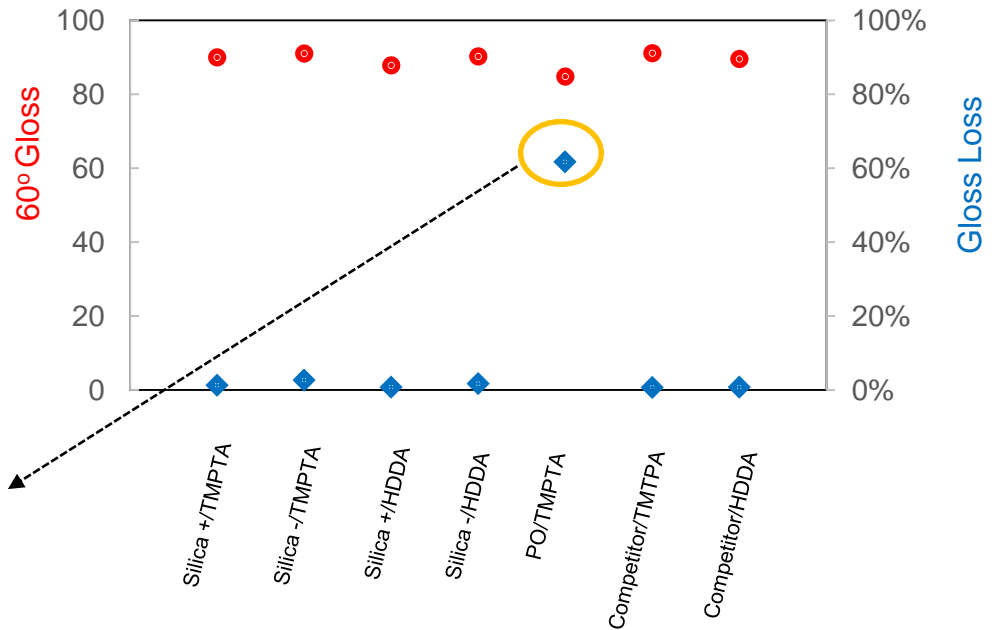


Crockmeter

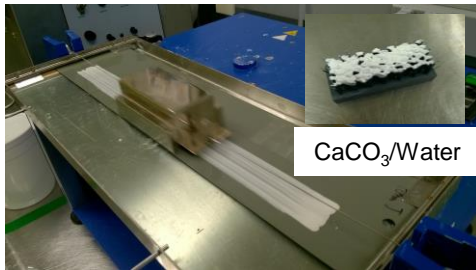


PO without Nano-silica

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



# Wet Scratch Resistance (Erichsen Car Wash)

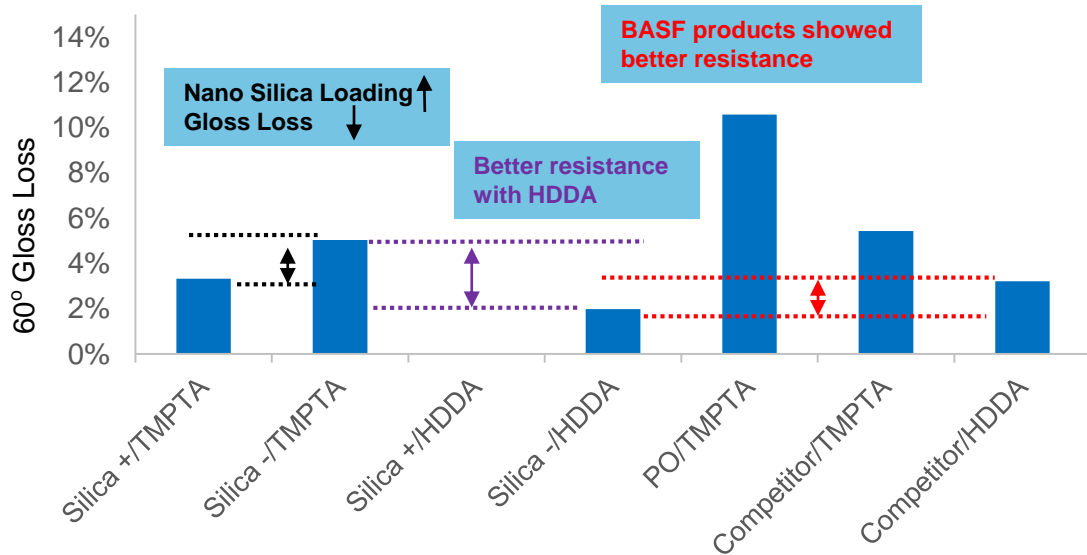


CaCO<sub>3</sub>/Water

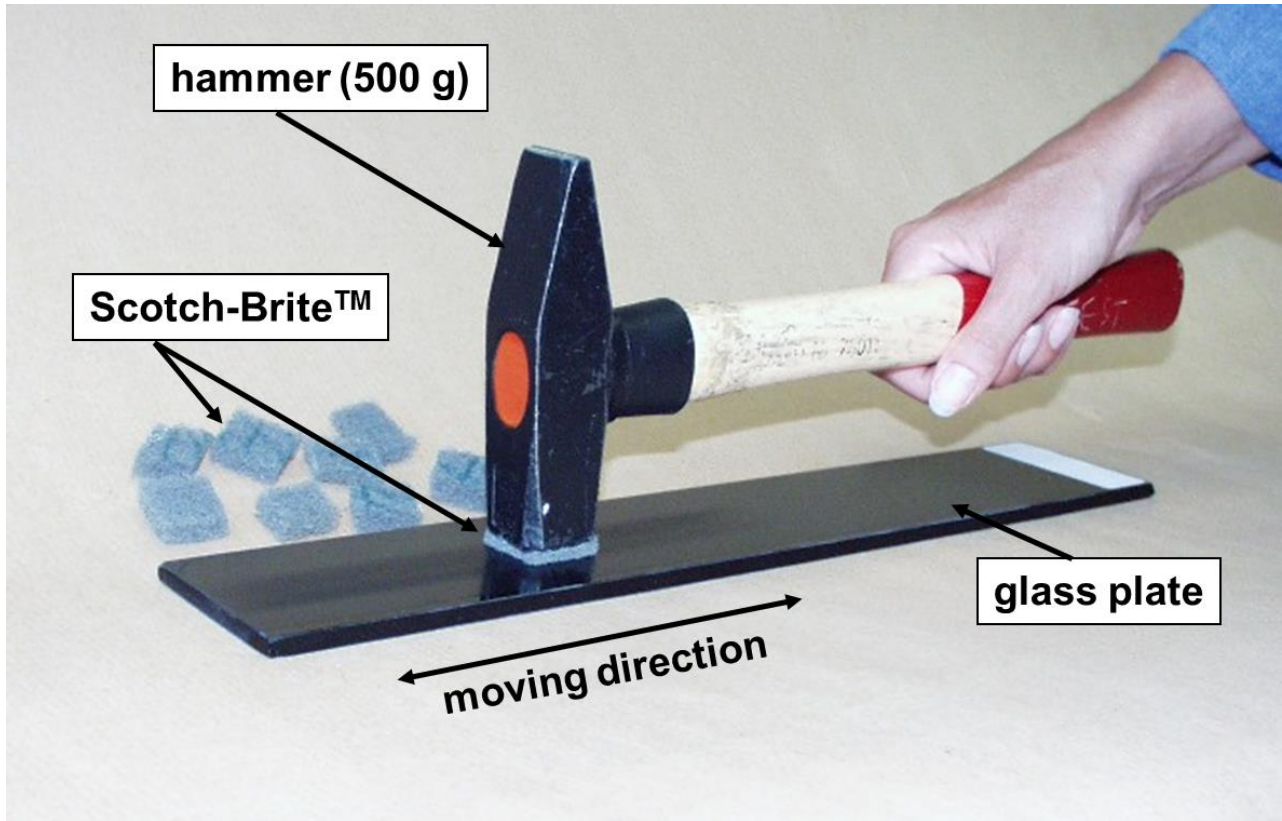
- Substrate: Baked Cold Roll Steel
- Coating Thickness: 1.5 mil
- Cycle: 200 times
- Method obtained from BASF Coating group



PO without Nano-Silica

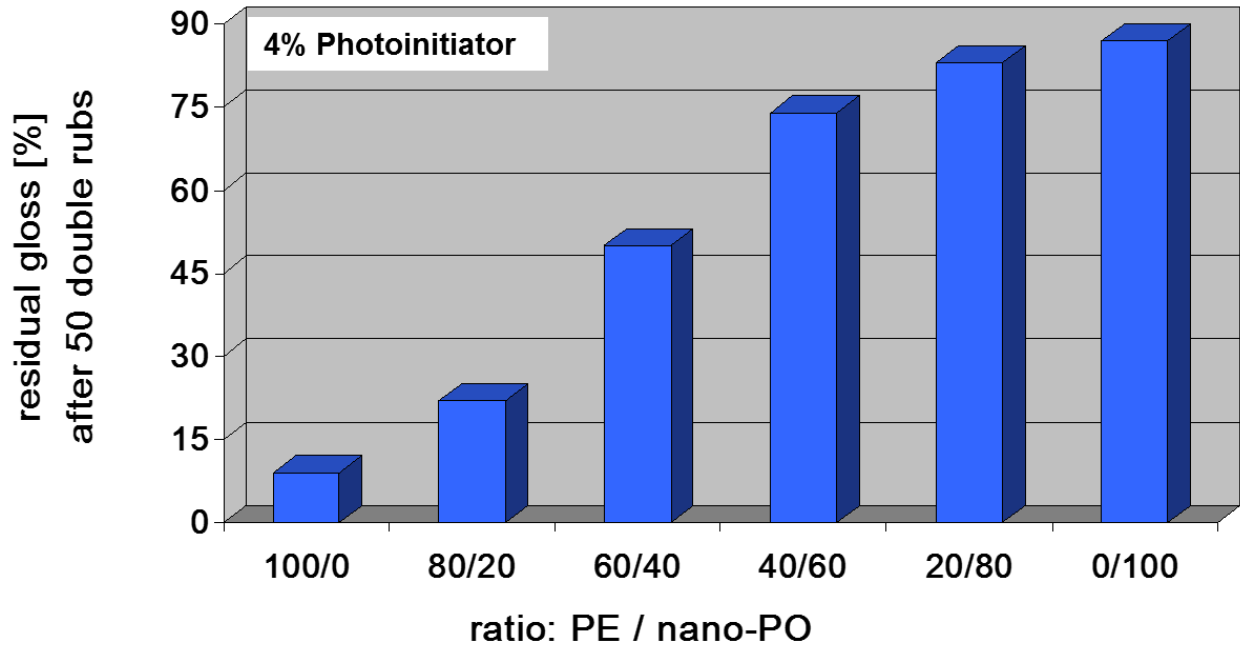


# Scratch Resistance: Hammer Test



# Influence of Nano Scaled Silica

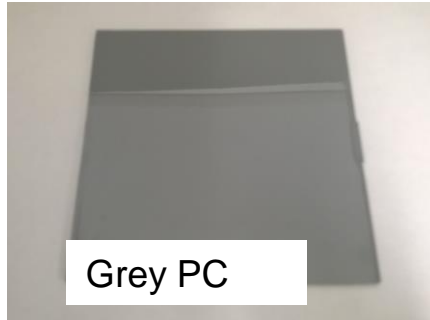
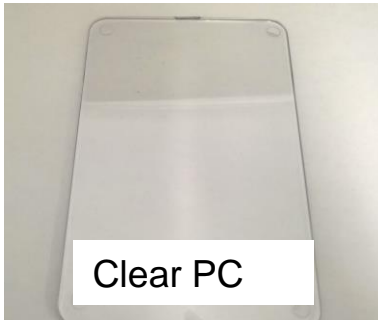
Hammer (500g) / Scotch-Brite™ Test



# Weathering Resistance

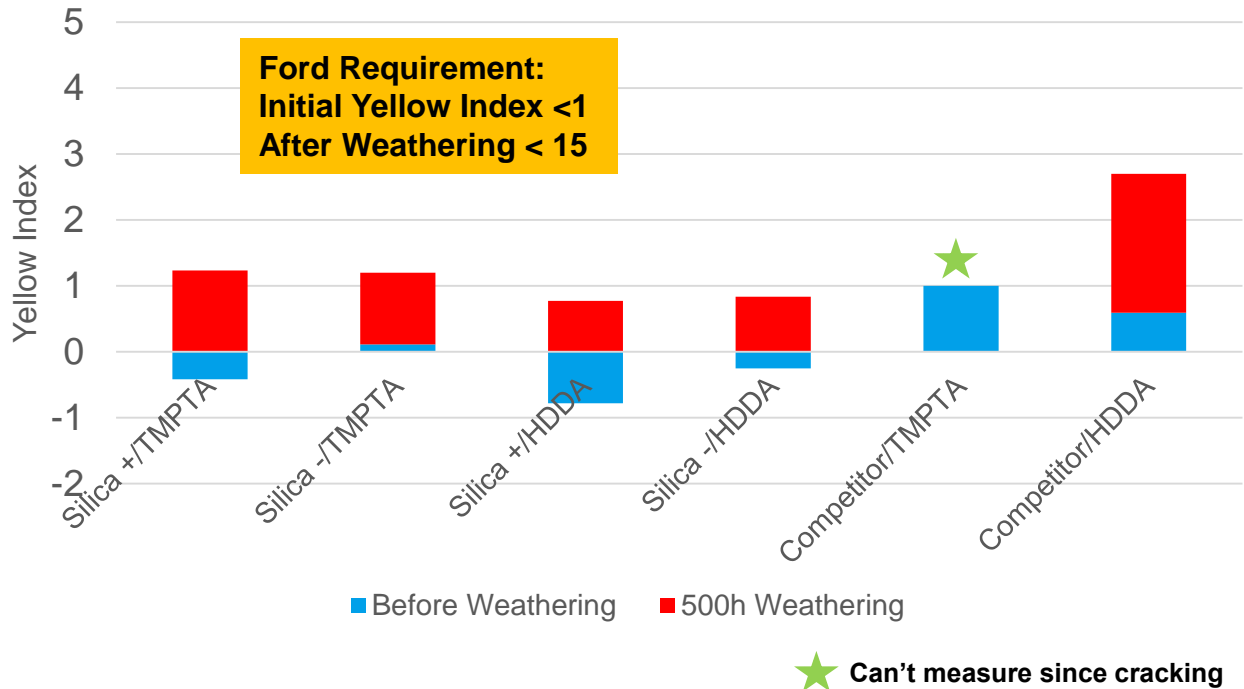
# Weathering Resistance

- **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



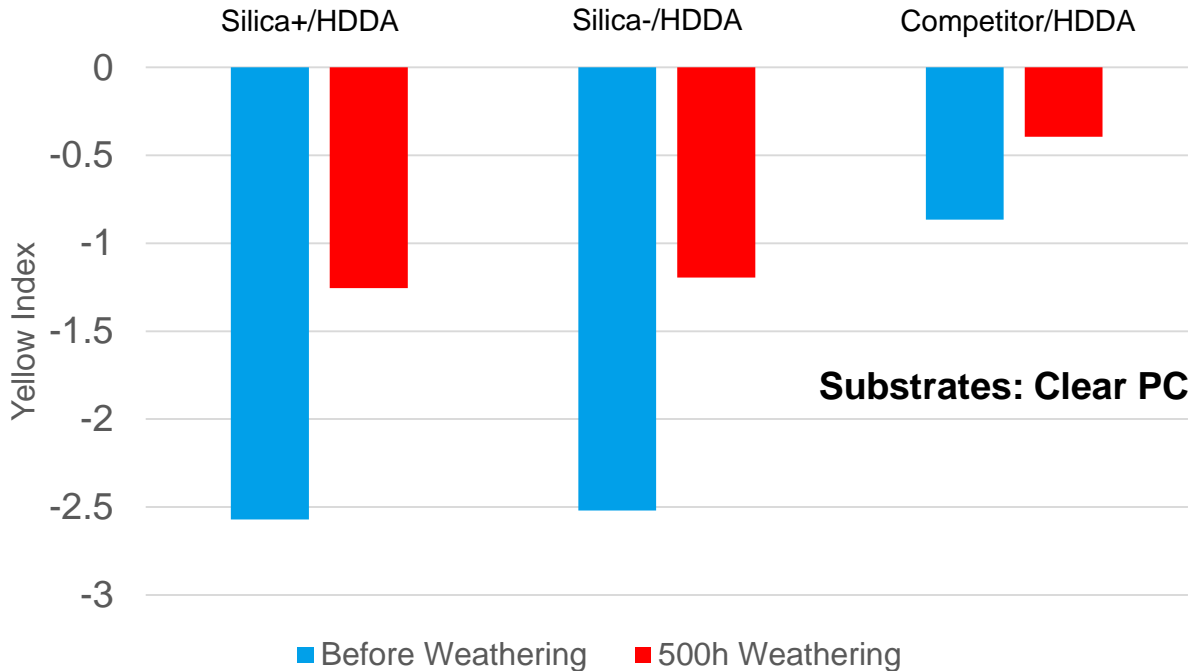
- ❑ Pigmented PC absorbed light and transferred to heat, which caused the cracking of higher crosslinking density coatings.
- ❑ Coating on Clear PC substrates didn't show any cracks.



# 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%	

- 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

## Adhesion Test ASTM D 3359 Method B

# 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



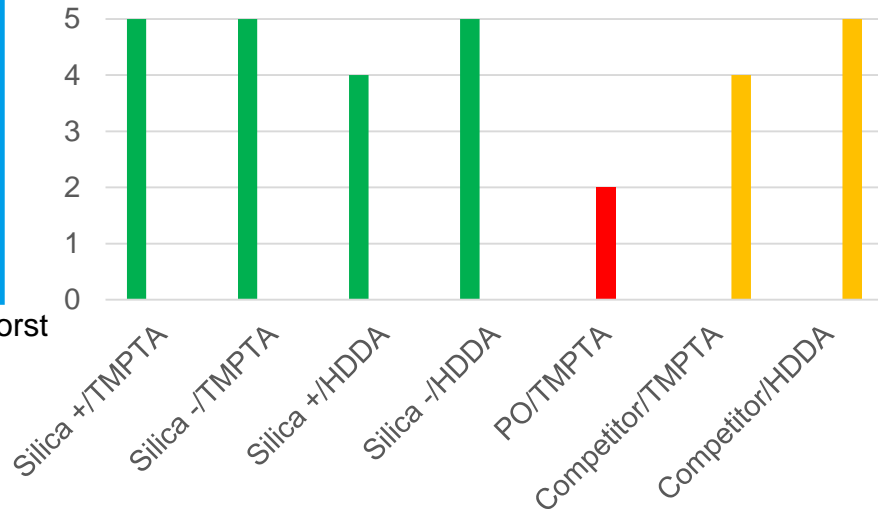
## Visual Evaluation

Best

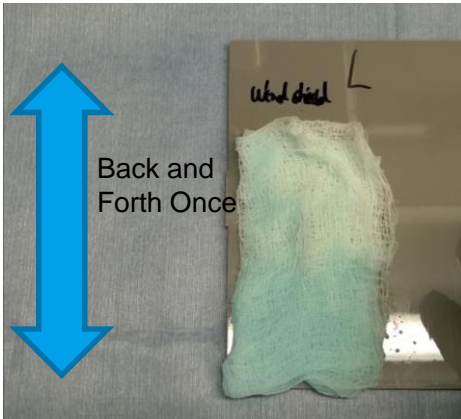


Worst

- PO with Nano-silica
- PO without Nano-silica
- Competitor Composite



# Chemical Resistance



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

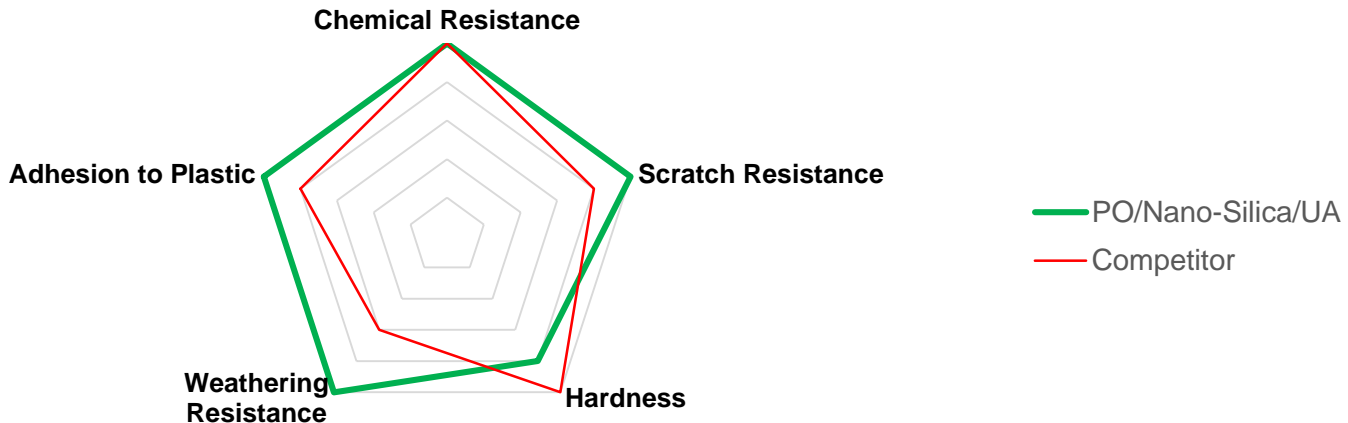
**Visual Evaluation** Worst 1  5 Best

	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

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***Questions?***

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