Nano-Clear NCI Industrial Coating - Competitive Analysis

Property	Method	Nano-Clear® NCI Coating	Axalta IMRON® 2.1 HG-C	Axalta IMRON® 3.5 HG-D	PPG Amercoat PSX® 700
Mfg. Recommended Use		**Newly Painted or In-Use Paint**	Newly Painted Only	Newly Painted Only	Newly Painted Only
Polymer Chemistry		**Nanostructured Polyurethane / Polyurea / Polysilane Hybrid**	Polyurethane Copolymer	Polyurethane	Epoxy Polysiloxane Hybrid
Mixing Ratio	Ratio	**1K - no mixing**	1K – no mixing	2:1 Mix Ratio	4:1 Mix Ratio
Recommended Dry Film Thickness (mils)	ASTM D5796	**2 mil**	3 mils	5 mils	5 mils
Pencil Hardness	ASTM D3363	**4H - 7H**	H	F	N/A
Pendulum Hardness (Persoz)	ASTM D4366	**220**	N/A	24	N/A
Abrasion Resistance (CS-17, 1 kg, 1000 cycles)	ASTM D4060	**8.4 mg loss**	N/A	N/A	53 mg loss
Impact Strength (kg-cm)	ASTM D2794	**> 140**	> 160	> 100	N/A
Water Immersion Test	ISO 2812-2	**Pass**	Pass	Pass	Pass
QUV Resistance (>1500 hr)	ASTM D4587	**100%**	94%	90%	50%
Xenon WOM (4000 hr)	ASTM G155	**99%**	N/A	N/A	N/A
MEK Resistance	ASTM D4752	**>1500**	>200	>100	>100
Salt Spray (5000 hr)	ASTM B-117	**No rust, no blisters.**	No rust, no blisters.	No rust, no blisters.	No rust, no blisters.
DMA Modulus MPa	E' at 23°C	**2110**	N/A	N/A	N/A
DMA X-Link Density	Kmoles/cc	**2.17**	N/A	N/A	N/A
DMA Tg	°C	**96.10**	N/A	N/A	N/A
Competitive Commentary		***Nano-Clear has been awarded the NACE Innovation of the Year Award for Corrosion, F&S Technology Leadership Award and PaintSquare Top Product Award for Steel.***	***NCI has 4X better scratch resistance, but similar UV resistance to Imron.***	***NCI has 5X better scratch resistance, similar UV resistance + 50% less DFT.***	***NCI has 6X better abrasion resistance, 50% better UV resistance + 50% less DFT.***

ALCOA

Alcoa/ Nanovere

Summary of Macro-Testing of Diamond-like Coatings

Alcoa Team: Dr. Skiles & Dr. Sullivan
Nanovere: Thomas Choate, CTO

Supplier	PreTreatment	Coating	Pencil
Nanovere	F-PAA	Vecdor 164-50	6H
Nanovere	Non-Chrome (ALX009)	Vecdor 164-50	4H
Nanovere	Cleaned Only	Nano-Clear NCI-RC	4H
Nanovere	Cleaned Only	Vecdor 164-50	3H
Nanovere	Chrome Conv.	Vecdor 164-50	3H
Nanovere	SAA type II	Vecdor 164-50	3H
Nanovere	Cleaned Only	Vecdor X-SC2K	3H
Nanovere	R-995	Vecdor 164-50	2H
Nanovere	Cleaned Only	Vecdor 164-50	2H
Nanovere	R-995	Vecdor 164-50	F

Hardness Scale:

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

Testing performed by Nippon Paint Singapore
Dr. Daniel Wang, Principal Scientist

Nano-Clear for Industrial Applications
Product # NCI Test Data

NIPPON PAINT

Dry film property*	Nano-Clear	Test Method
Pencil Hardness	4H	ASTM D3363
Pendulum Hardness (Persoz)	> 250	ASTM D4366
Abrasion Resistance (CS-17, 1kg, 1000 cycles)	8.4 mg	ASTM D4060
Impact Strength (kg-cm)	> 140	ASTM D2794
Water immersion test (240 hours @ 50°C)	Pass	ISO 2812-2
CASS @ 50°C	Pass 240 hr.	JIS H8502-7
% Gloss retention (> 1500 hours QUV 313)	> 100	ASTM D4587
% Gloss retention (> 4000 hrs Xenon WOM)	> 99	ASTM G155
MEK resistance	> 1500	ASTM D4752
Salt Spray	Pass 4000 hr.	ASTM B117

ICL employs some of the world's most innovative scientists in the areas of agro, food, water and materials. We employ over 500 R&D specialists to serve our customers and to develop new, sustainable products and applications at our central R&D facility located in Israel ("IMI") and at our business units worldwide. IMI has achieved ISO 9001, ISO 14001 and SI OHSAS 18001 certification from the Standards Institution of Israel.

EXECUTIVE SUMMARY

Nano Clear NCI is a polyurethane topcoating that is a one-component in a hybrid structure with high cross-link bonding that should provide it with corrosion, UV and abrasion resistance (this in addition to its suitability to a wide range of coating systems).

In this study, samples of Nano Clear NCI from Strategic Visionary Solutions were tested in a salt spray chamber for up to 6000 hours and then tested in field test for 1 full year at ICL plants; Dead Sea Works and Rotem, in different locations with severe corrosion conditions.

The results show high corrosion resistance of the Nano-Clear NCI coating during 6000 hours in a salt chamber. In addition, an abrasion test, adhesion and thickness measurements were performed before and after the salt spray exposure. The results of the field tests are summarized below.

Summary	Corrosion Performance	V Cut	Change in thickness	Test Location
Excellent	✓	✓	✓	Rotem plant area #4
Excellent	✓	✓	✓	DSW area #1
Excellent	✓	✓	✓	DSW area #2

- Summary Legend: Bad, Medium or Excellent
- Adhesion results are between 7-10 MPa.

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Testing performed by Musarrat Husain Jafri

Saudi Standards, Metrology and Quality Organization

SlNo	Characteristics	Test Results		Method of Tests
		Polyurethane White without Nano-Clear NCI	Polyurethane White with Nano-Clear NCI	
1	Gloss at 60°	80 (Good)	92.0 (Excellent)	SASO 2833
2	Scratch Hardness	1500 gm. (Good)	2500 gm. (Excellent)	SASO 2833
3	Abrasion Resistance (Loss in weight)	20.6 mg (Good)	8.5mg (Excellent)	SASO 2833
4	Impact Strength	100 kg-cm (Good)	145 kg-cm (Excellent)	ASTM D4060
5	Mar Resistance	2.0 kg (Good)	5.0 kg (Excellent)	ASTM D5178
6	Alkali Resistance	Good	Excellent	SASO 2833
7	Acid Resistance	Good	Excellent	SASO 2833
8	MEK Resistance	200 cycles (Gloss decreased -Fair)	> 1000 cycles (No effect on gloss - Excellent)	ASTM D4752
9	Flexibility	Passed 3mm mandrel test (Good)	Passed 1mm mandrel test (V. Good)	SASO 2833
10	Adhesion (Metal Surface)	1.5 Mpa (Poor)	9 Mpa (Excellent)	SASO ISO 4624
11	Pencil Hardness	3H (Good)	5H (Excellent)	SASO ISO 15184
12	Cross Cut Adhesion	Rating 2 (poor)	Rating 0 (Excellent)	SASO ISO 2409
13	Flexibility Cylindrical Mandrel	5 mm Passed (Good)	3 mm Passed (Excellent)	SASO ISO 1519
14	Impact Resistance	1kg – 120cm (Good)	1kg – 160cm (Excellent)	SASO ISO 3248
15	Flammability: Retardant / Flame Spread	Class 4	Class 1 / Class A (Excellent)	BS476 / ASTM E84
16	Salt Spray Resistance	500 hours	4000 hours (Passed)	SASO ISO 11997
17	Accelerated Weathering (1000 hours)	Fair (Change in color and gloss >10%)	Excellent (Change in color and gloss <2%)	SASO ISO 16474-2

GENERAL DYNAMICS
Land Systems

General Dynamics Land Systems
6000 E. 17 Mile Road
Sterling Heights, MI 48313

Nanovere Technologies, LLC.
4023 S. Old US 23, Suite 101
Brighton, MI 48114
C/O: Dennis Haag / Tom Choate

RE: GD Corrosion Resistance Certification

Dear Dennis & Tom,

Our test data showed that the steel part after primer and top coat with your Nano-Clear NCI product has no sign of corrosion after 4193 hrs. This is very unusual for steel parts to pass 4000 hrs based on my past experiences with coatings. For Aluminum / Titanium joints, no sign of corrosion after 4193 hrs, indicates that this coating is well suited for dissimilar metal joint protection.

I would recommend sharing this data with ARL (Army Research Laboratory) and further evaluation through ARL. The Aluminum / Magnesium tests we are performing will also provide more information after we are done - so more supporting information will be available later.

Thank you for your support.

Jing Zhang
CBRN and HazMat
Mechanical Systems & Materials
General Dynamics Land Systems
6000 E. 17 Mile Road
Sterling Heights, MI 48313

EonCoat™ was developed as a chemically bonded phosphate ceramic to provide a long term corrosive protective coating. These coatings are provided to large industrial customers and distributors throughout the world. EonCoat™ corporation is focused on corrosion prevention for a global scale, while working with other corporations and distributors worldwide.

EXECUTIVE SUMMARY

EonCoat™ noted the benefits from addition of a topcoat over their corrosion protective coating. The durability, color, and physical protection amongst other attributes of EonCoat™ requires a superior top-coat for use in highly acidic and extremely alkaline environments.

In this study, samples of Nano Clear® NCI for Industrial Application from Strategic Visionary Solutions® were tested to determine if they would provide the protection required by the EonCoat™ coating. Any top-coats would have to meet an extremely low to no VOCs and HAPs to be approved. Nano-Clear® was top coated over EonCoat™ panels with the below listed results.

Test Method	Properties	Results	Additional Information
ASTM D4541	Adhesion Testing	Passed	Approved for Use
ASTM B117	2500 hours Salt Testing	Passed	Approved for Use
ISO 12944-9	25 Cycles	Passed	Approved for Use

- Nano-Clear® is approved for use on EonCoat™
- Nano-Clear® meets all of EonCoat™ stringent requirements
- Nano-Clear® increases the long-term performance of EonCoat™ applications

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STONEBRIDGE
TECHNICAL SERVICES
Division of Stonebridge Technical Enterprises, Ltd.

Mr. Thomas Choate
Nanovere Technologies
4023 S. Old US 23, Suite 101
Brighton, MI 48116

We have completed 4,000 hour weatherometer (WOM) testing of your Nano-Clear NCI. It was compared to PPG's CeramiClear product and an OEM clearcoat from DuPont. In all categories tested, the Nano-Clear NCI product performed better than or equivalent to the PPG and DuPont products. Nano-Clear NCI performed exceptionally well after 4,000 hours of WOM exposure. Refer to Table 3 for detailed test results.

Table 1 details the clearcoats that were tested along with their physical properties. All tests were performed on the Nano-Clear NCI and PPG clearcoats (A & B) and some additional tests were performed on the DuPont OEM clearcoat (C).

Table 1: Clearcoats

Sample	A	B	C
Clearcoat	Nano-Clear	D8126/D8226 CeramiClear	Acrylic Silane
Manufacturer	Nanovere Technologies	PPG Industries	DuPont
% Non-Volatile (Weight)	37%	---	
% Non-Volatile (Volume)	---	49.8%	
Volatile Organic Content less Exempts	Solvents are VOC Exempt	2.01 lbs/gal	
Mix Ratio (by Volume)	1	2 : 1	
Potlife @ 68 °F / 20 °F	No Potlife	1 hour	
Recommended Dry Film Thickness	2 mils	2 - 2.5 mils	
Dry Times:			
Dust-Free @ 68-72 °F	30 minutes	30 minutes	
Dry-to-Handle @ 68-72 °F	4 hours	4 hours	
Dry-to-Handle @ 150 °F	30 minutes	30 minutes	

Clearcoats A and B were mixed according to their directions and applied to coated steel panels, within 15 minutes of mixing, using wire wound applicator method. They were allowed to flash off for 3 – 5 minutes prior to baking for 30 minutes at 150^{o}F. They were aged for 24 hours under ambient conditions prior to testing. Total clearcoat thickness for both clearcoats was 1.9 – 2.1 mils. Table 2 details the test panels that were prepared.

Table 2: Test Panels

Panel ID	A	B	C
Clearcoat	Nano-Clear	D8126/D8226 CeramiClear	RK8010A DuPont
Basecoat Code	542AC301 White	542AC301 White	542AC301 White
Primer	None	None	None
E-Coat	ED6060	ED6060	ED6060
Pretreatment	B952 P60 DIW: Unpolish	B952 P60 DIW: Unpolish	B952 P60 DIW: Unpolish
Substrate	Cold Rolled Steel	Cold Rolled Steel	Cold Rolled Steel
ACT Labs Product ID No.	APR45582	APR45582	APR44364

Panels were tested for appearance, mechanical and durability properties similar to those required of BMW. Descriptions of test methods can be found at the end of this report.

The Nano-Clear showed superior cold temperature chip resistance, direct and reverse impact resistance compared to the CermiClear and OEM clearcoats. It showed slightly more haze than the CermiClear product. Both Nano-Clear and CeramiClear showed no breakthrough of clearcoat after exposure to 100 liters of sand via the Falling Sand Abrasion Test. The OEM clearcoat failed after 100 liters.

The initial 20^{o} gloss of the OEM clearcoat was slightly higher than the other clearcoats, but the Nano-Clear (A) showed the best gloss retention (100%) after 4,000 hours of WOM exposure. It had similar color change than the DuPont OEM and PPG CeramiClear clearcoats. The CeramiClear showed better gloss retention than the control with little color change. Table 3 details the test results.

Please call me should you have questions or comments at (810) 750-0040. Thank you for the opportunity to perform the above work for Nanovere Technologies, Inc.

We look forward to working with you in the future.

Sincerely,

Debora L. Hense

Consultant

STS #306_1C

Table 3: Detailed Test Results

Sample	A	B	C
Clearcoat	**Nano-Clear**	**CeramiClear**	**Acrylic Silane**
Manufacturer		**PPG**	**DuPont**
Cure Schedule	**30' @ 150°F**	**30' @ 150°F**	**OEM**
Clearcoat DFT (mils)	**2.0 +/- 0.1**	**2.0 +/- 0.1**	**2.0 +/- 0.1**
Scrape Adhesion per ASTM D2197			
Scratch	0.25 Kg	0.10 Kg	
Gouge	> 11 Kg	> 11 Kg	
Chip Resistance Per ASTM D3170 *			
Room Temperature (23°C)	7A	6A	6A
Cold Temperature (-29°C)	7B	5B	5B
Falling Sand Abrasion per ASTM D968 (100 Liters)	Pass	Pass	Fail
Impact Resistance per ASTM D2794 at -18°C			
Direct (inch-pounds)	50P / 60F	30P / 40F	40 P / 50F
Reverse (inch-pounds)	20F / 10P	5F	5F
Humidity Resistance per ASTM D4585			
500 Hours - Blistering per ASTM D714	No Effect	No Effect	No Effect
500 Hours - Appearance	No Effect	No Effect	No Effect
Transmission & Haze per ASTM D1003			
Haze (%)	1.29	1.09	
Total Luminous Transmittance (%)	89.18	89.91	
Diffuse Transmittance (%)	1.15	0.98	
WOM Resistance per SAE J1960			
20° Gloss - Initial	82.0	82.4	87.8
20° Gloss - 500 Hours	88.0	86.8	88.0
20° Gloss - 1,000 Hours	95.0	91.0	95.0
20° Gloss - 2,000 Hours	83.5	79.9	84.0
20° Gloss - 3,000 Hours	83.4	77.9	82.4
20° Gloss - 4,000 Hours	83.1	78.4	80.8
% Gloss Retention - 4,000 Hours	**100%**	**95%**	**92%**
ΔE - 500 Hours	0.35	0.27	0.61
ΔE - 1,000 Hours	0.41	0.35	0.44
ΔE - 2,000 Hours	0.55	0.48	0.32
ΔE - 3,000 Hours	0.57	0.48	0.30
ΔE - 4,000 Hours	0.63	0.48	0.41

* Number & Letter Categories for Chip Ratings:

Rating	No. of Chips	Chip Size
10	0	A = <1 mm
9	1 - 4	B = 1-3 mm
8	5 - 9	C = 3-6mm
7	10 - 24	D = >6mm
6	25 - 49	
5	50 - 74	
4	75 - 99	
3	100 - 150	
2	151 - 250	
1	> 250	

DESCRIPTION OF TEST METHODS

Chip Resistance – Per ASTM D3170. This method covers the determination of the resistance of coatings to chipping damage by stones or other flying objects. One pint of standardized road gravel (~ ½" diameter) was projected by means of controlled air blast (70 +/- 5 psi) at the panels. One set was tested under ambient conditions and another set tested at -29^{o}C +/- 2^{o}C. After gravel blast, tape is applied and removed from the surfaces. The panels are rated using visual standards in the test method. They are summarized below:

Rating	No. of Chips	Chip Size
10	0	A = <1 mm
9	1 - 4	B = 1-3 mm
8	5 - 9	C = 3-6mm
7	10 - 24	D = >6mm
6	25 - 49	
5	50 - 74	
4	75 - 99	
3	100 - 150	
2	151 - 250	
1	> 250	

Delta E (ΔE) – Per SAE J1545. This method measures the color of the exposed samples and the color of the unexposed samples and calculates a color difference (ΔE) by the square root of the sum of the squares of the delta L*, a* and b* values obtained from the color measurements.

Falling Sand Abrasion – Per ASTM D968 Method A. This method covers the determination of the resistance of organic coatings to abrasion produced by abrasive sand falling onto coatings applied to a plane, rigid surface. A specified amount of sand was allowed to fall from a specified height through a guide tube onto the panels until a minimum of 4mm area of clearcoat was removed. This is the end point.

Gloss – Per ASTM D523. This method covers the measurement of specular gloss of non-metallic specimens for glossmeter geometries 20^{o}, 60^{o} and 85^{o}.

Humidity Resistance – Exposure per ASTM D4585. This practice covers basic principles and operating procedures for testing water resistance of coatings using controlled condensation. A vapor temperature of 60oC was maintained for the duration of testing. Immediately upon removal from the humidity chamber, the panels were observed for defects including blisters, blushing, color change, rust, water spots, etc. If no defects were observed, the panels were rated as PASS.

Impact Resistance – Per ASTM D2794. This method covers a procedure for rapidly deforming by impact a coating film and its substrate. A standard weight is dropped a distance so as to strike an indenter that deforms the coating and the substrate. The indentation can be either an intrusion (direct impact) or extrusion (reverse impact). Films generally fail by cracking. The results are reported as the maximum number of inch-pounds of force applied to the coating and substrate at which the coating does not crack (P for pass) or when the coating cracks (F for fail).

Scrape Adhesion – Per ASTM D2197. This method covers the determination of the adhesion of organic coatings when applied to smooth, flat (planar) panel surfaces. The adhesion is determined by pushing the panels beneath a rounded stylus or loop that is loaded in increasing amounts until the coating is removed from the substrate surface. Two measurements were recorded, the first the load at which marring of the surface was observed, and the second the load at which the clearcoat was removed by the stylus.

Transmission & Haze – Per ASTM D1003. This method covers the evaluation of specific light-transmitting and wide-angle-light-scattering properties of the planar sections of materials. The clearcoats were drawn down over glass panels, cured and measured.

Weatherometer Resistance – Exposure per SAE J1960. This method covers the practices and procedures for the simulated weathering of coated panels.

Table 3: Detailed Test Results

Sample	**A**	**B**	**C**
Clearcoat	**Nano-Clear**	**CeramiClear**	**SB Acrylic Silane Melamine OEM**
Manufacturer	**Nanovere**	**PPG**	**DuPont**
Cure Schedule	**30' @ 150 °F**	**30' @ 150 °F**	**OEM**
Clearcoat DFT (mils)	**1.8 - 2.0**	**1.8 - 2.0**	**2.1 - 2.0**
Gloss per ASTM D523 (20 °/60°)	86.0 / 92.2	85.8 / 92.0	88.1 / 94.1
Adhesion per ASTM D3359 Method B to White (A1 & B1)	5B / 100%	5B / 100%	5B / 100%
Adhesion per ASTM D3359 Method B to Silver (A2 & B2)	0B / 0%	0B / 0%	---
Pencil Hardness - Scratch per ASTM D3363	4H	F	4H
Pencil Hardness - Gouge per ASTM D3363	5H	3B	2B
Pencil Hardness - Gouge per ASTM D3363 After 24 Hr. Recovery	2H	3B	2B
Taber Abrasion per ASTM D4060 (mg lost per 1,000 cycles)	19.85	36.20	52.20
Impact Resistance per ASTM D2794 - Initial			
Direct (inch-pounds)	150 Fail / 140 Pass	90 Fail / 80 Pass	50 Fail / 40 Pass
Reverse (inch-pounds)	160 Pass	120 Fail / 100 Pass	10 Fail / 5 Pass
Impact Resistance per ASTM D2794 - After 48 Hrs. @°F (250n/lbs)			
Direct (inch-pounds)	70 Fail / 60 Pass	60 Fail / 50 Pass	20 Fail / 10 Pass
Reverse (inch-pounds)	5 Fail	5 Fail	5 Fail
Flexibility per ASTM D522	Pass 1/4	n/a	Fail 3/4" / Pass 1" **
Chemical Spot Resistance per ASTM D1308			
10% Sulfuric Acid	No Effect	No Effect	No Effect
10% Hydrochloric Acid	No Effect	No Effect	No Effect
10% Sodium Hydroxide	No Effect	No Effect	No Effect
10% Ammonium Hydroxide	No Effect	No Effect	No Effect
Isopropyl Alcohol	No Effect	No Effect	No Effect
Xylene	No Effect	Slight Softening	Slight Swelling
Xylene (24 hour recovery)	No Effect	No Effect	No Effect
MEK	No Effect	No Effect	No Effect
Skydrol 500 Fluid Resistance per ASTM D6943 Method A	No Effect	No Effect	No Effect
MEK Resistance per ASTM D4752 (Double Rubs)	> 1,500	260	> 1,500

July 17, 2017

Mr. Tom Choate
Nanovere Technologies
4023 S. Old 23, Suite 102
Brighton, MI 48114

Re.: SCLI Job No. 617_146D –Testing of Chemical Agent Resistant Coatings

Dear Mr. Choate:

We have completed the initial screening testing of your chemical agent resistant coatings. Two coated carbon fiber composite samples were received and labeled as CARC and CARC + Nano-Clear NCIM Matt Clear. Table 1 summarizes the samples received. The Sherwin Williams CARC paint was applied as per the enclosed instructions @ 2 mils DFT and allowed to air cure for 24 hours at RT w/50% R.H. The Nanovere NCIM Matte Clear Coating was also applied @ 2 mils DFT and allowed to air cure for 24 hours at RT w/50% R.H.

Table 1: Samples

	Sample ID	
	A **SW CARC Only**	**G** **CARC + NCIM Matt Clear**
Basecoat	Tan CARC CC-M25 *	Tan CARC CC-M25 *
Topcoat	None	NCIM Matt Clear**

* **Sherwin-Williams MIL-DTL-53039E, Type IX**, 1K Aliphatic Polyurethane 3.5 VOC, CARC

** **Nanovere NCIM Matte Clear**, Nanostructured Polyurethane/Polyurea Hybrid System

The samples were tested for a variety of optical and physical properties. On the following pages, Table 2 lists the tests that were performed while Tables 3 – 5 detail the test results. Test panels will be returned under separate cover.

We thank you for the opportunity to assist you in your testing needs.

Sincerely,

Debora L. Hense

Technical Manager

Table 2: Test Protocol

Property	**Test Method**
Optical Properties:	
Gloss	ASTM D523
Color	ASTM D2244
Infrared Reflectance	ASTM E-903
Physical Properties:	
Adhesion	ASTM D3359
Hardness (Pencil)	ASTM D3363
Resistance Properties:	
Acid Spot Resistance	MIL-DTL-53039E Sec 4.6.24
MEK Resistance (Double Rubs)	ASTM D4752
Water Immersion Resistance	MIL-DTL-53039 Sec 4.6.22

Regarding optical properties, the 20° and 85° gloss was unchanged by the addition of the topcoat, while the 60° gloss dropped. Color values were not significantly different. Regarding IR reflectance, the topcoat sample was comparable to the control without topcoat from 800 to 1100nm, slightly higher in % IRR from 700 to 800nm and lower than the control for wavelengths greater than 1100nm. Refer to Table 3 for detailed gloss and color measurements and Table 4 for % IR Reflectance.

Table 3: Optical Property Test Results - Gloss & Color

	Sample A **Tan CARC**	**Sample G** **Tan CARC with NCIM Matt Clear**
Gloss:		
20°	0.7	0.6
60°	3.6	1.3
85°	7.4	7.8
Color:		
L	65.05	66.66
a	6.36	6.02
b	20.88	20.71

Table 4: Optical Property Test Results – Infrared Reflectance

Wavelength (nm)	Sample A Tan CARC	Sample G Tan CARC w/ NCIM Clear
1500	70.76%	59.36%
1467	70.85%	61.55%
1433	71.49%	62.88%
1400	73.98%	66.65%
1367	76.18%	71.32%
1333	76.94%	72.75%
1300	76.94%	73.04%
1267	76.68%	72.04%
1233	74.20%	68.59%
1200	74.52%	69.86%
1167	74.60%	72.21%
1133	72.83%	71.98%
1100	68.72%	68.06%
1067	66.79%	66.79%
1033	65.25%	65.26%
1000	64.14%	64.37%
980	63.55%	63.92%
960	63.10%	63.30%
940	62.43%	62.63%
920	62.48%	62.67%
900	63.33%	63.38%
880	64.10%	64.02%
860	65.25%	65.32%
840	67.19%	67.24%
820	68.90%	68.95%
800	70.16%	70.13%
780	69.73%	70.36%
760	66.54%	67.69%
740	62.03%	63.24%
720	59.31%	60.41%
700	56.86%	58.27%

Regarding physical properties, both the control and topcoat samples showed good adhesion, acid spot and water immersion resistance. The topcoat sample showed superior hardness before and after water immersion and exceptional MEK resistance. The control showed moderate burnishing after 200 MEK double rubs and showed dissolving of the tan coating within 20 MEK double rubs. The topcoat sample was unaffected by 200 MEK double rubs. Table 5 details these test results.

Table 5: Adhesion, Hardness & Resistance Properties

	Sample A **Tan CARC**	**Sample G** **Tan CARC with NCIM Matt Clear**
Adhesion	5B	5B
Hardness (Pencil)	2B	>7H
Acid Spot Resistance	No Effect	No Effect
MEK Resistance:		
Double Rubs to Substrate	>200	>1500
Double Rubs to Start of Coating Dissolution	20	>1500
Appearance after 200 DRs	Moderate Burnishing	No Effect
Water Immersion Resistance:		
Visual Observation	No Effect	No Effect
Pencil Hardness	4B	>7H
Adhesion	5B	5B

MoDOT

Missouri
Department of Transportation
888-ASK MoDOT (275-6636)

Nano-Clear NCI for Industrial - Ammon Painting Restoration & Abatement

Summary of Bridge Testing, MoDOT Chemical Laboratory

Test Panels	Test Conditions	Test Method	Testing Time	Test Results Nano-Clear NCI	Test Results Conventional Topcoat
Coating applied over existing paint system	UV Exposure / Condensation	ASTM G154	2000 hr.	**PASS** No Weathering Observed	**Fail**
Coating applied over existing paint system	Salt Fog Exposure / Corrosion Resistance	ASTM B117	2000 hr.	**PASS** No Weathering or Corrosion Observed	**Fail**
Coating applied over existing paint system	UV Exposure on MoDOT Laboratory Roof	NONE	4000 hr.	**PASS** No Weathering Observed	**Fail**

Kit Bond Bridge - Kansas City, MO

Lewis & Clark Viaduct - Kansas City, MO

Nano-Clear®

COATINGS LABORATORY, INC.

July 17, 2017

Mr. Tom Choate
Nanovere Technologies
4023 S. Old 23, Suite 102
Brighton, MI 48114

Re.: SCLI Job No. 617_146D –Testing of Chemical Agent Resistant Coatings

Dear Mr. Choate:

We have completed the initial screening testing of your chemical agent resistant coatings. Two coated carbon fiber composite samples were received and labeled as CARC and CARC + NCIM Matt Clear. Table 1 summarizes the samples received. The Sherwin Williams CARC paint was applied as per the enclosed instructions @ 2 mils DFT and allowed to air cure for 24 hours at RT w/50% R.H. The Nanovere NCIM Matte Clear Coating was also applied @ 2 mils DFT and allowed to air cure for 24 hours at RT w/50% R.H.

Table 1: Samples

	Sample ID	
	A **SW CARC Only**	**G** **CARC + NCIM Matt Clear**
Basecoat	Tan CARC CC-M25 *	Tan CARC CC-M25 *
Topcoat	None	NCIM Matt Clear**

* **Sherwin-Williams MIL-DTL-53039E, Type IX**, 1K Aliphatic Polyurethane 3.5 VOC, CARC

** **Nanovere NCIM Matte Clear**, Nanostructured Polyurethane/Polyurea Hybrid System

The samples were tested for a variety of optical and physical properties. On the following pages, Table 2 lists the tests that were performed while Tables 3 – 5 detail the test results. Test panels will be returned under separate cover.

We thank you for the opportunity to assist you in your testing needs.

Sincerely,

Debora L. Hense

Technical Manager

Table 2: Test Protocol

Property	Test Method
Optical Properties:	
Gloss	ASTM D523
Color	ASTM D2244
Infrared Reflectance	ASTM E-903
Physical Properties:	
Adhesion	ASTM D3359
Hardness (Pencil)	ASTM D3363
Resistance Properties:	
Acid Spot Resistance	MIL-DTL-53039E Sec 4.6.24
MEK Resistance (Double Rubs)	ASTM D4752
Water Immersion Resistance	MIL-DTL-53039 Sec 4.6.22

Regarding optical properties, the 20° and 85° gloss was unchanged by the addition of the topcoat, while the 60° gloss dropped. Color values were not significantly different. Regarding IR reflectance, the topcoat sample was comparable to the control without topcoat from 800 to 1100nm, slightly higher in % IRR from 700 to 800nm and lower than the control for wavelengths greater than 1100nm. Refer to Table 3 for detailed gloss and color measurements and Table 4 for % IR Reflectance.

Table 3: Optical Property Test Results - Gloss & Color

	Sample A Tan CARC	**Sample G** Tan CARC with NCIM Matt Clear
Gloss:		
20°	0.7	0.6
60°	3.6	1.3
85°	7.4	7.8
Color:		
L	65.05	66.66
a	6.36	6.02
b	20.88	20.71

Table 4: Optical Property Test Results – Infrared Reflectance

	Sample A Tan CARC	Sample G Tan CARC w/ NCIM Clear
Wavelength (nm)		
1500	70.76%	59.36%
1467	70.85%	61.55%
1433	71.49%	62.88%
1400	73.98%	66.65%
1367	76.18%	71.32%
1333	76.94%	72.75%
1300	76.94%	73.04%
1267	76.68%	72.04%
1233	74.20%	68.59%
1200	74.52%	69.86%
1167	74.60%	72.21%
1133	72.83%	71.98%
1100	68.72%	68.06%
1067	66.79%	66.79%
1033	65.25%	65.26%
1000	64.14%	64.37%
980	63.55%	63.92%
960	63.10%	63.30%
940	62.43%	62.63%
920	62.48%	62.67%
900	63.33%	63.38%
880	64.10%	64.02%
860	65.25%	65.32%
840	67.19%	67.24%
820	68.90%	68.95%
800	70.16%	70.13%
780	69.73%	70.36%
760	66.54%	67.69%
740	62.03%	63.24%
720	59.31%	60.41%
700	56.86%	58.27%

Regarding physical properties, both the control and topcoat samples showed good adhesion, acid spot and water immersion resistance. The topcoat sample showed superior hardness before and after water immersion and exceptional MEK resistance. The control showed moderate burnishing after 200 MEK double rubs and showed dissolving of the tan coating within 20 MEK double rubs. The topcoat sample was unaffected by 200 MEK double rubs. Table 5 details these test results.

Table 5: Adhesion, Hardness & Resistance Properties

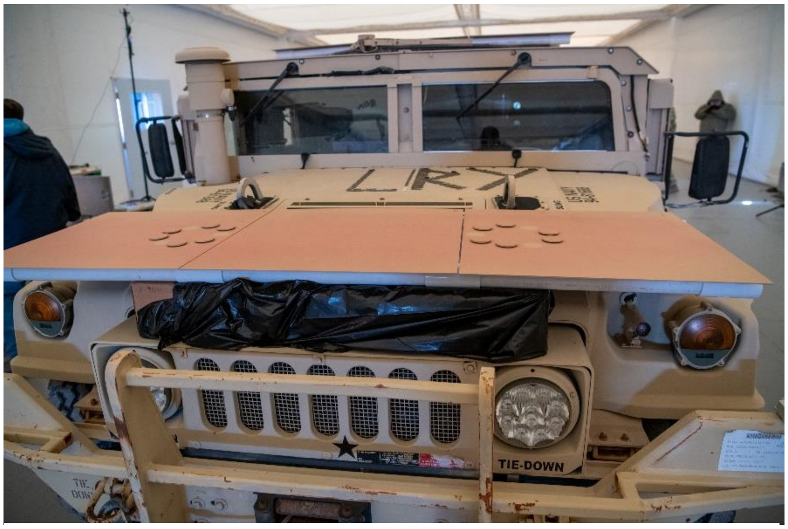
	Sample A **Tan CARC**	**Sample G** **Tan CARC with NCIM Matt Clear**
Adhesion	5B	5B
Hardness (Pencil)	2B	>7H
Acid Spot Resistance	No Effect	No Effect
MEK Resistance:		
Double Rubs to Substrate	>200	>1500
Double Rubs to Start of Coating Dissolution	20	>1500
Appearance after 200 DRs	Moderate Burnishing	No Effect
Water Immersion Resistance:		
Visual Observation	No Effect	No Effect
Pencil Hardness	4B	>7H
Adhesion	5B	5B

For Information: Richard Arndt, 410-436-1479

4 April 2023

Protective Overcoats Could Improve Vehicle Decontamination

By Aeriel Storey



A military vehicle undergoes testing and demonstration of a protective overcoating using sample panels during a demonstration in 2022. (U.S. Army photo by Dugway Proving Ground Public Affairs).

Aberdeen Proving Ground, MD – The U.S. Army Combat Capabilities Development Command Chemical Biological Center (DEVCOM CBC) is exploring the use of protective overcoats on military vehicles to reduce hazards to the warfighter and reduce the resources needed to decontaminate the vehicles. The aim of the project is to reduce the amount of time it takes to decontaminate military equipment and improve the readiness of warfighters during their missions.

When faced with the threat of exposure to hazardous chemicals, warfighters must wear their Personal Protective Equipment (PPE). The PPE is effective in keeping the warfighter safe from hazardous chemicals and protecting them from the possibility of continued exposure. The PPE can be removed or reduced when the threat of contamination is eliminated.

The protective overcoats will ultimately give the warfighter the ability to do an immediate decontamination and allow them to remove or reduce the level of PPE required to accomplish their mission. “Our primary mission is to protect the warfighter. This technology has the potential to reduce the hazards warfighters are exposed to,” said Kevin Morrissey, co-principal investigator for this project. “In addition to reducing the hazards to the warfighter, this technology has the potential to reduce the logistical burden of decontamination operations,” continued Janlyn Eikenberg, co-principal investigator for this project.

The protective overcoats, which consist of a clear topcoat over existing military coatings, are sprayed onto military vehicles similar to spray-painting a car. The coating reduces the amount of chemical agent retained while maintaining the characteristics of the underlying military paint. This coating prevents hazardous chemicals from penetrating into the paint of the vehicles, allowing the chemicals to evaporate off the surface or be more easily removed during decontamination operations.

This project, funded by the Defense Threat Reduction Agency's Joint Science and Technology Office, started in 2019 and is currently ongoing. Continued testing and a series of demonstrations sponsored by the Joint Program Executive Office for Chemical, Biological, Radiological and Nuclear Defense will allow the team to gather more information about the product early in the development cycle and figure out if it will be useful for the warfighters in the field. The current series of demonstrations have proven to be promising. The data gathered has allowed scientists and researchers to understand the potential of the coating and how it can assist warfighters in their missions.

One such demonstration took place in 2022. The demonstration allowed scientists and researchers to observe how the solution reacts in a real-world environment, similar to the conditions faced in Army missions. This demonstration, followed by an additional test, provided valuable information which could be monitored and analyzed in a controlled, large-scale setting. It also gave project teams the valuable experience of interacting with the warfighters directly and gathering their feedback.

In continuing these tests and demonstrations, researchers and scientists can refine the product as more information is gathered. It has also allowed the team to determine additional uses for the overcoats. Currently, the team is gearing up for another round of testing where they will put the coated samples out for weathering to get an understanding of how long the overcoats will last in the field.

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For more information about the DEVCOM Chemical Biological Center, visit https://cbc.DEVCOM.army.mil

The U.S. Army Combat Capabilities Development Command (DEVCOM) Chemical Biological Center (CBC) is aligned under the U.S. Army Futures Command (AFC) and U.S. Army Combat Capabilities Development Command (DEVCOM.)

AFC provides Army modernization solutions (integrated concepts, organizational designs, and technologies) in order to allow the Joint Force, employing Army capabilities, to achieve overmatch in the future operation environment. DEVCOM is a major subordinate command of AFC. DEVCOM leads in the discovery, development, and delivery of technology-based capabilities to enable Soldiers to win our nation's wars and come home safely. DEVCOM CBC is the Army's principal research and development center for chemical and biological defense technology, engineering, and field operations. DEVCOM CBC is headquartered at Aberdeen Proving Ground, Maryland.