Nano-Clear® - Third Party Test Results

CHEMISTRY: $3D^{-9}$ Nano-Structured Polyurethane / Polyurea Hybrid

DESCRIPTION

Nano-Clear® Industrial Coating (NCI) platforms are synthesized nanostructured plural polymer hybrid clear coats in a single component package (1K). NCI's high crosslink density* is made possible by its $3D^{-9}$ spherical globular molecular architecture resulting in an extraordinary high number of cross-link reactive sites (32 to 128). Once fully cured, NCI coatings generate a very formidable matrix. * *"Crosslinking can influence several end properties.....including: coating chemical resistance, polymer flow properties, coating toughness, coating flexibility, coating abrasion resistance...and much more."*

https:www.lubrizol.com/Coatings/Blog/2019/06/What-is-Crosslinking

TABLE 1

	TEST METHOD DETAILS			
	PRIMARY SPECIFICATIONS	**TEST STANDARD**	**RESULTS**	
1	VOC	ASTM D3960	1.25 lb / gal / - 150 g/l	1
2	Recommended Dry Film Thickness *(DFT)*	ASTM D5796	1.0 mil - 2.5 mils (/ 50.4µm to 63.5µm)	2
3	Coverage: *1 US Gal / 3.8 Ltr.*	Nanovere Inhouse	1,122ft^2 @1.0 mil	3
4	Specular Gloss: *@ 20º / 60º*	ASTM D523	86.0 / 92.2	4
	IN SERVICE PHYSICAL DAMAGE RESISTANCE	**TEST STANDARD**	**RESULTS**	
5	Abrasion Resistance by Taber: *CS-17, 1 kg, 1,000 cycles*	ASTM D4060	8.4 mg loss	5
6	Coating Hardness by Pencil Test: *Scratch*	ASTM D3363	4H	6
7	Coating Hardness by Pencil Test: *Scratch*	SASO 2833	2500 gm	7
8	Coating Hardness by Pencil Test: *Gouge*	ASTM D3363	5H	8
9	Coating Hardness by Pendulum Damping: *Persoz*	ASTM D4366	> 250 oscillations	9
10	Coating Rapid Deformation by Impact: *18°C Direct in./lbs.*	ASTM D2794	50 Pass / 60 Fail	10
11	Coating Rapid Deformation by Impact: *18°C Reverse in./lbs.*	ASTM D2794	10 Pass / 20 Fail	11
12	*Coating Rapid Deformation: Impact Strength*	ASTM D2794	145 kg - cm	12
13	Impact Resistance: *Single or Multi-coat Systems*	SASO ISO3248	1kg-160cm	13
14	Chip Resistance of Coatings: *23°C / 73.4°F @ 2.0 mils DFT*	ASTM D3170	7A	14
15	Chip Resistance of Coatings: *-29°C / -9.4°F @ 2.0 mils DFT*	ASTM D3170	7B	15
16	Abrasion Resistance by Falling Abrasion: *100 liters*	ASTM D968	Pass	16
17	Mar Resistance of Organic Coatings	ASTM D5178	5.0 kg	17
18	Flexibility - Conical Mandrel Bend	ATSM D522	1/4" Pass	18
19	Flexibility - Cylindrical Mandrel Bend	ASTM D522	Zero (0) - T	19
	ENVIRONMENTAL RESISTANCE	**TEST STANDARD**	**RESULTS**	
20	Controlled Xenon Arc-Lamp-Exposure Resistance: *4,000 hrs*	SAE J1960 ASTM G155	100% Gloss Retention 99% Gloss Retention	20
21	Fluorescent UV-Condensation Exposure: QUV 313 > 1,500 hrs	ASTM D4587	100% Gloss Retention	21
22	Water Immersion Resistance: *240 hrs @ 50°C / 122°F*	ISO 2812-2	Pass	22
23	Humidity Testing: @100% RH, 100°F / 37.8°C - 240 hrs	ASTM D1735-02	No loss of adhesion - No change	23
24	Corrosion Resistance: *PASS 240 hrs @ 50°C / 122°F*	JIS H8502	Pass	24
25	Salt Spray Fog: *6,360 hrs*	ASTM B117 / 2018	No corrosion points - Approved	25
26	Thermal Shock Test for Adhesion: *Heat: @ 100°F / 37.8°C for 3 hrs, Freeze for 3hrs, Steam Blast for 30 Sec*	GM9525P	No loss of adhesion - No Change	26
	CHEMICAL RESISTANCE	**TEST STANDARD**	**RESULTS**	
27	Effect of Household Chemicals on Clear & Pigmented Coatings: *10% Sulfuric Acid*	ASTM D 1308	No effect	27
28	Effect of Household Chemicals on Clear & Pigmented Coatings: *10% Hydrochloric Acid*	ASTM D 1308	No effect	28
29	Effect of Household Chemicals on Clear & Pigmented Coatings: *10% Sodium Hydroxide*	ASTM D 1308	No effect	29
30	Effect of Household Chemicals on Clear & Pigmented Coatings: *10% Ammonium Hydroxide*	ASTM D 1308	No effect	30
31	Effect of Household Chemicals on Clear & Pigmented Coatings: *Isopropyl Alcohol*	ASTM D 1308	No effect	31
32	Effect of Household Chemicals on Clear & Pigmented Coatings: *Xylene*	ASTM D 1308	No effect	32
33	Immersion Testing of Industrial Protective Coatings: *Skydrol® 500Fluid*	ASTM D6943-A	No effect	33
34	Measuring MEK Resistance by Solvent Rubs: *1,500 Double Rubs*	ASTM D4752	No effect	34
	FIRE RESISTANCE	**TEST STANDARD**	**RESULTS**	
35	Fire Resistance Testing of Building Materials	ASTM E84 / BS476	Class 1 (Excellent)	35

TABLE 2

DMA (Dynamic Mechanical Analysis)

	SAMPLE PANEL TESTED	E' @ 23ºC/73.4ºF MPA	XLD (Kmols/cc)	Tg (ºC)
36	Nano-Clear® (NCI)	2110	2.17	57.7

Based on historical data XLD has a 95% confidence interval of ~ +/- 0.5

Based on historical data Tg has a 95% confidence interval of ~ +/- 2.5

UNIAXIAL EXTENSION (INSTRON)

	SAMPLE PANEL TESTED	YOUNG'S MODULUS MPa	YIELD STRAIN %	YIELD STRESS MPa	STRESS @ BREAK %	STRAIN @ BREAK %	TOUGHNESS MPa
37	Nano-Clear® (NCI)	1506	4.59	51.6	52.7	52.4	5.09
38	95% *CI +/-	35	0.14	1.6	1.3	1.5	0.59

*Confidence Intervals based on 5 tests of this sample

Q. What is *DMA*?

A. *Dynamic Mechanical Analysis* is performed by a *Dynamic Mechanical Analyzer*

Q. What does a *DMA* do?

A. *DMA* measures the mechanical/rheological (crosslink density; XLD) properties of a material as a function of time, frequency, temperature, stress, and strain

NOTE: The *Dynamic Mechanical Analyzer* used for Table 2 tests, was a *TA Instrument Q800* unit

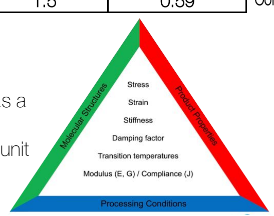


TABLE 3

TEST METHOD DETAILS	TEST STANDARD
The Japanese Industrial Standard is a quantitative antimicrobial surface test method that tests for antimicrobial activity and efficacy	non-GLP Modified JIS Z 2801Study

	Test Microorganism	Contact Time	Test Substrate	Replicate	CFU/Carrier	Average CFU/Carrier	Percent (%) Reduction Compared to 24 Hour Control	Log10 Reduction Compared to 24 Hour Control
		Time Zero	Control Glass Substrate	1	3.30E+05			
39				2	2.60E+05	2.80E+05	N/A	N/A
	E. coli ATCC 8739			3	2.50E+05			
		24 Hours	Control Glass Substrate	1	3.70E+05			
40				2	3.80E+05	3.97+05	N/A	N/A
				3	4.40E+05			
	S. aureus ATCC 6538		Nano-Clear® NCI 4.0	1	1.63E+02			
41				2	1.48E+02	4.87E+02	99.9993%	5.59
				3	1.15E+03			
			Nano-Clear® NCI 5.0	1	3.03E+01			
42				2	6.00E+00	1.53E+01	99.99998%	6.87
				3	9.50E+00			

TABLE 4

ANTI-ICE SCREENING

TEST SAMPLE INFO	T-PANEL (4" X 12") SUBSTRATE	NUMBER OF PANELS TESTED	SCOPE OF TESTING
Control	Aluminum	2	Contact angle - ice de-bond (shedding)
NCI +NCFP@5%	Aluminum	1	Contact angle - ice de-bond (shedding)
VX-SC	Aluminum	1	Contact angle - ice de-bond (shedding)
VX+SC+5% Fluoropolymer	Aluminum	2	Contact angle - ice de-bond (shedding)
NCI+NCIM@30%+NCFP@5%	Aluminum	2	Contact angle - ice de-bond (shedding)

ICE / FROST BUILD TESTING

1. Test sample panels were attached to the evap-cooler's fins along with thermo-couplers
2. Freezer door propped open by .5" for an 1 hour
3. Two pans of 40ºC tap water (500 grams) was added and the freezer door was then closed shut
4. The closed freezer was run for 16 hours and monitored using a picolog with thermocouplers and a computer
5. After 16 hours of run time the amount of ice/frost generated on the test panels was evaluated

CONTACT ANGLE TEST RESULTS

TEST SERIES 1	TEST SAMPLE INFO	CONTACT ANGLE
43	Control	43.12°
44	NCI +NCFP@5%	102.41°
45	VX-SC	103.15°
46	VX+SC+5% Fluoropolymer	98.535°
47	NCI+NCIM@30%+NCFP@5%	101.07°

ICE DE-BOND (SHEDDING) TEST RESULTS

TEST SERIES 2	TEST SAMPLE INFO	ICE DE-BOND (SHEDDING) TIME IN SECONDS
48	Control	58s
49	NCI +NCFP@5%	32s
50	VX-SC	49s
51	VX+SC+5% Fluoropolymer	47s
52	NCI+NCIM@30%+NCFP@5%	40.5s

TABLE 5

SCRATCH TESTING PARAMETERS

SCRATCH MODE	MAX. LOAD (N)	SCRATCH LENGTH (MM)	SCRATCH SPEED (mm/sec)	LOADING RATE (N/min)	PRE/POST SCAN LOAD (N)	SCRATCH TRACKS PER SAMPLE	SCRATCH TIP TYPE	TIP MATERIAL	SCRATCH TIP RADIUS (μM)
Progressive	100	2	2	200	1	3	Sphero-conical	Diamond	20

TEST STANDARDS

ASTM D7027: Method for Evaluation of Scratch Resistance of Polymeric Coatings and Plastics using an Instrumented Scratch Machine

ASTM D1624 Modified: Method for Adhesion Strength and Mechanical Failure Modes of Ceramic Coatings by Quantitative Single Point Scratch Testing

ASTM D7187 Modified: Method for Measuring Mechanistic Aspects of Scratch/Mar Behavior of Paint Coatings by Nanoscratching.

TEST REQUIREMENTS

1. Room temperature microscratch experiment using a mirco-scratch technique
2. The goal is to study and compare coating adhesion, strength / scratch resistance of the coatings through progressive scratch tests
3. The testing prodcedures follow a modified ASTM D7027 standard to scratch polymeric thin coatings with a diamond tip

SYSTEM EMPLOYED FOR TESTING

1. An Anton Parr Revtest (Macro) Scratch System
2. The system was calibrated on 04/30/2021
3. A 100 µm radius diamond spherical tip was employed for the scratch measurements
4. The system and the scratch tip were validated on a TiN reference sample before the experiments were conducted on the Assero supplied samples conducted as a blind test (X vs Y)

COMPARISON OF CRITICAL LOADS OF FAILURE LC1 OPTIC — ROOM TEMPERATURE

	TEST 1 SAMPLES	DATA 1	DATA 2	DATA 3	MEAN	STD DEV
53	X*	38.393	38.032	37.962	38.129	0.231
54	Y**	43.622	42.386	45.551	43.853	1.595

NOTE: X* (submitted sample) Nano-Clear® Gel-coated fiberglass *unsanded* preapplication.

COMPARISON OF CRITICAL LOADS OF FAILURE LC1 OPTIC — HEATED 8 HOURS @ 50ºC- COOLED OVERNIGHT

	TEST 2 SAMPLES	DATA 1	DATA 2	DATA 3	MEAN	STD DEV
55	X*	38.486	32.869	35.433	35.929	3.336
56	Y**	1.294	1.338	1.963	1.532	0.374

**Y (submitted sample) BASF DC92 *sanded* Gel-coated fibreglass pre application

Why Micro-Scratch Testing?

"Data from the nano-scratch test also proved best for determining how well the coating responded to physical assault based on its crosslink density, the measure of how tightly the polymer components are bound together," *Sung said.

"With this molecular-level understanding, clearcoat formulas can be improved so that they yield materials dense enough to be scratch resistant and resilient but not so hard that they cannot be worked with easily."

"The researchers concluded that to get the truest evaluation of clearcoat performance, the nano-, micro- and macro-scratch tests should be conducted in conjunction with the current industry standard methods." *Li-Piin Sung *NIST* research Physicist

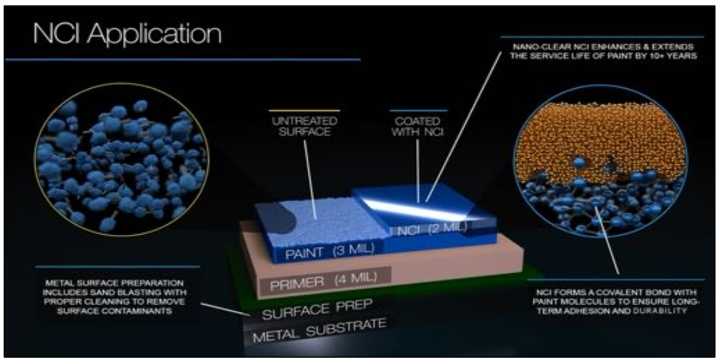
TABLE 6

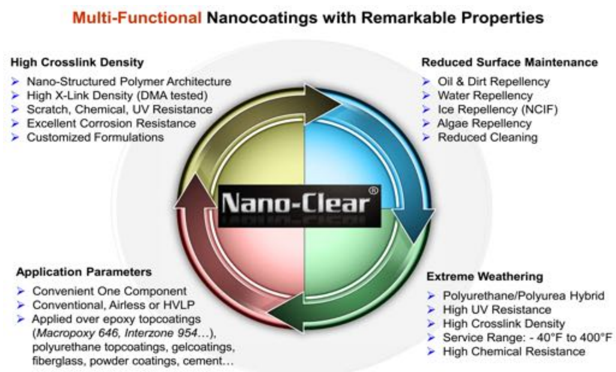
#	TEST METHOD DETAILS			
	OPTICAL PROPERTIES	**TEST STANDARD**	**CONVENTIONAL CARC RESULTS**	**NCI SuperCARC (NCI +MaT) RESULTS**
57	Specular Gloss: *@ 20º - 60º - 85*	ASTM D534	0.7 - 3.6 - 7.4	0.6 - 1.3 - 7.8
58	Calculating color differences from instrumentally color measured color coordinates: *L-, a-, b-*	ASTM D2244	66.66 - 6.02 - 20.71	66.66 - 6.02 - 20.71
59	Measurement of spectral absorptance, reflectance, and transmittance: *IR signature*	ASTM E-903	PASS	PASS
	PHYSICAL PROPERTIES	**TEST STANDARD**	**CONVENTIONAL CARC RESULTS**	**NCI SuperCARC (NCI +MaT) RESULTS**
60	Rating Adhesion by Tape Test	ASTM D3359	5B	5B
61	Rating Film Hardness by Pencil Test	ASTM D3363	2B	>6H
	CHEMICAL AND PHYSICAL DAMAGE RESISTANCE	**TEST STANDARD**	**CONVENTIONAL CARC RESULTS**	**NCI SuperCARC (NCI +MaT) RESULTS**
62	Acid Spot Resistance	MIL-DTL-53039E Sec 4.6.24	No Effect	No Effect
	MEK Resistance			
63	Double rubs to substrate	ASTM D4752	>200	>1,500
64	Double rubs to start of coating Dissolution		20	>1,500
	Water Immersion Testing:			
65	Visual Observation	MIL-DTL-53039 Sec 4.6.24	No Effect	No Effect
66	Pencil Hardness		4B	>6H
67	Adhesion		5B	5B

INTRODUCING A NEW APPROACH TO CARC

"The effectiveness of US military forces is highly dependent on the readiness (and safety) of the equipment and vehicles they use. Spray-applied coatings are used for many types of equipment, components and vehicles including aircraft, ground vehicles, water-borne vessels and ordnance. Improved......quality therefore results in reduced cost and readiness." Lea Ann Schellhorn, Iowa Waste Reduction Center, Cedar Fall - Spray Technique Analysis and Research for Defense (STAR4D)

Est 2003





NCI Best Practices

Assero Coating Technologies Inc.
20 De Boers Drive
Suite 202
Toronto, Ontario
M3J 0H1 Canada
1.888.588.6986
info@assero.co
https://www.assero.co

ENGINEERED FOR SUSTAINABILITY