FROST & SULLIVAN

Technology Leadership Award

Industrial Corrosion Protection Coatings Industry



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Background and Company Performance

Industry Challenges

Most assets in industrial applications, such as ships, oil or chemical storage tanks, oil rigs, fleet vehicles, and heavy machinery used in various industrial processes, are made of steel that is painted with powder coatings, either 2-component or 1-component, made from polyesters, polyurethanes, or epoxies. Typically, the surface of the metal is cleaned by sand blasting, and a 2-component epoxy or polyurethane is applied as a topcoat. Epoxies offer remarkable adherence to steel, compared to other coating technologies, thus making them the most preferred solution. However, conventional epoxies degrade and corrode from exposure to specific solvents, UV radiation, and acid rain. For example, the documented use life of coatings for marine vessel exteriors is limited to six months because the topcoat oxidizes from UV degradation. When UV rays hit the epoxy coating, the polymer molecules begin to disintegrate, leading to oxidation and chalking and thus to corrosion.

Technology Leverage and Business Impact

Founded in 2003, Michigan-based Nanovere Technologies leveraged its technical competencies built from over a decade of research and development in coating technologies for the automotive original equipment manufacturer (OEM) marketplace. Automotive OEMs commonly apply a clearcoat over painted exteriors to achieve environmental protection. A typical automotive exterior has a three-layer system, where an epoxy or polyurethane primer forms the first line of defense, and a clearcoat on top of the base coat becomes the last line of defense.

Nanovere took the proven clearcoat concept from automotive OEMs, improved its performance to match the rigors of harsh industrial applications, and then introduced the Nano-Clear[®] coating technology that surpasses traditional automotive clearcoats in terms of corrosion protection performance.

Commitment to Innovation

Nano-Clear NCI Industrial Coating is a high-density, cross-linked polymer network consisting of a 2-component polyurethane pre-polymer, 2-component polyurea pre-polymer, and polysilane, all of which come together in the form of a 3D nano-architecture with hydroxyl and isocyanate (NCO) functional groups. The polysilane promotes adhesion and reduces surface cleaning, the polyuria offers abrasion and chemical resistance, and polyurethanes deliver long-term UV resistance. A high dosage of UV absorbers is added to the polymers, which enables Nano- Clear to achieve superior UV degradation resistance, compared to traditional automotive clearcoats.

Nano-Clear NCI is a plural-component, high cross-link density polymer coating system that is stable in a single-component package. The high cross-link density is possible because of Nanovere's ability to tailor a 3D molecular architecture with an exponentially high number of cross-link sites, resulting in a tightly knit mesh. The unique architecture enables unmatched corrosion, chemical, and UV resistance, combined with low surface energy that renders the surface hydrophobic and easy to clean.



While most existing automotive OEMs' clear-coat technologies fail to sustain 2,000 hours of a salt spray test, Nanovere's Nano-Clear can maintain its integrity and corrosion protection performance even after 4,000 salt spray hours. As a testament to Nano-Clear's superior surface protection performance, notable customers, such as Pemex Oil & Gas (storage tanks), Petrobras Oil & Gas (ships), OSG America (ships), Ferrosur Railroad, a subsidiary of Grupo México (storage tanks), UPS UK, Department of Defense, Sterling Crane (fleet of cranes), have reported significant reductions in maintenance costs and an extended maintenance-free life of painted assets.

Commitment to Creativity

Nanovere's approach to solving corrosion in industrial applications is distinctly different from existing alternatives. Most new coating solutions marketed by competitors use graphene, diamond dust, or silica powders in epoxy matrices to improve adhesion strength and anti-corrosion performance. While the addition of nanoparticles is beneficial in some ways, they fail to solve the problem of UV degradation when exposed to sunlight. When oil rigs or marine exteriors are exposed to sunlight, the sun's UV rays do not differentiate between the graphene nanoparticle and the epoxy film. The epoxy film still degrades, irrespective of the presence of graphene nanoparticles, thereby exposing the underlying metal surface to oxidation and corrosion.

Nanovere has addressed this problem through its strong technical competency in clearcoat systems and has introduced Nano-Clear as a clearcoat technology that is designed to be compatible with all 2-component polyurethanes, 2-component epoxies, powder coatings, many 1-components, and even some latex systems. Nanovere works closely with

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customers through its distributor network to conduct spot tests to determine Nano-Clear's compatibility with underlying paint. Because solvents used in Nano-Clear are polar solvents, there is a trade off on compatibility issues with 1-component alkyds or other topcoats with poor solvent resistance. Therefore, Nanovere specifically positions Nano-Clear as the last line of defense against corrosion for most topcoats, with good solvent resistance applied to high-value, large-area, non-class A surfaces in industrial applications.

Commercialization Success

Frost & Sullivan commends Nanovere for developing an advanced coating solution to meet industrial customers' high-priority challenges. Nanovere strongly believes that field demonstrations are 24-hour sales tools for coatings. To build customer trust in Nano- Clear's performance claims, Nanovere encourages its distributors to conduct demonstrations at customer sites. Nano-Clear NCI is currently being used by Apple, UPS UK, Royal Caribbean, Sterling Crane, Altec Crane, Pemex Oil & Gas and Genco Shipping China.

Nanovere's distributors coated portions of ships and vessel exteriors with Nano-Clear NCI and allowed customers to monitor and track coating performance over a period of six months to two years. Customer feedback shows that Nano-Clear is far superior to competing industrial solutions, such as Axalta's Imron Coating and PPG PSX 700 Coating, in terms of scratch resistance, chemical resistance, UV resistance, and long-term corrosion protection performance.

Successful end-use customers and global strategic partnerships with Henkel, BASF and Nippon Paint have helped Nanovere become the first-to-commercialize 3D nanostructured polymer-based coatings with unmatched surface protection performance.

Application Diversity

Nano-Clear NCI is unique in its ability to go on both wet-on-wet and cured surfaces because it is humidity cured, whereas all other topcoat systems, such as 2-component epoxies and polyurethanes, have different curing mechanisms. Nano-Clear relies on humidity on the surface and in the air for higher crosslinking, thus enabling best-in-class scratch, chemical, and UV resistance with easier cleaning properties on painted assets.

In alignment with having the strategic advantage of offering the first clearcoat technology specifically designed for large-area surfaces with constant exposure to sunlight, Nanovere introduced Nano-Clear only for non-class A industrial applications. Even though Nano-Clear is far superior to existing automotive OEM and aftermarket clearcoat technologies, Nanovere does not compete in that segment because of warranty issues and nuances in the sales cycle for individual cars. Instead, Nanovere targets the larger market, where customers value corrosion protection more than aesthetic appearances.

Customer Acquisition

Nanovere's operating model is built on strong technical competencies in conceptualizing, developing, and manufacturing first-to-market nanocoatings that offer differentiated functional properties. Since its launch in 2015, Nano-Clear has won large customers

across multiple end-user segments. For example, in the marine segment, Royal Caribbean International, has realized the benefits of coating their lifeboats with Nano-Clear. In addition, OSG America, a leading provider of energy transportation services in the United States, uses Nano-Clear on its smokestacks and rails, and the US Army uses Nano-Clear on the deck surfaces of its Landing Craft Utilities. UPS uses Nano-Clear on its fleet of trucks in the UK. Apple Computer uses Nano-Clear on its Apple Park Campus.

Based on the success and positive feedback from these multinational shipping companies and the military, Nanovere is expanding its reach in specific markets, including oil and gas, with customers such as Pemex in Mexico for their above-ground storage tanks and pipelines. In addition, building on its traction with shipping companies, Nanovere is targeting the merchant marine segment for all non-class A, large-surface area applications with an anti-barnacle requirement. The third segment of interest for Nanovere is the fleet market, especially the military, for which Nanovere has already developed a custom matt version of the Nano-Clear coating, which is infrared neutral with dramatically superior abrasion and scratch resistance to withstand sandstorms.

Furthermore, Nanovere is taking the Nano-Clear NCI Industrial Coating to customers such as Caterpillar, John Deere, Amazon and FedEx to provide the clearcoat on trucks and semis. Nanovere is currently evaluating opportunities for customer validation and partnerships in the infrastructure segment, which includes bridges, building structures, and painted steel structures. Nanovere is an intellectual property owner and manufacturer of an advanced 3D high cross-link density clear coating that meets customers' surface protection needs through a well-established network of distributors. Nanovere trains distributors on the Nano-Clear coating technology and application process, which is the same as conventional spraying techniques used for other coatings.

Growth Potential

Frost & Sullivan recognizes Nanovere as the technology leader in industrial corrosion protection because it has successfully developed, validated, and commercialized its market-ready specialty clear coating technology for industrial customers. In a segment where stakeholders, such as oil and gas pipeline operators, tank farm owners, process plant operators, and marine shipbuilding companies, repeatedly face the problem of asset value degradation because of corrosion, the value delivered by Nanovere's Nano-Clear coating saves customers millions of dollars every year by extending the maintenance-free operational life of assets by over 10 years, thereby reducing the total cost of ownership.

Nanovere's market opportunity, unlocked by the disruptive Nano-Clear coating, includes a new category of coating solutions specifically designed with the unique combination of high cross-link density and flexibility, thus offering unmatched topcoat durability in the industrial segment. As a first-to-market provider of clearcoat products in the industrial market, Nanovere believes that the oil and gas industry provides the biggest growth opportunity, primarily driven by the immediate need to optimize costs in a low-price environment. Nanovere's differentiated capabilities in nanocoating development, along with its successful implementation and industry-proven corrosion protection performance,

position Nano-Clear as the corrosion protection coating of choice for the oil and gas industry.

Conclusion

Nanovere transitioned from a research and development company to a leading provider of first-to-market 3D high cross-link density polymer nanocoatings and has transformed its corrosion protection strategy for industrial customers in the oil and gas, shipping, merchant marine, military, and building infrastructure industries. The company's advanced

Nano-Clear is the "first" and "only" clear coat product based on a standalone technology specifically designed to enhance and extend the surface life of newly painted and oxidized painted non-class A surfaces by over 10 years.

As a clear coating product, Nano-Clear is agnostic and can be applied over all well-known industrial top-coat systems including the coatings products offered by Akzo Nobel and PPG Industries making Nano-Clear a complimentary functional durability enhancer over conventional top coats. With the launch of Nano-Clear in 2015, Nanovere disrupted the industrial corrosion protection coating industry and continues to offer value to its customers in terms of maintenance cost savings and the enhanced durability of mission-critical assets.

For its strong overall performance, Nanovere has earned the Frost & Sullivan's 2023 Technology Leadership Award in the North American industrial corrosion protection coatings industry. Frost & Sullivan commends Nanovere for developing an advanced coating solution to exceed industrial coating specifications.

Significance of Technology Leadership

Technology-rich companies with strong commercialization strategies benefit from the demand for high-quality, technologically innovative products that help shape the brand, resulting in a strong, differentiated market position.



Understanding Technology Leadership

Technology leadership recognizes companies that lead the development and successful introduction of high-tech solutions to customers' most pressing needs, altering the industry or business landscape in the process. These companies shape the future of technology and its uses. Ultimately, success is measured by the degree to which a technology is leveraged and the impact it has on growing the business.

Key Benchmarking Criteria

For the Technology Leadership Award, Frost & Sullivan analysts independently evaluated 2 key factors—Technology Leverage and Business Impact—according to the criteria identified below.

Technology Leverage

Criterion 1: Commitment to Innovation Criterion 2: Commitment to Creativity Criterion 3: Technology Incubation Criterion 4: Commercialization Success Criterion 5: Application Diversity

Business Impact

- Criterion 1: Financial Performance Criterion 2: Customer Acquisition Criterion 3: Operational Efficiency Criterion 4: Growth Potential
- Criterion 5: Human Capital

Best Practices Award Analysis for Nanovere Technologies

Decision Support Scorecard

To support its evaluation of best practices across multiple business performance categories, Frost & Sullivan employs a customized Decision Support Scorecard. This tool allows research and consulting teams to objectively analyze performance according to the key benchmarking criteria listed in the previous section, and to assign ratings on that basis. The tool follows a 10-point scale that allows for nuances in performance evaluation. Ratings guidelines are illustrated below.

RATINGS GUIDELINES



The Decision Support Scorecard considers Technology Leverage and Business Impact (i.e., the overarching categories for all 10 benchmarking criteria; the definitions for each criterion are provided beneath the scorecard).

The research team confirms the veracity of this weighted scorecard through sensitivity analysis, which confirms that small changes to the ratings for a specific criterion do not lead to a significant change in the overall relative rankings of the companies. The results of this competitive analysis are shown below.

Measurement of 1–10 (1 = poor; 10 = excellent)			
Technology Leadership	Technology Leverage	Business Impact	Average Rating
Nanovere Technologies	9	9.5	9.25
PPG Industries, Inc.	8	9	8.5
Akzo Nobel N.V.	7	8	7.5

Technology Leverage

Criterion 1: Commitment to Innovation

Requirement: Conscious, ongoing development of an organization's culture that supports the pursuit of groundbreaking ideas through the leverage of technology.

Criterion 2: Commitment to Creativity

Requirement: Employees rewarded for pushing the limits of form and function by integrating the latest technologies to enhance products.

Criterion 3: Technology Incubation

Requirement: A structured process with adequate investment to incubate new technologies developed internally or through strategic partnerships.

Criterion 4: Commercialization Success

Requirement: A proven track record of commercializing new technologies by enabling new products and/or through licensing strategies.

Criterion 5: Application Diversity

Requirement: The development of technologies that serve multiple products, multiple applications, and multiple user environments.

Business Impact

Criterion 1: Financial Performance

Requirement: Overall financial performance is strong in terms of revenue, revenue growth, operating margin, and other key financial metrics.

Criterion 2: Customer Acquisition

Requirement: Overall technology strength enables acquisition of new customers, even as it enhances retention of current customers.

Criterion 3: Operational Efficiency

Requirement: Staff is able to perform assigned tasks productively, quickly, and to a high quality standard.

Criterion 4: Growth Potential

Requirements: Technology focus strengthens brand, reinforces customer loyalty, and enhances growth potential.

Criterion 5: Human Capital

Requirement: Company culture is characterized by a strong commitment to customer impact through technology leverage, which enhances employee morale and retention.

Decision Support Matrix

Once all companies have been evaluated according to the Decision Support Scorecard, analysts then position the candidates on the matrix shown below, enabling them to visualize which companies are truly breakthrough and which ones are not yet operating at best-in-class levels.



Best Practices Recognition: 10 Steps to Researching, Identifying, and Recognizing Best Practices

Frost & Sullivan analysts follow a 10-step process to evaluate award candidates and assess their fit with select best practices criteria. The reputation and integrity of the awards are based on close adherence to this process.

STEP		OBJECTIVE	KEY ACTIVITIES	OUTPUT
1	Monitor, target, and screen	Identify award recipient candidates from around the world	Conduct in-depth industry researchIdentify emerging industriesScan multiple regions	Pipeline of candidates that potentially meet all best practices criteria
2	Perform 360-degree research	Perform comprehensive, 360-degree research on all candidates in the pipeline	 Interview thought leaders and industry practitioners Assess candidates' fit with best practices criteria Rank all candidates 	Matrix positioning of all candidates' performance relative to one another
3	Invite thought leadership in best practices	Perform in-depth examination of all candidates	 Confirm best practices criteria Examine eligibility of all candidates Identify any information gaps 	Detailed profiles of all ranked candidates
4	Initiate research director review	Conduct an unbiased evaluation of all candidate profiles	 Brainstorm ranking options Invite multiple perspectives on candidates' performance Update candidate profiles 	Final prioritization of all eligible candidates and companion best practices positioning paper
5	Assemble panel of industry experts	Present findings to an expert panel of industry thought leaders	 Share findings Strengthen cases for candidate eligibility Prioritize candidates 	Refined list of prioritized award candidates
6	Conduct global industry review	Build consensus on award candidates' eligibility	 Hold global team meeting to review all candidates Pressure-test fit with criteria Confirm inclusion of all eligible candidates 	Final list of eligible award candidates, representing success stories worldwide
7	Perform quality check	Develop official award consideration materials	 Perform final performance benchmarking activities Write nominations Perform quality review 	High-quality, accurate, and creative presentation of nominees' successes
8	Reconnect with panel of industry experts	Finalize the selection of the best practices award recipient	 Review analysis with panel Build consensus Select recipient	Decision on which company performs best against all best practices criteria
9	Communicate recognition	Inform award recipient of recognition	 Announce award to the CEO Inspire the organization for continued success Celebrate the recipient's performance 	Announcement of award and plan for how recipient can use the award to enhance the brand
10	Take strategic action	Upon licensing, company is able to share award news with stakeholders and customers	 Coordinate media outreach Design a marketing plan Assess award's role in strategic planning 	Widespread awareness of recipient's award status among investors, media personnel, and employees

The Intersection between 360-Degree Research and Best Practices Awards

Research Methodology

Frost & Sullivan's 360-degree research methodology represents the analytical rigor of the research process. It offers a 360-degree view of industry challenges, trends, and issues by integrating all 7 of Frost & Sullivan's research methodologies. Too often companies make important growth decisions based on a narrow understanding of their environment. resulting in errors of both omission and commission. Successful growth strategies are founded on a thorough understanding of market, technical, economic, financial, customer, best practices, and demographic analyses. The integration of these research disciplines into the 360-degree research methodology provides an evaluation platform for benchmarking industry



players and for identifying those performing at best-in-class levels.

About Frost & Sullivan

Frost & Sullivan, the Growth Partnership Company, helps clients accelerate growth and achieve best-in-class positions in growth, innovation, and leadership. The company's Growth Partnership Service provides the CEO and the CEO's growth team with disciplined research and best practice models to drive the generation, evaluation and implementation of powerful growth strategies. Frost & Sullivan leverages nearly 60 years of experience in partnering with Global 1000 companies, emerging businesses, and the investment community from 45 offices on 6 continents. To join Frost & Sullivan's Growth Partnership, visit http://www.frost.com.

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