Rosa Raskin, Rosa S Raskin & Associates discusses the benefits of collaboration when researching for innovative technology for automotive coatings

Automotive coatings: innovation and collaboration

The compound eye of an insect serves as a template for the development of anti-reflective coatings. The night vision of moths and bees has been used as a model to carry out research to improve a driver's night vision

Collaboration, documented in the historical record of the automotive coatings industry, offers an attainable and realistic strategy for innovation. The alternative, to be first in research and development, is expensive.

The knowledge base of automotive coatings moved from alchemy to polymer science as the automobile industry drove technological change in the paint industry. As new chemically-based materials were invented, paint suppliers moved from Africa and Asia to chemical companies in Germany, Great Britain and the USA[1]. In general, automotive OEM coatings are produced where they are applied[2].

Coatings advanced in step with developments in related industries. The earliest automobile finishes were varnishes used on furniture and horse drawn carriages. These coatings were labour intensive, had a limited life-span and few colours. A time line for automotive coatings includes varnishes, nitrocellulose, alkyd resins, lacquers, acrylic resins, electrocoats (e-coats), primers, topcoats (basecoats plus clearcoats), smart and nanocoatings, and green technologies.

Automotive coatings include an electrocoat, a primer and a topcoat. Coatings are critical to automobile aesthetics, durability, resistance to chemical or physical impact and cost[3]. Engineers in the automotive industry partnered with colleagues in aerospace as early as NASA's first manned space mission[4].

In the last 15 years, the automobile and aerospace industries created alliances to collaborate on nanotechnology research to advance coatings technology[5]. In the November, 2009, issue of ***PPCJ***, Geert-Jan Doggen details the roles of each of five partners co-operating in the research and development project targeting bumpers, lightweight construction using thermoplastic nanocomposites[6].

BIOINSPIRATION

Biological systems evolved over millions of years to acquire unique and complex features that require teams of multidisciplinary scientists to decode nature's mysteries.

The compound eye of an insect has structural features in the cornea to reduce reflectivity. The unique structures, termed nonclose-packed nipples (ncp), serve as templates for the development of anti-reflective coatings[7].

A prototype of an insect-inspired colour camera is being tested in Belgium. The compound eye of nocturnally active moths, bees and dung beetles is a model for vision research in dim light. Automotive engineers interested in developing safety features in cars, joined mathematicians and biologists of Sweden's Lund University to imitate insect vision. The night vision of the insect is converted into mathematical algorithms that serve as a basis for digital image creation for a new type of night camera to improve a driver's night vision[8].

MATERIALS

A recent patent, US 7649044, designed for automotive coating applications, includes the use of pulverised rubber particles made from waste rubber. The coating is described as having financial advantages and reducing waste. The automotive coating is designated for optical and/or tactile effects as the rubber particles impart a soft feel, display a matte finish or have a leathery appearance. The coating may be applied to internal parts such as dashboards, door panels or as a protective coating to the underbody of the vehicle.

Clear overcoats can be applied to the rubber coating and cured at ambient temperature or by thermal energy. Pulverised rubber can include the additives in the original vulcanised rubber including sulphur, carbon black and oils. The rubber is sized for spraying, with particles at least 200 US mesh. In addition to rubber, the coating includes a binder component having hydroxyl-functional groups and a curing agent having functional groups reactive with the binder[9].

The background section of the patent indicates that earlier patents on the use of crumb rubber were limited to adhesives, included an epoxy-functional polymer and/or designated for automotive applications such as truck bed liners.

News on the physorg.com website states: 'Spray-on liquid glass is about to revolutionise almost everything'. Glass is composed of silica. Liquid glass spray is an ultra-thin layer of silicon dioxide, SiO_2. The spray is nearly pure silicon dioxide from quartz sand to which water or ethanol is added. Quantum forces, rather than additives, bond the nano-scale glass coating to the substrate. The coating is water-resistant and around 100nm thick.

The thin glass coating is breathable and flexible. The coating is reported to be non-toxic, easy to clean with water or a damp cloth and resists water, dirt, UV light and acids[10]. Resistance to acids is a property that may prove beneficial

Author:
Rosa S Raskin, MS, MLS, proprietor of Rosa S Raskin & Associates, LLC, 451 Lassiter Drive, Highland Heights, Ohio 44143, USA
Tel: +1 440 461 4125; rosa@raskinfo.com; www.raskinfo.com

for automotive finishes exposed to pollution.

Liquid glass, SiO_2-ultra thin layering, was invented in Turkey. The patent is held by Nanopool of Germany, which created 30 variations for special uses that can be re-applied easily. Research on the glass product was performed at the Saarbrücken Institute for New Materials. Industries from food to transportation are testing liquid glass against weathering and graffiti. Liquid glass technology is available for domestic use in Germany as described on the Nanopool website at www.nanopool.eu/couk/index.htm. The price of liquid glass spray in DIY stores in Britain is estimated at £5 (US$8)(11).

An innovative bisphenol-A '1'-type solid epoxy resin dispersion cured with modified amine has been formulated. The new zero-VOC, water-based epoxy topcoat is reported to offer high gloss, fast cure, long pot life and excellent resistance to water, humidity and corrosion on metal and concrete substrates. The coating resists motor oil, brake fluid, bleach and many industrial chemicals(12).

RESISTANCE

The US EPA states that the general consensus within the auto industry is that some form of environmental fallout causes damage to automobile coatings. The environmental fallout includes acid rain, decaying insects, bird droppings, pollen and tree sap. Damage is not universal to all vehicles or to all coatings, suggesting that technology exists to protect the automobile(13).

Appropriate protective coatings preserve the original finish and are an alternative to frequent washing and hand drying. In acid rain, damage occurs to vehicle exteriors on the evaporation of the acidic moisture(13).

A recent feature article on NASA's website at www.nasa.gov/topics/technology/features/corrosionmicrocaps.html describes anti-corrosion research at the Space Life Sciences Laboratory at NASA's Kennedy Space Center in Florida. The NASA Corrosion Technology Laboratory is developing a new weapon to ward off rust and corrosion on metals using a smart coating. The coating is of interest to automobile companies as millions of microcapsules are embedded in paint to inhibit rust. The chemicals stay inside the capsules until rust begins to form, limiting environmental impact. Some of the microcapsules, filled with material that changes the colour of the affected area, highlight corrosion. The research is ongoing to identify how best to use microcapsules to fight corrosion(14).

The automobile industry envisioned nanocoatings with high levels of scratch resistance in 2004 at Strasbourg University in France. A future clear topcoat was described as incorporating nanocomposites(15).

During the economic downturn, several European coating companies expanded production capacity, put more resources in innovation and launched a new scratch-resistant clearcoat for automobiles(16).

A recent article compares the scratch resistance and recovery of a polyurethane clearcoat with an acrylic/melamine/silane clearcoat. The polyurethane clearcoat showed improved scratch recovery after warming for two hours at 60°C. The polyurethane formulation is reported to have superior scratch and mar resistance. After 2000hr of weathering, the performance of the polyurethane coating continued to be superior to that of the acrylic/melamine/silane(17).

Self-cleaning polyurethane clear coats offer a high gloss, wet look for exterior automobile finishes. Polyurethane coats are compatible with basecoats, are tough yet elastic due to the urea structure(18).

A colour engineering group from Iran noted that incorporating increased amounts of hydrophobic nano silica particles into an automotive clearcoat increased toughness. As the nano silica content of the acrylic/melamine clearcoat increased, the nature of the scratch changed from a fracture type to plastic(19).

One desired property for automotive parts is resistance to chipping. A 2009 patent application, US 20090110934, includes a chip resistant powder top coat for a corrosion resistant powder (basecoat) coated steel substrate. Steel substrates identified in the patent include automotive suspension coil springs made of high tensile steel. High tensile steel coil springs are scratch sensitive requiring protection from impact damage caused by flying stones and gravel on roads. The inventors describe an economical coating for high tensile steel in which the top coat is reduced in thickness by 40%(20).

A thermal spray coating process for aluminium engine blocks, termed Plasma Transferred Wire Arc (PTWA), improves fuel efficiency and replaces heavy cast iron liners. The weight of the engine is reduced as are internal piston friction losses. PTWA uses air and electricity to create a plasma jet of 35,000°F, melting a steel wire that is fed into a rotating spray gun. The process includes coating the internal surfaces of engine cylinder bores with the plasma jet of melted steel wire resulting in a 150-micron-thick nanoparticle composite coating of iron and iron oxide. Thermal spray coatings have been used for years in the aerospace industry for increasing the durability and performance of aircraft turbine engines. Collaboration is cited as key to transferring this technology to the auto industry(21).

The Intellectual Property Owners Education Foundation honoured the inventors of the Ford-patented PTWA technology with the 2009 National Inventor of the Year Award(22).

Hard coatings are enabled by nanotechnology(3). Premature punch failure in stamping 0.157in-thick-strength low-alloy steel for the automotive industry was overcome by applying a nanocoating including chromium-nitride to increase the hardness and wear resistance of the punch. The newly coated punches save the company hours of downtime and the expense of replacing punches. The lubricity from the new coating prevents material catching in the punch(23).

COLOUR, BRILLIANCE AND GLOSS

A new patent for durable glass enamel for creating dark, opaque borders in the perimeter of automotive windows includes bismuth oxide and has no lead or cadmium(24).

Nanotechnology enables new colouration effects in automobile paints. The current market is estimated around US$133M, rising to US$330M+ by 2015 in a recent report, 'Nanocoatings for the Automotive Industry', published by Future Markets, Inc.

CURING

Curing coatings on automotive bodies may include high energy electron beams or x-rays. The energy beam penetrates multiple layers of steel including the thicker coating that accumulates in surface cracks and crevices. A patent application describing the process states that the use of electron beam curable coatings reduces fire hazard and air pollutants due to volatile organic compounds associated with non-reactive solvents in solvent based paints[26].

RECENT PATENTS AND PATENT APPLICATIONS

A search of the recent patent literature identifies hundreds of patents and patent applications related to automotive coatings. Recent inventions include coatings that protect flammable substrates, resist corrosion, offer customisation, demonstrate antibacterial activity and are sun proof or sound proof as identified in the table below.

CONCLUSION

Automotive coatings continue to reap benefits from affiliations and synergistic partnerships sowed many years ago. Innovative coatings are designed and tested in collaboration with engineers in multiple industry sectors.

Driving forces to improve automotive coatings include efficiency in production, materials research, waste reduction, regulations, environmental effects, environmental impact, quality, beauty, and cost. Automotive coatings benefit from research in novel materials. Inventions such as sprayed glass and NASA's microencapsulated smart coatings represent state-of-the-art, collaborative research.

Using nature as a model, engineers partner with scientists to discover technological solutions to challenges in the automotive industry.

As documented in recent patents, automotive coatings continue on the offense. Collaboration inspires innovation in the development of automotive coatings, remains a cost-effective method to move from concept to production, and benefits the driver.

References

1. Todd, Jan. Cars, Paint, and Chemicals: Industry Linkages and the Capture of Overseas Technology between the Wars. Australian Economic History Review, Volume 38, Number 2, pp. 176-193, January 1, 1998.

2. Detiveaux, Scott. The automotive OEM coatings market: impact of the global economic downturn. JCT CoatingsTech, p. 1894, June 1, 2009.

3. SpecialChem. Application Overview: Automotive Refinish and OEM Coatings. 2010 http://www.specialchem4coatings.com/tc/automotive.aspx

4. Chang, Emily. Advancing Automotive Design with Innovative Collaboration. NASA Tech Briefs, Volume 34, Number 3, pp. 18-20, March, 2010.

5. Loebbaka, Charles R. Alliance with Ford, Boeing Announced. Northwestern University Newscenter, October 6, 2005. http://www.northwestern.edu/newscenter/stories/2005/10/ford.html

6. Doggen, Geert-Jan. Potential of nano-scale fillers. PPCJ: Polymers Paint Colour Journal, Volume 199, Number 4542, pp. 33-36, November, 2009.

7. Min, Wei-Lung et al. Bioinspired Self-Cleaning Antireflection Coatings. Advanced Materials, Volume 20, pp. 1-5, 2008.

8. Insectlike Night Cameras. Photonics.com, News & Features, January 11, 2010. http://www.photonics.com/Article.aspx?AID=40772

9. Czorniij, et al. Automotive coatings comprising pulverized rubber. Patent US 7649044, January 19, 2010.

10. Edwards, Lyn. Spray-on liquid glass is about to revolutionize almost everything. Physorg.com, February 2, 2010. www.physorg.com/news184310039.html

11. Biofilm Resistant Nano Surfaces. Cleanroom Technology: The European Journal of Contamination Control, pp. 18-21, June, 2009.

12. Zhao, Wendy. Zero-Voc, Water-Based Epoxy Topcoat. PCI: Paint & Coatings Industry, March 1, 2010.

13. U.S. EPA, 2007. Effects of Acid Rain - Automotive Coatings. www.epa.gov /acidrain/effects/auto.html

14. Siceloff, Steve. Corrosion Fighters Develop Microscopic Tools. Feature, NASA Kennedy Space Center, February 26, 2010. http://www.nasa.gov/topics/technology/features/corrosionmicrocaps_prt.htm

15. Milmo, Sean. Affordable nanocomposites? Researchers are tackling cost concerns through careful selection of materials. Cited in The Free Library, from Coatings World, Editorial, July 1, 2004.

16. Milmo, Sean. Europe. Recession Restructure. Coatings World, Volume 14, Number 12, pp. 16-17, December, 2009.

17. Seubert, Christopher, et al. The effect of weathering and thermal treatment on the scratch recovery characteristics of clearcoats. Journal of Coatings Technology and Research, Volume 7, Number 2, pp. 159-166, March, 2010.

18. Henderson, Karen. Self-healing polyurethane clearcoats: new developments for exterior automotive coatings. Paint & Coatings Industry, Volume 25, pp. 40-43, May, 2009.

19. Tahmassebi, N. et al. Effect of addition of hydrophobic nano silica on viscoelastic properties and scratch resistance of an acrylic/melamine automotive clearcoat. Tribology International, Volume 43, Number 3, pp. 685-693, March, 2010.

20. Cinoman, Douglas S. et al. Thin chip resistant powder topcoats for steel. Patent Application US 20090110934, April 30, 2009.

21. 2011 Ford Shelby GT500 Goes Lightweight with Aluminum Engine, Offers Ultimate in Handling. Ford Motor Company, Press Release, February 8, 2010.

22. Energy-efficient Engine Technology Wins Ford Team National Inventor of the Year Award. Ford Motor Company, Press Release, May 28, 2009.

23. New Coating Prevents Punch Ends from Ripping Off. Metalforming, Volume 44, Number 3, pp. 18-19, March, 2010.

24. Emlemdi, Hasan B. Durable functional glass enamel coating for automotive applications. Patent US 7528084, May 5, 2009.

25. Nanocoatings for the Automotive Industry. Future Markets, Inc., January, 2010.

26. Kerluke, David R., et al. Method of curing coatings on automtotive bodies using high energy electron beam or X-ray. Patent Application US 20090155480, June 18, 2009.

Selected Recent Patents or Patent Applications

Title	Application Publication No or Patent No	Publication Date	Inventor
Flame retardant polymer compositions (includes automotive coatings industry)	US 20100056687	March 4, 2010	Diakoumakos, C.D. et al
Solar reflective coatings and coating systems (for dark coloured autos that absorb heat on sunny days)	US 20100047620	February 25, 2010	Decker, E.L. et al
Coating compositions exhibiting corrosion resistance properties, related coated articles and methods	US 20100044235	February 25, 2010	Scott, M.S. et al
Automotive substrate having a coating layer system with a barrier coating composition layer	US 20100047583	February 25, 2010	Miles, M.S. et al.
Coating for harsh environments and sensors using same	US 20100038997	February 18, 2010	Andle, J.C. et al
Nanosized particles of benzimidazolone pigments (for automotive paints and coatings)	US 20100037955	February 18, 2010	Carlini, R. et al
Fine-grained metallic coatings having the coefficient of thermal expansion matched to the one of the substrate	US 20100028714	February 4, 2010	Palumbo, G. et al
Process for producing coating compositions with customisable properties (for automotive refinish applications)	US 7652099 (patent)	January 26, 2010	Fiori, D.E. et al
Protective coating (protect auto parts, from heat and flame)	US 7652087 (patent)	January 26, 2010	Dimanshteyn, F.A. et al
Photoluminescent pigment, and photoluminescent coating composition and automotive outer panel each comprising the same	EP 2145927 (A1)	January 20, 2010	Kitamura, T et al
Transparent porous SiO_2 coating for a transparent substrate material for headlight housings in automobile engineering	US 20100009195	January 14, 2010	Berndt, A et al
Aqueous polyurethane clear coating material useful as a finishing coating of automobiles possessing antibacterial properties (coating includes natural antibiotic urushiol)	KR 20090038269 (A)	April 20, 2009	Jung Woo Chul
Soundproofing coatings, method for the production thereof and use of the same	US 20090000865	January 1, 2009	Zisch, P. et al