A S Khanna, J Material Sci Eng 2015, 4:3
http://dx.doi.org/10.4172/2169-0022.S1.019

OMICS International
conferenceseries.com

International Conference on
Smart Materials & Structures
June 15 -17, 2015 Las Vegas, USA

Inorganic-organic hybrid based smart coatings

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Inorganic-organic hybrid (IOH) coatings are the best example of eco-friendly high performance coatings. They differ from conventional coatings in several counts: use water as solvent, form chemical bond with the substrate, have superior corrosion resistance, better mechanical properties and excellent UV blocking effect. They are also considered as nano-structured coatings. The best way to synthesise them is by solgel route. Sol-gel method starts with a hydrolysis reaction of a methoxy or ethoxysilane, followed by a condensation reaction with any functional polymer, epoxy, alkyd, polyester or urethane, provided there is an –OH group in the long chain of the monomer. The resultant precursor can then be treated with a suitable cross-linking agent to form an inorganic-organic hybrid coating. This coating can be applied on any metal substrate by spray, dipping or spin coating process after lightly activating the substrate. Such coatings were prepared in our lab using epoxy silanes, alkyds, polyurethane and polyester based monomers. These coatings showed excellent corrosion resistance much superiortothe conventional coatings as well good mechanical and UV properties. These coatings were however hydrophilic in nature with a contact angle of 65°-68°.

An epoxy based IOH coating was then modified to a Self Cleaning Smart Coating. This was done by systematically treating the coating developed as discussed above with a set of PSMorine based silanes which gave excellent hydrophobicity with a contact angle of above 110°. The coating under these conditions followed Wenzel model and in order to give it self-cleaning property, it was treated with different nano-particles, nano-ZnO and nano SiO_2. A detailed treatment was then carried out to optimize the concentration of nano particles and their surface roughness and arrangement was studied using AFM and Raman spectroscopy. It was found that nano silica functionalised by a long chain polymer, gave the best sliding angle, suitable for self-cleaning. This coating was found to create hydrophobicity on metal such Al, card board, paper, fabric, wood, concrete and glass.

However, to use this coating as smart coating to clean glass panels in multi-storeyed buildings or solar panels in a huge solar power plant, the coating needs to be transparent. Further work was carried out using a non-PSMro approach using PDMS as long chain polymer, followed by insitu generation of silica particles. This helped in creating a transparent coating with good hydrophobicity, a contact angle of 109° and a sliding angle of 25°. Detailed analysis using Raman confirmed presence of tiny nano silica particles on surface, but went under the coating after heat treatment. The coating technique also varied the properties of the coating. Spin coating under certain RPM gave the best hydrophobic and sliding effect. These coatings are now being planned to create anti-glare and anti-fog coatings.

Another method to create super-hydrophobic coating was developed using functionalization of titanium oxide particles. Functionalization using PDMS was found to be the best, giving a contact angle of 150°. This, when mixed with epoxy coating showed strong super-hydrophobic behaviour.

A few examples of other smart coatings developed in our lab such as self-healing coatings and conductive coatings will also be discussed.

Biography

A S Khanna is a Professor at Indian Institute of Technology, Bombay, India with responsibility for teaching, research and consultancy in the field of corrosion, coatings, surface engineering and corrosion management. Prior to joining IIT Bombay in 1991, He worked in Atomic Energy and carried out R & D work at several International Labs / universities / Institutions, including Forschungszentrum Juelich (as Humboldt Fellow), Oslo University (Royal Norwegian Fellow), University de Provence, Marseille France and IHI Heavy Industry, Japan (Fellow Japan Key Centre). Notable is his 23 years as Professor for IIT Bombay. He has guided 22 PhD and more than hundred Masters and Bachelors' projects. He has published more than 275 papers in various National and International Journals. He is widely travelled and participated in umpteen numbers of conferences and meetings. He has written two books and edited 4 books. One of the books is High Performance Coatings, Woodhead publications, UK. His professional interests focus on Coatings, Industrial corrosion prevention, surface engineering, high temperature materials. His current projects include development of smart coatings and nano-technology for enhancing paint coatings, development of grapheme and its applications in protective coatings. He is consultant / Advisor to many oil & Gas industries such as ONGC, GAIL, Reliance. In addition, he serves as Chairman for SSPC India, and is a member of NACE and ASM. He was awarded NACE Fellow in 2002 and ASM Fellow in 2005, for his contributions to the work in corrosion and coatings

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