Enhancement of polymeric materials through nanotechnology

Performance Enhancement of Polymeric Materials through Nanotechnology

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Abstract: In the last decade or so, nanotechnology has gained tremendous and widespread attention. Currently, nanotechnology is being applied in many fields to formulate materials with novel functions due to their unique physical and chemical properties. The major nanotechnology applications are identified as energy, agriculture productivity, water treatment, disease diagnosis, drug delivery system, food processing, air pollution & control, construction, health monitoring etc. In the construction sector, nanotechnology is being used in a variety of ways to produce innovative materials. Using nanotechnology as a tool, it is possible to modify the nano/basic structure of the materials to improve the bulk properties. The applications of nanomaterials in construction improve the essential properties of building materials and novel collateral functions such as energy saving, self healing, anti fogging and super hydrophobic. Present paper focuses on how nanotechnology has improved and enhanced the performance of polymeric materials in buildings.

Introduction

Nanotechnology is gaining widespread attention and being applied in many fields to formulate materials with novel functions due to their unique physical and chemical properties. Major nanotechnology applications are identified as energy, agricultural productivity, water treatment, disease diagnosis, drug delivery system, food processing, air pollution & control, construction, health monitoring etc. In the construction sector, nanotechnology is being used in a variety of ways to produce innovative materials. Using nanotechnology as a tool, it is possible to modify the nano/basic structure of the materials to improve the material's bulk properties such as mechanical performance, volume stability, durability and sustainability. The applications of nano materials in construction improve the essential properties of building materials such as strength, durability bond strength, corrosion resistance, abrasion resistance, novel collateral functions such as energy saving, self healing, anti fogging and super hydrophobic.

Newer applications in the field of advanced materials are related to matter for which the surface-to-volume ratio is very high. Nanotechnology significantly improves and enhances the performance of these materials. In fact nanotechnology based polymeric materials can be developed into multifunctional materials. Therefore, the combination at the nano size level of inorganic/ organic components into a single material may lead to an immense new area of materials science leading to development of multifunctional polymeric materials (Cao et al., 2001; Kowalczyk and Spychaj, 2009; Lee et al., 2010; Thapliyal, 2011; Zhao et al., 2012).

Role of nanotechnology in polymeric materials

Today's buildings contain many polymeric materials including neoprene, silicone, poly(vinyl chloride) (PVC), ethylene tetrafluoroethylene (ETFE), laminated glass using polyvinylbutyral and fiber-reinforced polymer composites. Many of these polymeric materials were discovered and used successfully in industry decades before their application in buildings. Polymeric materials are also important components of paints and coating systems. These polymeric materials are expected to have characteristics such as (a) excellent weather ability (exterior durability), (b) film integrity, (c) tunable mechanical performance, (d) process ability, (e) amenable for environmentally friendly coating formulations, among others.

Using nano technology, polymeric materials including advanced coatings systems can improve energy efficiency, durability, aesthetics and other functionalities of buildings and superstructures. For example, cool-roof coatings (high solar refection and thermal emission) have been very effective in increasing building efficiency and thereby reducing energy consumption for cooling. Solar heat-absorbing polymeric materials are becoming essential components of solar collectors used in solar energy harvesting. Super-durable coatings with self-cleaning properties are in much demands for applications on super-structures, monuments and areas where re-painting is very costly.

Current status

Polymeric materials such as coating systems are reported for the corrosion prevention based on alkyds, acrylics, polyurethanes, polyesters and epoxies. Among them epoxies have number of advantages such as better physico-mechanical properties and improved chemical resistance. Its low UV resistance and higher cost led to develop innovative epoxies by blending with low cost renewable natural resins. The epoxy resin and modified epoxy cardanol resin based coatings form a kind of inter penetrating network (IPN) on the surface of steel and concrete, thus providing a barrier to the attack by moisture. IPNs possess several interesting characteristics in comparison to normal polyblends, because varied synthetic techniques yield IPNs of such diverse properties that their engineering potential spans a broad gamut of modern technology (Sperling, 1981; Thapliyal, 2010).

In Indian scenario ongoing research efforts on polymeric materials at IIT Bombay, researchers are taking into consideration of the basic issues like homogeneous dispersion of CNT in polymer matrix and adequate interfacial adhesion among the phases and a novel CNT material i. e., SMA-g-MWNT is being by grafting acid functionalized MWNT with styrene maleic anhydride (SMA) dissolved in THF solvent. The R&D work on development of heat reflecting coating on flat glass is being done at CSIR-CGCRI. CSIR-CBRI has the expertise in the area of polymeric materials especially adhesives, sealants and coatings. In the past, CSIR-CBRI scientists have done work in the field of synthesis, formulation and testing of different types of polymeric materials. As a result CSIR-CBRI had published a number of research publications and several technologies were transferred to the private organizations. For example, CSIR-CBRI has developed natural cardanol resin based epoxy coating systems for corrosion protection. (Aggarwal et al., 2007; Thapliyal, 2010)

A new era of polymeric material innovations for buildings

Recent developments in the field of the fabrication and characterisation of objects at the nano-scale make it possible to design and realise new materials with special functional properties. For example, materials can be strengthened or, conversely, made more flexible, or materials can be given greater electrical resistance and lower thermal resistance. The possibilities are virtually endless, particularly in relation to the coupling between living cells and specific functional nanoparticles, nanosurfaces or nanostructures. Artificially inserted organic particles or surfaces can influence a cell to the extent that it takes on an entirely new functionality, such as fluorescence or magnetism. Insertion of these particles or surfaces in cells may even result in the production of new biomaterials. These couplings open up many new scientific and commercial avenues.

New material—polyamide, or nylon—has emerged in applications as a “ smart” vapour barrier in exterior envelopes. Its water vapour permeability increases ten times even in conditions of very high humidity. This is particularly useful when moisture is trapped inside a wall assembly. The vapour barrier becomes more permeable and allows moisture to escape, reducing the risk of corrosion, rot, and the growth of mould and mildew. Although nylon was discovered in 1931, its properties as a vapour barrier were not described until 1999, and it was recently commercialized for this purpose. Both of these examples illustrate opportunities that arise from addressing the needs of the built environment with polymeric materials science and engineering. The first resulted from an unintended consequence of an aesthetic choice, the second from an overlooked property of a common polymeric material. Both examples raise the question of why our built environment has been so resistant to change when new polymeric materials may offer better performance and more satisfying aesthetic results (Munirasu et al., 2009; Thapliyal, 2010; Singh et al., 2010).

Conclusions

Building new polymeric materials at the atomic and nano scale and structuring or combining existing materials, resulting in entirely new characteristics of these materials, make the application area virtually limitless. The international interest in this area is demonstrated clearly by the growing number of major research programmes being funded in Europe, Japan and the USA as well as in Australia, Canada, China, S. Korea, Singapore and Taiwan, etc. However, the introduction of unfamiliar polymeric materials in buildings is difficult because of life safety concerns, first-cost constraints, and the reluctance of builders to adopt new practices in the field. In addition, the very long life of buildings that serve as host to unproven polymeric materials compounds the risk of legal exposure for all involved, from researchers to builders. However, it is likely that latent opportunities for achieving a substantially improved built environment await the attention of building experts and the polymeric/materials science community united in common research goals.

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