Electrodeposited Functional Polymer Nano-composites (EFPNC) – Futuristic Materials for Aerospace and Electronic Applications

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ABSTRACT

Polymer Nano-composites (PNCs) have been the subject of intense research for more than a decade owing to their enhanced properties, viz. thermal, mechanical, electrical and corrosion resistance, etc., and also their versatility for incorporation of specific functionality, compared to their conventional counterparts. Such PNCs are currently synthesised by conventional mixing of nano-particles with the liquid polymer matrix using mechanical roll-mixing and ultrasonication techniques [1, 2]. These nano-compositions are applied on the substrate surface by conventional methods like spraying, brushing, dipping, and more recently reported by screen-printing [3].

Range of PNCs based on epoxy matrix have been recently reported [2-4] incorporating specific nano-fillers (e.g., nanoclays, metal-oxides, graphite, carbon nano tubes, iron oxide etc.) resulting in a variety of corresponding nano-composites with insulating, semiconducting or magnetic properties. Such semi-conducting PNCs containing CNTs have been reported [3, 5] for Electromagnetic Interference Shielding Effectiveness (EMI-SE) in electronic equipments. Recent advent of Inherently Conductive Polymers (ICPs) viz., Polyaniline, Polypyrrole, Polythiophene etc. [6] in combination with conductive nano-fillers has led to another class of PNCs having enhanced electrical conductivity.

However, the conventional techniques used to prepare the PNCs, are reported to have the limitation of loading of the nano-phase in the polymer matrix due to viscosity build-up, thereby limiting the functional property of the resultant nano-composite, namely, electrical conductivity that directly affects the EMI-SE property of the PNC, besides posing the difficulties in handling the viscous compositions and hazardous organic solvents.

In this article, the author reports a novel Electro-phoretic process of co-deposition (EPD) of electro-activated polymer matrix together with the nano-filler particles resulting in a PNC coating on to a cathodic substrate surface (metallic or composite) under the influence of dc electric field, followed by appropriate curing. The process utilises a commercial grade bifunctional epoxide polymer duly electro-activated and converted into an aqueous emulsion in which the nanoclay particulates (NP) of montmorillonite (MMT) are dispersed and ultrasonicated. The novel process permits the NP content more than10% by weight of the polymer in aqueous bath. EPD process parameters like, bath composition, dc voltage and throwing power have been studied. The author highlights some results in one of the studies [7] showing significant improvement in mechanical properties like adhesion (No peeling as per ASTM D-3359-87), corrosion resistance (after 800 h. exposure to 5% salt fog), increase in dielectric strength by 2 times (36kV/mm), volume resistivity by 10 times (4.3×10^{16} Ωcm) at 8% by weight MMT loading, as compared to the pristine polymer.

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Further studies are in progress to extend this EPD process to electrodeposit semi-conducting and conducting PNCs containing the conducting nano particles like, nano-ferrites, CNTs, graphenes, and their hybrid combinations dispersed in the same host epoxy matrix, targeted for EMI shielding of electronic devices including the strategic aircraft systems. The EPD process has the advantage of permitting higher loadings of the nanophase particles in the polymer matrix in aqueous medium (viscosity not an issue) resulting in superior functional properties, besides being eco-friendly (clean and green) and economical. In summary, in this paper, the author has attempted to showcase the novel Electro-phoretic deposition process to produce functional PNCs that could turn out to be one of the futuristic processes for versatile applications.

ACKNOWLEDGEMENT

I acknowledge thankfully the research grant received from DRDO-EMR, New Delhi for initial part of the project. I also thank the Management of EPCET for permission to present this work at the ICTACEM-2017. I gratefully thank the Composite Expert Dr. R.M.V.G.K. Rao (Retired-CSIR-NAL), for valuable scientific suggestions and constant encouragement.

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