Engineering and Technology Journal for Research and Innovation (ETJRI)
ISSN 2581-8678, Volume III, Issue II, July 2021

Review on Conducting Nano-composites and Their Applications

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***Abstract*—This paper presents a review article on the usage on conducting nanocomposites for electronic applications. The various synthesis procedures of nanocomposites are also presented. The changes in structural, morphological effects the electrical properties are discussed. Possibilities of various conducting nanocomposites are elucidated.**

***Keywords*—Nano-materials, Nano-composites, Conducting Nano-composites**

I. INTRODUCTION

A Nanometer is equal to 10^-9 of a meter. In Nanomaterials a single unit is sized between 1 to 100nm. It involves Research and technology development at the atomic, molecular or macromolecular levels, in the length scale of approximately 1 – 100 nm range. Because of their small and intermediate size, they provide novel properties and functions for systems and devices. Nanometer-scale is crucial for technology because Nano atoms are a portion of a nanometer in size and as the few atoms are combined together to produce a device, that device has the dimensions of nanometers. The tiny size and strength, extraordinary physical and electrical properties present them a quite different material with a complete range of encouraging applications. The tiniest transistors, motors, memory cells, pumps, lasers and sensors for security systems, displays for hand-held computer games, high-resolution cinema screens, and water purification units for manned spacecraft are all some nanometers in size. Nanotechnology has the potential to build many new materials and devices with wide-ranging applications, such as in medicine, electronics, and energy production.

A composite material typically consists of one or more fillers (fibrous or particulate) in ascertain matrix. A carbon fiber composite is one in which at least one of the fillers consists of [1, 2]. Carbon fibers (short or continuous, unidirectional or multidirectional) The characteristics of composites depends on physical properties of the components and on interfacial region. Effective fillers require good bonding (chemical, mechanical, and physical) between the fibers and the matrix. Fillers improve performance. Non-functional fillers are mainly used to reduce costs, and functional fillers improve new properties in the composites. The parameters that are used in determining the effect of fillers on the properties of composites are the filler geometry (size, shape, aspect ratio) and the filler matrix interactions [3].

A. *Structure of the Composites*

According to the structure three different types of clay-polymer compo sites can be distinguished [4] a) When the matrix polymer chains are unable to penetrate between the Layers of the silicate particles a conventional composite is formed. b) Intercalated structures are formed when one or more polymer chains intercalate between the layers. Hereby the interlayer spacing is increased but the ordered layer structure of the clay particles is retained as can be observed by wide angle X-ray diffraction (WXRD). c) In exfoliated composites the clay particles are completely delaminated and the silicate layers do not show any periodicity in their arrangement.

The addition of nano-particles exhibits drastic improvement in super conductivity, magnetism, thermal stability [5, 6], and mechanical properties [7, 8]. The improvements are due to the high surface-to-volume ratio of nano-particles. Magnetic polymer nano-particles can be tailor-made depending on the final applications [8-10]. Polymers & their composites are finding ever increasing usage for numerous industrial applications such as bearing material, rollers, seals, gears, cams, wheels, clutches and transmission belts etc. [11, 12]. Different types of polymer show different friction and wear behaviour [13-16]. In recent decades, conducting polymers have attracted

much attention because of their potential applications in various fields such as molecular electronic, antistatic coatings, electromagnetic interference (EMI) shielding, rechargeable batteries, chemical sensor, corrosion inhibitors, microwave absorbing materials [17-23] etc. Among the conducting polymers, polyaniline (PANI) has been extensively studied due to its easy synthesis, low cost, excellent environmental stability, and high electrical conductivity [24,25][26,27,28]. Incorporation of magnetic constituents in conducting polymeric materials opens new possibilities for the achievement of good shielding for various electromagnetic sources. Nano-particles (NPs) from transition iron-group metals such as iron,[29-33] cobalt[33-45] and nickel[27,33,20-27] are of great interest due to their unusual physicochemical properties such as enhanced magnetic moment[46-54]and enlarged coercively[29-55] arising from their tiny size less than 100 nm and high specific surface area (ratio of the surface to the mass/volume). CNTs)/carbon fibers [56-62] and carbon–carbon bonds,[63-67] ultrahigh density magnetic recording media,[68-72] magnetic fluids,[73-75] structural polymer Nano composites (PNCs)[76-84] and biomedical drug delivery [85]. Additionally, iron-group metal NPs have been synthesized as alloys either within the iron-group elements[86-100] or with other metals such as Au[101] Pd[102,103] Pt[104-108] Ru(Rh)[109] Cu[110] and C[111-117] which broaden the potential applications of these iron-group metal NPs.

In shell materials, a polymer shell has the following advantages: (1) it can serve as a surfactant or stabilizer to prevent the agglomeration of NPs; (2) it can be used to fabricate the nano capsulation through the layer-by-layer method; and (3) it can be compatible with or functionalized with other materials by selectively choosing the shell materials such as branched poly (ethylenimine) shell around the poly (methyl methacrylate) (PMMA) core. The physical and chemical properties of the core–shell NPs will determine the application of the multifunctional materials. And the effectiveness of the shell in the prevention of the iron-group metal core from oxidizing in air and from dissolving in acid environments is an important factor in the practical biological and other applications.

B. *Synthesis techniques of Nano-composites*

The synthesis of these nano-particles can be broadly classified into two categories: bottom-up and top-down. The bottom-up approaches can be further segmented into three classes: (i) simultaneous fabrication, where both the core and the protective shell formation takes place simultaneously; (ii) sequential fabrication, where the core is fabricated followed by the formation of a protective shell, and (iii) displacement reaction (redox) fabrication, wherein the protective shell is fabricated through the displacement of surface atoms of the metal core. A method which offers significant contribution to the shell preparation is that which creates a gap between the core and the shell. This gap is composed of some layers of polymers, which interact with core structures through hydrophobic interactions. Direct intercalation of the prepolymer without the use of a solvent may also be a feasible path to produce Nano composites [119].

Composites will be prepared both as free standing films and as adhesive layers between two polymer films. Since the surfaces of the filler particles are polar while those of the polymers are non-polar, modification of the filler surfaces to be compatible between the two phases is necessary. These surface modifications will either be non reactive or may react with the polymer. The influence of the different surface modifications on the properties of the final Composites will be studied and compared to unmodified samples. For the preparation of the Nano composites either commercial organically modified clay will be used or clays will be modified by exchange of their surface cations against organic ions to achieve the desired filler-matrix compatibility [120].

Taking technological challenge and scientific importance, researches such as ceramic method [121], sol-gel [122], co-precipitation [123], solvent evaporation [124], hydrothermal [125], combustion [126], micro emulsion [127] and citrate methods [128] have been made into various synthesis routes of Nanocrystalline ferrites. In the earlier report, cobalt ferrite nano-particles have been synthesized by the polymeric precursor method [129]. While the

nano-particles obtained usually have a strong tendency to aggregate, this makes it very difficult to exploit their unique physical properties [130]. To reduce the unwanted crystallite coarsening and particles aggregation, attempts have been made to synthesize Nano composites by embedding ferrite nano-particles in a suitable matrix [131-135]. Studies on magnetic Nano composites of ferrite nano particles dispersed in the silica matrix [136,137] have revealed a behaviour different from that of bulk systems. Among various synthetic routes, sol-gel process has proved to be an efficient method to prepare homogeneous particles dispersed in different matrices. The preparation parameters can be modified to have a good control on the material by sol-gel technique [138].

The strength of the nano-composites with different volume fractions of nano-particles was measured using three-point-bending specimens and the fracture toughness was obtained from the indentation test, which has been accepted as a standard test for toughness measurement of brittle materials. Three effects of nano-particles on the toughness, namely, Nano-particle clustering, crack pinning, and trans-granular fracture, are identified from both the experimental and analytical studies. They studied that Nanoparticle clustering can reduce toughening induced by crack pinning. The theoretical prediction, based on the combination of the three effects of Nano-particles, is in agreement with the experimental data. Also the toughness ratio between the matrix ceramic and nanoparticle has more significant influence on the overall toughness of nano-composite.

In the synthesis of polymer Nano composites the insertion of nano- metric inorganic compounds, the properties of polymers improve and hence this has a lot of applications depending upon the inorganic material present in the polymer.[139] .It was reported [5] that incorporation of Nano Particles of Cobalt Ferrite into conjugated Polymer Matrix for EMI Shielding Applications . In this conducting ferromagnetic Nano composite prepared by the in situ emulsion polymerization of aniline monomer with cobalt ferrite was prepared using aqueous solution of dodecylbenzene sulfonic acid (DBSA). Vijay Bansal [6] prepared (Na0.5K0.5) NbO3 [NKN] and (Ni0.6Zn0.4) Fe2 [NZFO] were prepared by coating method and combustion method respectively. V. Chirila et.al [7] given a method for Modifying Mechanical Properties of Carbon Nanofiber Polymeric Composites. Composites consisting of different quantities of vapor grown carbon nano-fibers (untreated and oxygen plasma treated) in a polypropylene matrix prepared using extrusion and injection moulding technique. The adhesion between fibers and polymer matrix, oxygen plasma treatment onto the carbon nano-fiber surface is applied. The graphitization degree, the electrical resistivity, the water contact angle, the surface energy, the morphology, and the structure of the carbon nano-fibers are characterized. In [11] the Magnetic Nano composites properties are studied. They are an important class of advanced functional materials on the basis of a magnetic material and a matrix. To achieve unique mechanical, physical, chemical, and biomedical properties, the surface properties are tailored. This requires the deposition of ultra-thin and uniform films using the possibility offered by cold-plasma polymerization process. It has been reported that the rate of polymer condensation on the nanoparticle surfaces may be influenced by many parameters such as electron density, temperature, and energy density. To achieve a thin and uniform coating on such small nanoparticles, all these synthesis parameters must be optimized.

B. N. Ravi kumar.et.al [19] studied the two-body abrasive wear performance of neat LDPE and nano-clay filled LDPE/EVA composites with and without compatibilizer is investigated. Poly (ethylene-co-glycidylmethacrylate) was used as the compatibilizer. The results indicate that the nano-clay filled LDPE/EVA with compatibilizer composite exhibits superior abrasion resistance.

Magnetic Nano composites consisting of spinel ferrite nanoparticles in a nonmagnetic SiO_2matrix exhibit interesting properties arising in size effects and magnetic interactions [140-144]. Among them, $CoFe_2O_4$-SiO_2magnetic Nanocomposites have high potential for applications as magnetic fluids [145], drug delivery [146], and high density information storage [147] due to remarkable properties of bulk cobalt ferrite (high saturation magnetization and coercively, strong anisotropy, mechanical hardness and chemical stability) [148], combined with the magnetic properties characteristic of nanoparticles, which depend strongly on particle shape and size,

particle-matrix interactions and degree of dispersion throughout the matrix. Recently, cobalt ferrite Nano particles were also known to be a photo magnetic material that shows a remarkable light induced coercively change [149-151]. Mehrnaz Gharagozlou.et.al [118]studied the Effects of calcination temperatures varying from 400 to 1000°C on structural and magnetic properties of Nano composites formed by formed by co-ferrite dispersed in the sol-gel silica matrix using tetrakis(2-hydroxyethyl) orthosilicate (THEOS) as water-soluble silica precursor. It has been observed that the magnetic behaviour of samples for some materials depend on the crystallinity and size caused by the calcination temperature. Special emphases are given on the filler types that affect the conductive properties of these composites. Then, the mechanisms of electric conduction are addressed. Polymer composites containing ferrites are increasingly replacing conventional ceramic magnetic materials because of their mouldability and reduction in cost. They are also potential materials for microwave absorbers, sensors and other aerospace applications. The designing of ferrite based conducting polymer nanocomposites increases the shielding effectiveness. Also polymer nanocomposite can be used as microwave absorber [152,153].

Cheng Huang .et.al synthesized an electroactive polymer nanocomposite, in which high dielectric constant copper phthalocyanine oligomer (o-CuPc) nanoparticles are incorporated into the block polyurethane PU matrix [154]. Fei Teng.et.al done the work on In-situ hydrothermal synthesis of three-dimensional MnO2–CNT nanocomposites and their electrochemical properties observed that the 3-D MnO2–CNT nanocomposites reported herein have provided a promising electrode material for supercapacitors and other electrochemical energy storage/conversion devices [155].

C. *Applications*

The applications of nanocomposites and conducting Nanocomposites of various materials are given in the above. Few more applications are mentioned below.

3.1 Printed circuit boards: Printed circuit boards are used in electrical and electronic instruments. They contain copper coated epoxy resins which are expensive and have less adhesive nature. Polymer sheets coated with conducting polymers are inexpensive and have better adhesive properties.

3.2 FET Sensor: The interaction among the neutral gases and organic semiconductor has been utilized as the principle of transduction in (FET) sensors. The category of sensors three kinds of Micro Fabricated Devices which are; "Chemically sensitive Diodes, chemically sensitive capacitors, and chemically sensitive FET's (CHEMFETS).

3.3 Solar cell: Polymer solar cells have attracted broad research interest because of their advantageous solution processing capability and formation of low-cost, flexible, and large area electronic devices. Polymer-Au-Nanoparticle (AUNP), nanocomposite as whole transport layer improves performance of solar cell which improves conversion efficiency.

3.4 Energy generation using Noise: It uses the electro mechanical sensors. This electromechanical sensor uses viso elastic graphene polymer Nanocomposites. Graphene is added to a lightly cross linked polysilicon, often encountered as silly putty to change its electro mechanical properties.

II. CONCLUSION

The developing arena of Nano science is assuming prominent places in allthe facets of life. Nano composites using Ferrites and Nano particles can create mysterious Characteristics to the specimen which have a wide variety, extensive range and imposing application when put to use as technological tools. Nano composites started its span very recently and promises extensive potential in each and every walk of life for the developing technological advancement.

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Engineering and Technology Journal for Research and Innovation (ETJRI)
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