



A CASE STUDY ON POLYMER

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Abstract

The nanoparticles having special morphology can easily achieve the percolation threshold compared to spherical particles. So, here we use both spherical nanoparticles and some interesting nanostructures (like nanorods, dendrite-shaped nanostructures etc.) as fillers in PVDF matrix to see the enhancement in dielectric constant of composite film. The aspect ratio of nanostructures plays a very important role in this enhancement; because if the aspect ratio is high, the percolation value of composite is very low (i.e. high dielectric constant). Therefore, here we concentrated on the synthesis of nanostructures with high aspect ratio and studied the structural, morphological, optical, and dielectric properties of composite films. Even though lead and tin chalcogenides are given attention, we have arranged our investigations in three different chapters for sulfides, selenides and tellurides separately. So, the mechanism in each group may be discussed in detail separately.

Keywords: Nanocomposite, non-material multiphase, colloids, gels, polymers.

1.1 INTRODUCTION

A nanocomposite is a non-material multiphase, where one phase has a Nano dimensional structure (one, two or three dimensions of less than 50 nm). In the broad meaning of the term the strong mix of the mass grid and nano-layered phase(s) with unmistakable attributes inferable from different designs and science might incorporate pores, colloids, gels, and copolymers. The primary, mechanical, electrical, warm, optical, electrochemical and reactant attributes of nanocomposites are significantly different to those of their component materials. The size limits have been predicted for mechanical strengthening or

restriction of the movement of the matrix, making the hard magnetic material softened or achieving superparamagnetic, optical (band gap, refractive indices) changes and catalytic activity, and are proposed below 100 nm, 50 Nm or 100 Nm, 20 Nm, polymers, and inorganic metal oxide nanoparticles. The characteristics of nanocomposites of this kind rely heavily on the nanomaterial concentration to be added. Conducting arrangement of a leading polymer polymer composites is the proper with at least one inorganic nanoparticle to truly consolidate metal oxide its ideal characteristics The metal-oxide polymer composites core combine the electrical capabilities the magnetic, optical, electrical of the polymer core with or the metal oxide core catalytic features of, which may significantly increase the use for catalytic, electronic and optical applications. Nan composite material consisting of leading polymers & oxides also open additional fields such as the delivery of drugs, conductive paints, rechargeable batteries, photocopying toners, intelligent windows, etc. A polymer consists of many simple molecules which repeat structural components known as monomers. A single polymer molecule may have a linear, branching or network structure and hundreds to a million monomers. Covalent connections keep the atom together in polymer molecules while secondary links tie polymer chains together to create the polymer substance. Copolymers are polymers consisting of two or more monomer types. Polymers are a macro molecule consisting of a smaller molecule, combining into a large molecule. It is a collection of ringlets of the same size and manufactured of the same material that may be regarded to represent a polymer from the molecule of the same chemical when these rings are connected. Alternatively, multiple rings of various sizes and materials may be

interconnected to represent a polymer made up of distinct chemical molecules.

Exploration in nanotechnology and Nano science can be traced back 40 years to a 1959 talk by Richard P. Feynman, 'There's Plenty of Room at the Bottom'. Nonetheless, the field of nanotechnology has developed well through various disciplines during the last ten years. From science to science, from materials science to electrical designing, researchers are building tools and mastering nanotechnology to once again save testing labs to commercial hubs. These days, polymers play an important role in various areas of regular daily existence because of their advantages over traditional materials such as softness, safety from consumption, simplicity of handling and minimal expenditure generation. Further improvements in their presentation, including the overall construction, really remain subject to focused examination. Modification and upgrading of polymer properties can occur through doping or mixing with various nanofillers such as metals, semiconductors, natural and inorganic particles and fibers, as well as carbon designs and pottery. Such added substances are used in polymers for an assortment of reasons, for example: further developed handling, thickness control, optical effects, hot conductivity, control of hot expansion, electrical properties that allow charge diffusion or electromagnetic barrier protection, Attractive qualities, empowers the fire. resistance, and further developed mechanical properties such as hardness, ductility, and wear-resisting.

Nanostructured composite materials using natural polymers and inorganic nanofillers address a coherence between traditional natural and inorganic materials, bringing exactly half-and-half pieces. Natural inorganic composites with nanoscale facets are developing interest due to their one-of-a-kind properties, and various potential applications, for example, conductivity enhancement, durability, optical action, reactive action, compound selectivity and so on. In these materials, Inorganic and natural parts are mixed or hybridized on the nanometer scale for all intents and purposes, any organization prompting the crossover/arrangement of nanocomposite materials.

Dielectric materials are used to continuously dissipate energy and play an important role in

electrical power structures. Since polymers comprise an important class of dielectrics, there is great interest in research on polymers for future energy-storage media and also in the fields of implanted capacitors for microwave special gadgets, simulated muscles, and miniature electromechanical structures. There are applications. Weight, size-compatibility, cost feasibility, and great processability of the material are also important variables for these applications, which is the basic motivation behind using polymer composites in many exploration efforts. The principle point of this current work is to additionally foster the dielectric consistent of the polymer. Nowadays, the most notable strategy used to additionally foster the dielectric similarity of polymers is to scatter an exceptionally dielectric stable cast powder, for instance, to frame barium titanate (BaTiO_3) and lead titanate (PbTiO_3) to composites. In polymers for forming.

To get a high worth dielectric consistent, an enormous number of earthenware fillers should be stacked, which can prompt loss of versatility and inhomogeneous composites. As a result of this hindrance, a really uplifting technique has been made to acquire high dielectric viable composites without the absence of flexibility. It is to involve inorganic semiconductors as nanofillers in the polymer cross section (nearer to their travel edge). For that, the underlying one needs to pick the best piezoelectric polymer. Among the most well known polymers, polyvinylidene fluoride (PVDF) stands separated because of its astounding pyro and piezoelectric properties and has different mechanical applications from fundamental condensers to sensors and actuators.

Hence, in the present study, we use PVDF polymer for our further investigations. Some important and peculiar properties of PVDF polymer is discussed in the following section.

1.2 POLYMER

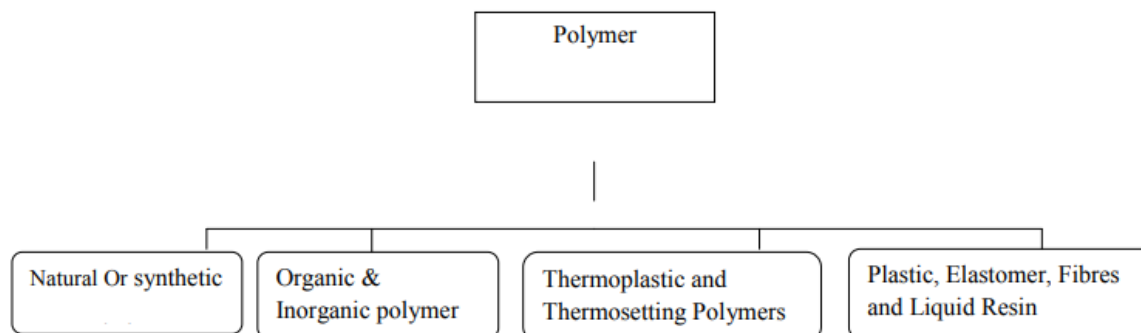
Polymers are materials consisting of long repeating molecular chains. The materials have distinct characteristics, depending on the kind and bonding of the molecules. Some polymers like rubber and polyester flex and stretch. Others are robust and difficult, such as epoxy and glass. Nearly every area of contemporary life is touched by polymers. It is likely that in the past five minutes most individuals were in touch with at least one polymer containing

product, from water bottles to tires. The word polymer is frequently used to denote manmade polymers. Natural polymers exist, however, too. According to Encyclopedia Britannica, rubber and wood, for example, are natural polymers consisting of a simple hydrocarbon, isoprene.

1.2.1 Types of Polymers

❖ Depending on the availability and source

Polymers are divided into different categories which are shown below in flow chart.



• Natural or Synthetic Polymer

Polymers may be classified as natural or synthetic depending on their origin. The so-called natural polymers, for example cotton, silk, wool and rubber, cellophane, DNA, protein, cellulose rayons, leather etc. Polymers produced from low molecular components are termed synthetic polymers. Synthetic polymers. Like polyethylene, nylon and ethylene are PVC (polyvinyl chloride).

• Organic & Inorganic polymer

A polymer that mostly consists of a backbone chain of carbon atom is called organic polymer. However, hydrogen, oxygen, nitrogen etc. are typically the atoms connected to the side valves of the backbone carbon atoms. Most synthetic polymers are organic and have been researched quite thoroughly. There is really no organic polymer, if we say polymer, we mean organic polymer. On the other hand, inorganic polymer molecules usually do not include carbon atoms in the backbone of their chain. Silicium and rubber and glass

Thermoplastics and Thermosetting Polymers

Some polymers mellow upon heating and can be converted into any structure they can maintain. These polymers that soften when heated and harden upon refrigeration are called "thermoplastics". Examples of thermoplastic polymers include polyhetene, PVC, nylon, and fixing wax. Then again, some polymers undergo some substance transformation in warming and turn into an incompressible mass. They resemble the yolk of an egg, which cannot be

Natural polymers are proteins consisting of amino acids; nucleic acids (DNA and RNA) are polymers of complicated nucleotides consisting of nitrogen-containing molecules, sugars and phosphoric acid for instance.

changed when heated and set into a mass. These polymers, named "thermosetting polymers", become an insoluble and insoluble load of warming.

• Plastic, Elastomers, Fibres and Liquid Resin

Polymers may be categorized as plastic, elastomer, fibre and liquid resin depending on the use. For example, when a polymer is moulded by applying heat and pressure into a rigid and hard utilitarian item, it is utilized as a plastic. Polysterene, PVC and polymethacrylate are utilized as "elastomers," when vulcanized into rubber goods with excellent strength and elongation. Synthetic rubber, silicon rubber, of course. Drawing polymers into long filaments like materials with a length at least 100 times higher than their diameter is considered to have been transformed into fibres. Nylon and tereylene for instance.

1.2.2 Classification of Polymers

Polymers cannot be grouped under one classification due to their mind-boggling structures, different practices and vast applications. So we can formulate the modes in the light of corresponding considerations.

Sequence of polymers in light

There are three types of arrangement under this classification, specifically, natural, synthetic and semi-engineered polymers.

• Regular Polymers

They occur normally and are found in plants and organisms. For example, protein, starch,

cellulose and elastic. To add, we also have biodegradable polymers called biopolymers.

- Semi-finished polymers

They are derived from commonly occurring polymers and undergo additional synthetic transformation. For example, cellulose nitrate, cellulose acetic acid derivation.

- Engineered Polymers

These are man-made polymers. Plastic is the most well-known and commonly used engineered polymer. It is used in businesses and various dairy items. For example, nylon-6, 6, polyether etc.

Order of polymers in terms of structure of monomer chain

This class has the following arrangements:

- Straight Polymers

The design of polymers with long and straight chains falls into this class. PVC, for example poly-vinyl chloride, is commonly used to make lines and electrical links are an example of a straight polymer.

- Fand Chain Polymer

At the point where the polymer structure is branched straight chain, such polymers are arranged as branched chain polymers. For example, low-thickness polyethylene.

- Cross-connected polymers

They are composed of bi-functional and tri-functional monomers. They have a more basic covalent bond in contrast to other straight polymers. Bakelite and melamine are models in this classification.

1.3 CONDUCTING POLYMER

There are so many polymers that lead. Organic polymers are usually conducting polymers. Alternatively, these polymers feature a single and double bond. Polypro (PPy) and Polyaniline (PANI) are polymer conductors. Polymers have α -bond conjugated on the backbone. Because of this, electrical and optical characteristics of conducting polymers play a significant role. This μ -bond is extremely readily oxidized and only this generates electric and optical characteristics. The use of these conducting polymers is relatively brief because of their low solubility, process ability and strong electrical conductivity

1.3.1 Types of Leading Polymers

Leading polymers can be broadly described into three classes

- Leading Polymer Composites (CPC)
- Inheritedly Conducting Polymers (ICP)

- Strong Polymer Electrolytes (SPE) Composites (CPC)

These composites are composed of conductive fillers in essential polymer networks. The required polymer networks were used as polymeric polymers, for example, polycarbonate, polyethylene, polyvinyl chloride and so on. The conductive fillers are carbon strands, hardened steel, aluminum bottles, nickel-covered mica, and so forth. The exchange of charge is caused by electrons and through the process of buoying or jumping the whole system. The planning and improvement of console switches, micro circuits and contact cushions are among CPC's major jobs.

- Characteristically Conducted Polymers (ICPs)

These are polymers where the special conductivity of the substance structure, for example fl, is formed. The transmission of charges is done by electrons and opening creation through the engendering or jumping process. ICPs include polyacetylene, polythiophene, polyaniline, polypyrrole, etc. and for the most part ICPs include sensor, EMI protection, electrochromic show, level board show and antistatic covering applications.

- Strong Polymer Electrolytes (SPE)

These are basically ionic salts such as lithium perchlorate, zinc dibromide and similar arrangements in polymers, for example, PEO, PPO and so on. Particle growth causes charge movement. An important use of SPE is in batteries with battery operated capacity.

1.4 PVDF Polymer

PVDF is a polymer of judgment for some researchers, at which point interests are coordinated for piezoelectricity, durability and synthetic hindrance, mechanical strength and processability. PVDF and its copolymers show unprecedented electro-mechanical properties and have incredible potential as future electrical storage media and have recently been widely used in biotechnology, biomedical fields, photorecording and microwave tweaking. Among various polymers, PVDF exhibits attractive electrical properties that are associated with its gem structure. It is a semi-translucent polymer containing four unique structures of CH₂-CF₂ (the subatomic construction of the PVDF polymer is displayed in Fig. 1.1). It is generally viewed as a non-polar α -phase. It likewise exists in polar phases,

for example, β , γ , and δ . Of these, the β -phase is the one that has the highest polarization and will be the subject of this review.

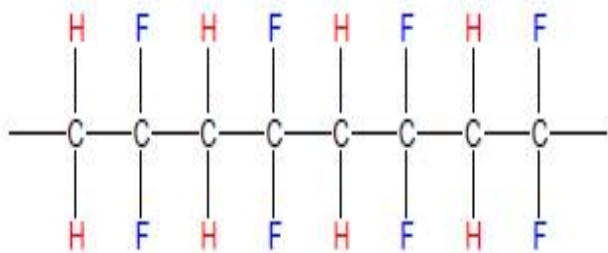


Figure 1.1 Molecular Design of PVDF Polymer. The spatial scheme of substituting CH_2 and CF_2 clusters with polymer backbones creates a high dipole sec that records for a kind of extreme, [32]. Routinely, PVDF unusually high dielectric polymorphism, and high constant, complex pyroelectric movement of the piezoelectric and polymer has three critical series compliances. The most stable polymorphism of PVDF is the α -structure. The series of α -phases (TGTG') form the adaptation chain a medium dipole second. The design of the α phase is displayed in Fig.1.2.

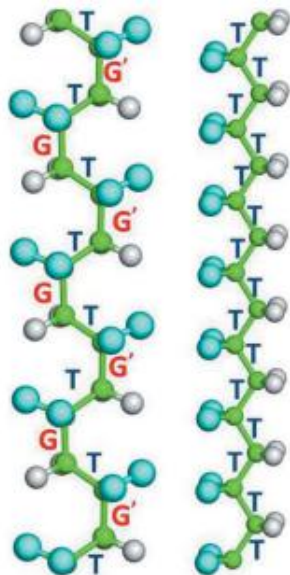


Fig. 1.2 PVDF chain in TGTG' (α -phase) (left) and all-trans TTTT (β -phase) (right) arrangement

The β -phase forms under mechanical deformation of the liquefied material, usually at temperatures near its solubilization progression. This design gives PVDF (ie) piezo and pyroelectric action some of the exceptional properties in this current review; We channeled our exams directly towards the β -stage. The β -stage PVDF has a planar TTTT (all trans) crisscross chain conformation as shown in Fig. 1.2. -Stage has a series adaptation which is roughly 'TTTGTTTG'. A trans (t) assignment

indicates a dihedral point of 180, although g and g' suggest dihedral points of ~ 57 and ~ 57 , obtained individually from the calculation of the first standards.

Various states exist in PVDF, depending on the association conditions such as solubility, liquefaction temperature, projecting strategy, expanding short films and hardening conditions. The occupation and most commonly accessible phase is the α -structure. From that, we need to streamline the expected step by using different types of union boundaries. Buonomenna et al. showed the effect of projecting, dissolvable and coagulation conditions on the glass-like fabrication of PVDF. Being the piezoelectric stage, here we mostly focused on the β -stage PVDF. At a specific temperature, the deformation of the α -function leads to a change in the β -phase. Mohammadi et al. showed the effect of the stretch rate on the transformation of the α -phase to the β -phase, finally completing the β -phase at 90oC. In line with this, Vijayakumar et al. The β -phase is completed at 65 °C. The versatility of conformers is fundamentally influenced by atomic strength and as a result we can change the phase using different amalgamation temperatures. Normally, the PVDF polymer is combined at 40 and 50 oC, here the atomic force is not sufficient to pivot the CF_2 bunch and thus no trans-gauch structure changes. So due to projecting, short films remain in alpha-stage. At the point when the arrangement is formed at a higher temperature, such as 70–90 oC, the nuclear force drives the CF_2 dipole to the pivot point, which is largely through the trans-gauch conformational change by the co-utilization of adjacent CF_2 clumps. Brings appropriate movement. Along these lines, the conformers are adjusted to either TTTGTTTG' or TT structure.

As expressed above, the oxides, metal NPs graphene with conductive polymers framework consisting parallel mixing of metal, CNTs and is synergistic, which aids in streamlining the sensor. Recent investigations into the Ternary Cross Breed Framework have yielded a higher premium for the added detail to trace performance. Recently, several gas sensors have been made in the light of ternary nanocomposites for the study of gas detection, basically metal particles - metal oxide driving polymer metal particulate matter - carbon

nanotube leading polymer metal particulate matter. Metal Oxide Graphene Metal Oxide of Metal Oxide-Metal Oxide-conductive Polymer Metal Oxide-Metal Oxide-Metal Oxide-Direction of Metal Oxide-Polymer Oxide of Graphene In 2017, Liu et al. A one-place self-aggregation strategy for assembling minor film NH₃ gas sensor for Au-TiO₂-PANI ternary nanocomposite is involved. He researched the reaction characteristics at room temperature for NH₃ values from 10 to 50 ppm. The results show that the sensor given the PANI-TiO₂-Au ternary composite

were more responsive than the PANI-TiO₂ binary film, 48.6 percent to 123 percent, and the response period was reduced by 52 to 122s, plus improved selectivity, and reversibility, due to nano-joints synergy and the combined effects of Au nano catalyst.

1.5 HISTORICAL DEVELOPMENT OF POLYMERS

First of all, polymeric materials in wood, leather, rubber have been utilised, but only after doping by the Shirkawa and collaborators in research play a very significant part. Some conjugated (conducting) polymers are polythiophene (PTh), polyaniline (PANI) and polypyrrolle (PPy). In 1935, Yasui developed the reaction strategy for aniline electro-oxidation. When Buvet and his colleagues discovered that polyanilines have active redox in 1967, PANI pellets replaced electrodes with conductivity measurements. Inorganic-organic hybrid composite materials have had considerable attention in recent decades owing to their broad range of uses. Polyaniline (PANI) is one of the appropriate conducting polymers for cations on the backbone of the polyaniline. The aim is to build a common conductivity frame in conducting polymers and to prepare a large number of diverse technical applications such as sensors, optoelectronic devices, electrodes, coating for corrosion and solar cells. Polyaniline takes great care of its excellent conductivity, simple preparation and the environment, and its costs are also too cheap. PANI is a copolymer block that transforms the shape of benzenoides into the form of quinoids. The structure exists in three phases. When treated with protonic acid green emeraldine salt form it is an emeraldine basis. This is Polaniline's most significant form. Dramatic improvements may be applied to the intercalation, doping,

loading, ionization, expulsion and photodoping of various metals, ions, oxides, structural semiconductors, optical, electrical and mechanical properties of pure PANI. These materials are thus of considerable interest to the researchers.

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