IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 09, Issue 5 (May. 2019), ||S (VII) || PP 51-55

A Use of Nano Sized Particular in Combination of With Ultrafine Particular: A Review

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Abstract: *In present study, the nano particles used by many researcher based upon the application of research work , but in case of use nanoparticles as filler in plastic is not possible to constraint on size of the material limiting to 100nm only . In this review paper different research is reviewed and view of each researcher based on their application is highlighted and try to recommend the used of combination of ultrafine (sub micron sized) & nano sized in filler used for most of the plastic applications .*

Keywords: *HDPE , Nanoparticle , Ultrafine , filler plastic*

I. Introduction

The term "nanoparticle" is not usually applied to individual molecules; it usually refers to inorganic materials. Ultrafine particles are the same as nano particles and between 1 and 100 nm in size, as opposed to fine particles are sized between 100 and 2,500 nm, and coarse particles cover a range between 2,500 and 10,000 nm. The reason for the synonymous definition of nanoparticles and ultrafine particles is that, during the 1970s and 80s, when the first thorough fundamental studies with "nanoparticles" were underway in the USA (by Granqvist and Buhrman) and Japan, (within an ERATO Project) they were called "ultrafine particles" (UFP). However, during the 1990s before the National Nanotechnology Initiative was launched in the USA, the new name, "nanoparticle," had become more common (for example, see the same senior author's paper 20 years later addressing the same issue, lognormal distribution of sizes). Nanoparticles can exhibit size-related properties significantly different from those of either fine particles or bulk materials. [1]

Nanoparticles are particles with at least one dimension smaller than 1 micron and potentially as small as atomic and molecular length scales (~0.2 nm). Nanoparticles can have amorphous or crystalline form and their surfaces can act as carriers for liquid droplets or gases. To some degree, nanoparticulate matter should be considered a distinct state of matter, in addition to the solid, liquid, gaseous, and plasma states, due to its distinct properties (large surface area and quantum size effects). Examples of materials in crystalline nanoparticle form are fullerenes and carbon nanotubes, while traditional crystalline solid forms are graphite and diamond. Many authors limit the size of nonmaterial to 50 nm or 100 nm, the choice of this upper limit being justified by the fact that some physical properties of nanoparticles approach those of bulk when their size reaches these values. However, this size threshold varies with material type and cannot be the basis for such a classification. A legitimate definition extends this upper size limit to 1 micron, the sub-micron range being classified as nano[2].

The definition of nanoparticles differs depending upon the materials, fields and application concerned. The particles in the three digit range of nanometre from 1 nm to100nm could be called as nanoparticles, but most frequently nanoparticles are in the size range of 1–100 nm. This range lies between single atoms or molecules and bulk materials, and their chemical and physical properties differ markedly from those of the bulk solids. [3]

Nanoparticles have very high surface area to volume ratio. So if you think about the surface of any material, the cohesive forces between molecules in the bulk are shared with all neighbouring atoms. However, on the surface of the material there are a lot of unsatisfied atoms that do not have neighbouring atoms above them. So surface atoms exhibit stronger attractive forces between their nearest neighbours on the surface. i.e surface tension. This is primarily what causes the agglomeration of Nano particles as they strive to reduce their higher surface energies by clumping together.[4]

Nanoparticles present possible dangers, both medically and environmentally. Most of these are due to the high surface to volume ratio, which can make the particles very reactive or catalytic They are also able to pass through cell membranes in organisms, and their interactions with biological systems are relatively unknown. However, it is unlikely the particles would enter the cell nucleus, Golgi complex, endoplasmic reticulum or other internal cellular components due to the particle size and intercellular agglomeration.

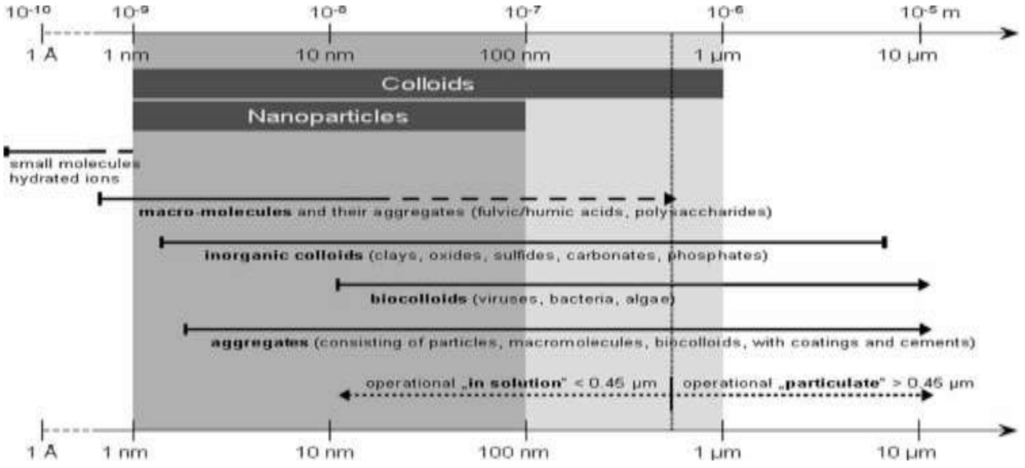
When alkaline earth metal carbonates are processed with thermoplastic polymer products, cavitations, or the formation of voids or air pockets, can occur around particles of a certain diameter (typically 1 to 3 microns) upon stretching or orientation. These formed micro-pockets of air can either scatter light in films, such as polypropylene or copolymer films, creating a pearlescent appearance, or can create micro void passageways for moisture.[4]

Because of cavitations and other effects that occur when carbonate fillers and polymer compositions are processed, physical properties of the alkaline earth metal carbonate fillers, particular particle size properties, can impact the performance and appearance of end products that contain the filler. Ultra-fines, for example, which are very small particles, cannot properly undergo cavitations and typically only add undesirable weight to the final product. Very small particles can also cause filler agglomeration due to inter-particle attraction forces. Larger particles (e.g. , particles greater than 10 microns in diameter) and agglomerates tend to tear polymer films. Additionally, if the average particle size of the filler is too small, the filler may not effectively debond from the polymer and micro voids may not form at all.[5]

Calcium carbonates are difficult to prepare with controlled and narrow particle size distributions. It is known that CaCO3 has a great tendency to form agglomerates, in fact, agglomeration is a well-known phenomenon, and its probability increases with decreasing particle size. The occurrence and extent of agglomeration are determined by the relative magnitude of the forces, which either bind together the particles or try to separate them.

Hornsby listed mechanical interlocking, electrostatic forces, van der Waals forces, and liquid and solid bridging as the principle adhesive forces between particles. All of these factors could have participated in the agglomeration of the CaCO3 particles[6]

Fig. 1 Size domains and typical representatives of natural colloids and nanoparticles. Operationally defined cut-off is given for filtration at 0.45µm.



Although it is consider nanoparticles as simple molecules, they are in fact complex mixtures. Even in the simplest cases one must consider the interactions of at least two different aspects of the material. A second important consideration when discussing the core of a nanoparticle is the immense variation that may be found there. This is particularly the case when considering inorganic nanoparticles. It is well known that most inorganic materials may exist in more than one phase and that the phase of the material may have a dramatic effect on its physical properties. Whilst nanoparticle may be prepared in a pure single phase, it is sometimes the case that two phases are present. It is tempting to assume that the fate and behaviour of the nanoparticle are independent of the phase; however this is also unlikely to be the case (Rempel et al. 2006).[7]

As per Scientific Committee on Consumer Products (SCCP) nanoparticle is At least one side is in the nanoscale range. And nano material is Material for which at least one side or internal structure is in the nanoscale,

Nanomaterials describe, in principle, materials of which a single unit is sized (in at least one dimension) between 1 to 1000 nanometres(10^{-9} meter) Surface fictionalization of NPs is considered a prerequisite for their biomedical applications. In general, an ideal surface of NPs should provide good water stability and chemical functionality for further fictionalization and maintain the NPs' unique physical and chemical properties. Through the approaches discussed here, ligand exchange involves a simple process without affecting the particles size. However, it often compromises the stability of the NPs, as the ligand tend to dissociate from the surface, leading to particle aggregation. In the case of QDs, the dissociation of the ligand can result in decreasing the fluorescence efficiency. Coating NPs with a hydrophilic layer, SiO2 shell, or polymer layer results in better stability and multifunctional properties (e.g., luminescent MNP s). The drawback, however, is that encapsulation increases the particle size significantly. On the other hand, different bioconjugation strategies have been developed to efficiently engineer NPs in interacting targeted biological molecules/systems. The covalent bioconjugation approach is probably the most common bio-conjugation method as it forms stable linkages. Biological affinity through antibody /antigen conjugation offers highly specific interaction. Recently, small protein-mediated conjugation shows high selectivity in the interaction between NPs and biological systems. With further development in the surface fictionalization and bioconjugation of NPs with enhanced chemical and physical properties, it is expected that new biomedical devices made of engineered NPs with miniaturized structures but multi functional properties can have a significant impact on personal health care[8].

This paper addresses the subject of mixing of ultrafine particles and the available methods for characterizing the degree of mixing of nanoparticles to form nanocomposites. This is a relatively new area of research, which has a high potential for many commercial applications, both industrial and military. However, very few papers are found in the literature regarding the mixing of highly cohesive powders, let alone the mixing of nanoparticles. This is due to the fact that most traditional powder technology applications do not deal with powders smaller than about 20 μm. Thus, the vast literature available in the area of mixing and characterization of non-cohesive powders has little to offer, since the behavior of nanoparticles is very different from the behavior of conventional powder materials. It is expected that the next generation of high performance structural materials and coatings will routinely employ nanoparticles and nanocomposites due to their attractive qualities such as wear resistance, corrosion resistance, mechanical strength and hardness. Nanoparticles and nanocomposites are also being used as high-performance catalysts, and as advanced energetic, electronic, photonic, magnetic and biomedical materials. All of these applications require an understanding of the handling and mixing properties of nano structured materials.

The unique properties of nanoparticles arise from their size reduction. When a particle is reduced down to the nano size range (usually defined as 1–100 nm), a much larger surface area per unit volume is achieved, and even more importantly, a dramatically increased Percentages of molecules or atoms are found to be present on its surface. At the point where the interaction length scales of physical, chemical and biological phenomena become comparable to the size of the particle, crystal or grain structure, new properties and phenomena emerge (Roco, 1999; Siegel, 1999). These unique properties of nano structured materials are extremely important, for example, in developing new and advanced catalysts (Trudeau & Ying, 1996; Moser et al., 1996; Ying, 1997; Zhang et al., 1998; Fokema et al., 2000). Furthermore, when two or more phases are mixed together to make a nano composite, a combination of properties can be obtained, which are not available in any of the individual components, since at this scale, macroscopic material properties are strongly influenced by atomic or molecular interactions. Since the building blocks of a nano composite are of nanoscale, many interfaces exist between the two intermixed solid phases and the special properties of a nano composite arise from phase interactions at these interfaces (Ajayan, 1995; Gross et al., 1996; Ajayan et al., 1997; Carter et al., 1997; Maser et al., 1997; Imanaka et al., 2000). Thus, the ability to prepare well-mixed nanocomposites is extremely important. Two different approaches, spray forming and powder processing (Kear & Skandan, 1997; 1999) have been proposed for the preparation of nanocomposites. Spray forming combines nanoparticle synthesis, heating and consolidation into one single operation. In powder processing, nanoparticles of the desired materials are first synthesized by some convenient chemical or physical methods, and then structurally assembled via some steps that may include mixing, and finally consolidated through sintering or some other methods.[9]

Over Recent years advancement in nanoparticles drug delivery is widely expected to change the landscape of pharmaceutical industries for the foreseeable future. Nanotechnologies have become a significant priority worldwide. Several manufactured nanoparticles - particles with one dimension less than 100 nm – are increasingly used in consumer products. At nanosize range, the properties of materials differ substantially from bulk materials of the same composition, mostly due to the increased specific surface area and reactivity, which May be lead to increased bioavailability and toxicity. Thus, for the assessment of sustainability of nanotechnologies, methods of manufacturing Nanoparticles, properties have to be studied. Despite all the above mentioned, the data on the potential environmental effects of nanoparticles are rare. The pipelines of pharmaceutical companies are believed to be drying up in many cases, and a number of blockbuster drugs will come off patent in the near-term. Using nanoparticles, it may be possible to achieve improved delivery of poorly water-soluble drugs by delivering drug in small particle size increase the total surface area of the drugs allowing faster dissolution in blood stream. Faster the dissolution translates in to faster absorption by human body targeted delivery of drugs in a cell- or tissue-specific manner. A nanoparticle has emerged as a promising strategy for the efficient delivery of drugs used for the treatment of some diseases by specific targeting. These carriers are designed in such a way that they are independent in the environments and selective at the pharmacological site. The formation of nanoparticle and physiochemical parameters such as pH, monomer concentration, ionic strength as well as surface charge, particle size and molecular weight are important for drug delivery. Further, these nanoparticles have the capability to reverse multidrug resistance a major problem in chemotherapy.[10]

Large quantities of clay minerals (and other micron-sized mineral powders) are used widely in materials science. Mineral fillers are major components, for example, of paints, rubber, plastics and paper and board. While the original object of such incorporation was to reduced costs, performance is now being "engineered" by design or choice of the relevant mineral particles. This paper concentrates on the use of mineral powders in polymer and paper science. In both application areas, the size and shape of the mineral particles can be affected mechanical properties such as stiffness and tensile and impact strength. However, other characteristics are also modified. For example, the drainage rate in paper formation and the rheology of a polymer melt, properties which are critically important to the rate of processing of the relevant materials, can be greatly affected. Finally, the size and shape of the mineral particles also affect appearance, i.e. the smoothness, uniformity, optical properties etc. Mechanical and rheological data are presented for mineral-filled polypropylene, as are mechanical and optical data for filled and coated paper.[11]

II. Conclusion

Nano composite are defined as solid consisting of mixture of two or more phase separated material , where one or more dispersed phase is in nanoscale and a polymeric major phase .

Technique used is direct mixture of polymer and particulates . In this technique , dispersing nanoparticle with polymer are mixed together by direct melt compounding without requiring any surface modification of nanoparticle.

This type of method is suitable for polymeric based composite containing nano and or submicron sized filler with a dimensions one or more order of magnitude larger than the filler domain dispersed in the molecular hybrid material.

This technique is suitable for industrial scale production of nanocomposites with wide volume fraction range of nanofiller and various combination of filler and polymer material.

Using 100 % Nano particles for blending with polymer is very much difficult , due to surface area to volume ratio of nanoparticles is increases means surface area is increases as the size of particle is reduces and as the surface area increases , possibility of formation of agglomerates and aggregates is increases with the reduces size of particle.

The agglomerates is the collection of weakly bound particles or aggregates or mixture of two , agglomerates are held together by relatively weak forces such as Vander Waal forces , and aggregates that have been formed is not possible to break under normal processing condition , so thus arises the dispersion problem during the processing of nanocomposites and that effect the properties of nanocomposites .

Hence in normal industrial practice is advisable to use combination of nano and sub micron particle to reduces the formation agglomerates / aggregates and for proper dispersion of the filler within the polymer during processing .

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