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Physical Science & Biophysics Journal
ISSN: 2641-9165

Role of Surfactant in Dispersion of Carbon Nano Tubes to Use as Reinforcing Material for Biodegradable Nano Composites

Ansari NH*

Department of Physical Sciences (Chemistry), Sant Baba Bhag Singh University, India

***Corresponding author:** Nizamul Haque Ansari, Department of Physical Sciences (Chemistry), Sant Baba Bhag Singh University, Jalandhar, Punjab, India, Email: nizamulchem@gmail.com

Editorial
Volume 7 Issue 2
Received Date: October 02, 2023
Published Date: October 13, 2023
DOI: 10.23880/psbj-16000254

Keywords: Composite Materials; Biodegradable; Surfactant; Homogeneous

Abbreviations: CNTs: Carbon Nanotubes; CMC: Critical Micelle Concentration; SWCNT: Single-walled Carbon Nanotubes; TEM: Transmission Electron Microscopy.

Introduction

The new trend in composite materials development, which is made utilizing natural or synthetic matrix and reinforcement materials, is a result of rising environmental concern. For a variety of applications, the development of commercially viable biodegradable composites based on natural sources is on the rise [1-4]. When natural fibers (bio fibers) like wood (hardwood and softwood) or non-wood fibers (such wheat, kenaf, hemp, jute, sisal, and flax) are combined with polymer matrix (resin) derived from both renewable and nonrenewable resources, the result is a material known as a bio composite. A reinforced phase of stiff, strong material, frequently fibrous in character, is embedded inside a continuous matrix phase that is typically weaker and more compliant to form composites. Composites are made up of two or more separate constituents or phases. Composites are not easily recyclable or reusable. They typically wind up in landfills, where they take decades to decompose. The creation of biodegradable nano composites is a scientific endeavor to solve this issue. Nano-composites are substances that integrate nanoscale particles into a matrix of conventional substance. Properties like mechanical strength, toughness, and electrical or thermal conductivity all significantly enhance as a result of the incorporation of nanoparticles. The strength of some nano-composite materials has been demonstrated to be 1000 times greater than that of their bulk components.

Nano-composites are mechanically different from traditional composite materials because the reinforcing phase has an unusually high surface to volume ratio. Particles, such as exfoliated clay particles, short fibers, such as carbon nanotubes, or long fibers, such as electrospun fibers, can all be used as reinforcing materials. Carbon nanotubes (CNTs) are proven to be adaptable nanomaterials with exceptional and appealing electrical, optical, chemical, physical, and mechanical characteristics. There are several different varieties of CNTs, and their corresponding characteristics have been actively investigated and extensively utilized for anything from theoretical work to real-world use. It would be ideal to have access to high-quality CNTs in large quantities, particularly for scalable electrical, photonic, chemical, and mechanical systems [5,6]. Purified CNTs can be obtained by sorting procedures from the raw soot of CNTs, which can be dispersed in solutions as a cost-effective means to secure immaculate CNTs. Individual CNTs are often hydrophobic and not easily soluble, therefore successful dispersions requires, the aid of a substance called a surfactant.

In a solution (water or oil phase), surfactants form self-assembling molecular clusters known as micelles and adsorb to the interface between a solution and a separate phase (gases/solids). A surfactant must have a chemical structure that has two distinct functional groups with diverse affinities inside the same molecule in order to exhibit these two physical qualities [7-10]. Surfactants typically contain compounds with an alkyl chain of 8–22 carbons. The chain in question is referred to as a hydrophobic group since it has no attraction for water.

Specific Applications of Surfactants for Dispersing Carbon Nanotubes

The hydrophobic tail of CNTs interacts with the hydrophobic CNT surface during their dispersion in water with the help of amphiphilic surfactants, while the hydrophilic head group is oriented into the surrounding aquatic environment. Surfactant molecules form micelles when their concentration rises above the critical micelle concentration (CMC) [11-15]. These micellar assemblies can be found on CNT dispersions and serve to stabilize them [16]. If the surfactant molecules align perpendicular to the surface of the single-walled carbon nanotubes (SWCNT), they will form a cylindrical assembly when thinking about surfactant interactions with a single SWCNT. According to Matarredona, et al. [17] and Yurekli, et al. [18], the hydrophobic tails in this instance point in the direction of the SWCNT surface, while the polar head groups are positioned radially to interact with water. Richard, et al. [19], found that a half-cylindrical assembly of micelles can form either parallel to the CNT tube axis or perpendicular to the CNT tube axis. The radial and half-cylindrical structures were revealed by Richard et al. using transmission electron microscopy (TEM) [19,20].

Conclusion

A carbon nanotube (CNT) is a tube consisting of carbon with a diameter in the nanometer range (nanoscale). They are a type of carbon allotrope. The diameter of single-walled carbon nanotubes (SWCNTs), which is 100,000 times smaller than the breadth of a human hair, ranges from 0.5 to 2.0 nanometers. They can be visualized as cutouts from a rolled-up, hollow cylinder of two-dimensional graphene. Disaggregation and homogeneous CNTs dispersion in various media are crucial for the effective application of their characteristics. There have been several methods proposed to reduce the agglomeration of nanotubes, including ultrasonication, high shear mixing, and techniques designed to change the surface chemistry of the tubes either covalently (functionalization) or non-covalently (adsorption). One important finding is that the behavior of surfactants in dispersing carbon nanotubes is comparable to that of dispersing solid particles, or traditional colloidal chemistry. The size and dispersion of nanoparticles are typically controlled by the use of surfactants or capping agents. The formation of big particles appears to gradually slow down when a capping molecule is present through altering the dynamics of nucleation and accretion.

Acknowledgement

Dr. Nizamul Haque Ansari would like to express, profound gratitude to Prof. (Dr.) Dharamjit Singh Parmar, Vice Chancellor, Sant Baba Bhag Singh University, Jalandhar, Punjab, India, for moral support.

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