Properties and Potential Applications of Carbon Nano Horns Over Carbon Nano Tubes as a Nano Fluid – A Review

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Abstract
Nano fluids play a vital role in enhancing the performance of major thermal systems such as heat exchangers, Refrigeration & Air conditioning systems, Internal Combustion Engines. Among those carbon nano tubes is the most predominantly used nano particle. But the major problems associated with the carbon nano tubes are poor stability and lower dispersion in excess saline environment which leads to fouling in heat exchangers which in turn reduces the heat transfer rate when used as a nano fluid. Therefore in this review article properties such as thermal conductivity, thermal diffusivity, viscosity etc., potential applications and merits of carbon nano horns (which is synthesized by structural modifications of carbon nano tube) over carbon nano tubes when used as a nano fluid has been discussed.

Keywords: Carbon nano horns, Thermal systems, Dispersion, Stability

1.Introduction
Thermal systems like internal combustion engines, refrigerators, heat exchangers and air conditioners play a vital role in our day to day life [1]. Energy conservation via improving the performance of the thermal systems is of major interest for researchers [2]. Nano Materials has been considered as an important tool in improving the performance of the above mentioned thermal systems [3]. Nano materials have shown enhanced mechanical properties than their bulk form and so it is recommended to make use those nano materials in the form of nano fluids for various applications [4]. Nano fluid plays a major role in becoming the part of these thermal devices like various nano powders have been mixed with diesel in internal combustion engines, with refrigerants in refrigerators & air conditioners and with coolants in heat exchangers[5]. The nano materials should possess the following characteristics to be used as the nano fluid in the above said thermal systems which are as follows:
(i). High thermal conductivity
(ii). High thermal diffusivity
(iii). Free from even negligible amount of impurities
(iv). Low viscosity
(v). high solubility
(vi). High resistance towards fouling
(vii). High corrosion resistance
It is very important that the suitable nano fluid be chosen with the above said requirements [6]. Many metal oxide nano particles like copper oxide, titanium di oxide has been widely used as the nano fluid in various thermal devices [7]. Copper oxide nano fluid has been found to increase the performance of the diesel engine by 12% and has contributed in reducing the nitrogen emission by 15% [8]. The incorporation of copper oxide nano particle has also contributed to reduction in fuel consumption and improving the combustion characteristics of the diesel engine [9]. Similarly titanium di oxide nano particle and ethylene glycol mixture has been used as a coolant in automobile radiator[10] and contributed to increase in thermal conductivity of ethylene glycol [11], overall heat transfer coefficient which in turn improves the heat transfer rate of the automobile radiator [12]. The metal oxidennano fluids have been used with refrigerants also. Incorporation of zinc oxide nano particles with LPG refrigerants have contributed to improvement in performance of the refrigerators [13]. The main problem associated with metal oxide nano particles high potential [14] towards oxidation reaction due ready availability of oxygen content and due this reason the metal oxide nano particles have low corrosion resistance [15] which leads to the corrosion of thermal system walls especially in heat exchangers like automobile radiators [16]. It leads to increase in scale formation in heat exchangers which in turn increases the fouling factor [17] and therefore the comprehensive thermal energy dissipation amount of the heat exchanger reduces and so the attainment of the thermal equipments[18]. Due to this problem [19] associated with the metal oxide nano particles carbon nano tubes gained attention as a replacement of metal oxide nano particles [20].

2. Carbon nano tubes (CNT)

Carbon nano tubes have been synthesized by rolling the graphite sheets into tubes which are usually in nanometer scale. There are two types of carbon nano tubes which are used often and generally this classification has been made based on the number of concentric tubes present in it. The first type is called as single walled carbon nano tube (SWCNT) which could be visualized as a cutout of a 2D carbon molecule hexagonal lattice vector which forms a hollow cylindrical shape. The second form of carbon nano tube is the carbon nano tube with nest shape which is called as Multi walled Carbon nano tube (MWCNT). The vanderwallinteraction between the adjacent tubes in the multi walled carbon nano tubes is very weak. Carbon nanotubes are the most durable and rigid particles which have been identified yet with respect to their values of tensile stress and their elastic strength respectively. This is due to the fact that each of the carbon atoms has been made up of sp² covalent bond. Due to these arrangements of bonds of type C-C, the carbon nano tubes are found to be the strongest known carbon based nano particle and have a extremely high values of Young’s modulus along their cross section.

The single walled carbon nano tube has a Young Modulus value of about 1 Tpa approximately. Due to this extremely higher value of Young Modulus the carbon nano tubes are very commonly used in scanning microscope as probing tips. The elastic modulus of the single walled carbon nano tube is directly related to its chirality as well as their diameter. But it is not the same in case of multi walled carbon nano tubes as it is depending upon the extent of sidewall defects. It has been inferred from the various experiments that in case of multi walled carbon nano tubes stress could be supported along the outer shell of graphitic wall when they are submerged in epoxy resin and in case of single walled carbon nano tubes it is carried out with the help of bundles which is otherwise known as ropes. It is also observed that the application of shear stress because of lighter cohesion among the tubes applies lower modulus in comparison with the individual tube.

The carbon nano tubes can exhibit the property of both the good thermal conductors as well as the insulators. The carbon nano tubes can act as a very good conductor of heat along the axis of the tube and it acts as an insulator in the lateral tubular axis. It has been inferred from the experiments that the carbon nano tubes can transfer 6000 watts of heat energy per meter Kelvin at the room temperature while copper the metal which popular its heat conduction can transfer only 385 watts of heat energy per meter Kelvin at the room temperature. Experimental data have shown that the carbon nano tube can be stable in vacuum
up to the temperature of 2800°C and 750°C in air. The traditional well known graphite fibers are extremely anisotropic whereas the carbon nano tubes are purely isotropic upon thermal expansion. Thus the carbon based composites have the advantage and it can be used for wide range of applications and we could guess that the carbon nano tubes may have very low thermal expansion coefficient.

3. Carbon nano horns

Carbon nano horns (CNH) are single-walled, horn-like carbon nanostructures with diameters of around 3 to 25 nm and lengths from 20 to 150 nm. It might be uni walled, bi walled or even it may consists of many walls. They are black in color and they may graphitic carbon tubes with cylindrical shape. They resemble a horn shape and somewhat similar to that thimble sewing and have a wide range of applications. They can be used in proton exchange membrane (PEM) as well as in the fuel cells of polymer electrolyte form (PEFC) as they have the capacity of offering open path for gas and layer for conduction with very surface area. The carbon nano horns are available in uni walled, bi walled and multi walled form either as bundled or unbundled. The tube length of the carbon nano horn may vary from 5 to 30 nanometers and their surface area may vary from 50 to 500 meter square per gram. Unlike carbon nano tubes, carbon nano horns can be synthesized with extreme purity either as dispersed or as suspended form. Nowadays research has been carried out in various fields such as bio sensors, MEMS, nano electronics, NEMS, bio nano particles and the various carbon based nano structured particles, for use in refrigerators, heat exchangers, solar panels, fuel cells, composites and bio composites.

Nano powders are simulated for chemical ingredients, distribution of particle size with the help of diffraction of laser, area of the specific surface with the help of multi point correlation method. Greater surface area can also be attained by using chemicals and by utilizing a minute layered film by scattering the targets and by evaporative techniques by utilizing the foils, pellets and also the rods. The Carbon Nano horns finds its applications in wide range of areas such as bio fuels, displays of various electronic devices, various microscopes, solar panels, composite and bio composites, lubricants, sensors, cancer detection, sports equipments, air conditioners, refrigerators. In addition to this carbon nano horns also finds its application in the field of bio science.

As with other graphic nanostructures, CNH properties such as high specific surface, high mechanical strength or good electrical and thermal conductivity can be commonly used on the nano scale. Based on these physical properties, CNH show great potential for innovation in materials science as a base material, a functional filler or coating. In industrial applications, property improvements, for example of thermoplastics, thermo sets, elastomers, or also metallic and ceramic sintering materials are evident.

Fig.1 Particle size distribution of two CNH types each with two peaks that represent different populations

The carbon nano horns are often placed in suspension for further processing, where the formation of stable star-shaped aggregates plays a major role in the function or later use. Here, the particle size distribution is an important term for identifying various nano particle populations. With NANOPHOX...
you quickly and reliably receive accurate and reproducible information about your product. The energetic light scattered with the PCCS and a manual NNLS interpretation form contributes a large perseverance for steady differentiation of large number of particle samples. Identification of particle populations

The volume-related particle size distribution (Q3 distribution) shows two particle populations. The first peak comes from the desired spherical combines with the radius of about 50 nm. The large agglomerates from around 200 nm up to the micrometer range in the second peak are coarse particles (agglomerates) that are formed from the spherical, star-shaped aggregates.

4. Properties Of Cnt V/S Cnh

Thermal Conductivity
Thermal conductivity of CNT is about 6000 W/m K. Thermal conductivity of CNH is slightly greater than CNT which is approximately about 6250 W/m K. It is attributed to the structure of CNH. Diameter of the CNH is slightly higher which allows free movement of molecules. Nano horns generally comprises of a tapered front-apex passage which is followed by a small barrel shaped nano tube passage. At the same time the apex of the CNH generally have five lustrum, a sixth lustrum from the apex is needed for the walls of the nano tubes to remain concurrent to the nano horn “axis” in the general fashion similar to the carbon nano tube. Each of the extra lustrums defends the curving diversity of each lustrum, and generally it is very common to infer that the spaced pairs of heptagon and lustrums. Beyond these they would not shift the net nano horn bending but raises the radius of the cylindrical passage. The nanotube sections of nanohorns have typical radius of about 2 to 2.5 nm, typically greater than that of the general diameters for traditional “infinite” cylindrical SWCNT which is about 1–2 nm. It is due to the fact that the traditional tubes disrupt about the critical radius to form a “dogbone” transverse section and after the power gain from Vanderwall synergy swamps the power cost from raised curve at the corner of the disrupted nanotube and therefore the conductivity of the nano horns are greater than that of CNT.

Thermal Diffusivity
Thermal diffusivity of CNT is about 4.6 cm² s⁻¹. For CNH it is about 4.78 cm² s⁻¹. Higher thermal diffusivity in CNH is due to the presence of curve originates the weaving of the π and σ orbital, that causes the assimilation among the orbital. The intensity of assimilation increases as the radius of a SWCNT decreases. Therefore the carbon nanotube susceptibility is precisely linked to the π-orbital imbalance induced by an added curving. The outcome is two sub categories for all the 2-, 3-, and 4-pentagon cones. This is fascinating that all the sub categories are spitted one another depending on vector length steadily the implication of Clara orbital arrangement in graphene and also the metallic characterization in the carbon nanotubes. All the classes are assumed to have a cone like structure so that they can be revamped from one form to another form by inclusion or exclusion of nearby carbon atoms. In contradictory to the carbon nano tubes, nano cone helicity is not a stable one and it increases gradually with the axis of the cone. In addition to this the choral as well as archrival nano cones are possible. Due to this reasons the CNH has higher thermal diffusivity than all other carbon nano structured materials.

Resistance to corrosion
The simulations of the carbon nano horn’s density structured function reveals that the contagious deviation in nano cone with acute strobilus featuring the fullerenes and strobilus which is merely an implication if graphene and the greater sized nano tubes. It is inferred from the experimental results that the inculcation of oxygen atoms to graphene is endothermic and it is most probably found at the tip of nano cone. Therefore it ensures 2+2 cyclic inclusion of fullerene which is very similar that of C60-O-C60 evolution. The carving was sustained by the preliminary indication of fullerene inclusion to the entire top edge of the nano cone apex with existence of oxygen. Similarly the simulation of covalent radical inclusion of the alkyl group to the carbon nano structures reveals that improved apex reactivity. Along
with the improved apex reactivity, the regional enzymatic reactivity has also been improved in the areas of greater curvature because of pyramidal exaggeration of covalent carbon sp² bonding. Due to this reason, the chemical reactivity of CNH is presumed to be dominant. Therefore CNH has higher resistance towards corrosion than any other nano particles.

**Purity**

Complete removal of impurities in CNT is not possible yet. It always has some impurities with it. It leads to scale formation in heat exchanger walls which in turn reduces the comprehensive thermal energy dissipation amount. Therefore the attainment of the automobile radiator got reduced. CNH can be synthesized with extremely high quality. The technique by which the carbon nano horns was synthesized earlier was the submerged arc discharge method by utilizing the DC arc immersed between graphite which is electrodes and liquid nitrogen with an yield of about 17 grams per hour. Another method was suggested later to fabricate CNH by utilizing arc discharge between water and nitrogen in gaseous phase. This method has a yield of about 1 kg per day which is far away greater than the yield of the previous method. This method proved to be more effective offering CNH even without negligible impurities. Therefore CNH can be produced with extra high purity but there has not been a possibility to produce CNT without impurities yet. Therefore the above mentioned problems can be rectified.

**5. Conclusion**

Carbon nanohorns are an engrossing and to a limited extend it is neglected carbon nano structured product which has a wide range of applications. Carbon nano horns can be produced in bulk quantities, at normal conditions even without the requirement of any metallic or non metallic catalyst. They have a lot of merits and it is proved to be the best alternative to carbon nanotubes, and possibly graphene, in an ample spectrum of appositeness. Realizing not only the exclusive precise tapered framework of nanohorns network but also their fabrication and choreography is of principle priority for propelling their exploring and advancement CNH has higher lifetime than CNT. It has high solubility than CNT. CNH can form a more stable nano fluid. Therefore it is recommended to use CNH as the nano fluid to enhance the attributes of the thermal systems like heat exchangers, refrigerators etc.

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