Review On Recent Benchmarks in the Field Of Carbon Nano Tubes

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***Abstract* - With continued advancement in technology, human imagination continually seeks to persevere towards achievement of more remote and difficult benchmarks. Carbon has been since long, is and will continue to be the center of all the studies and researches because it is something available all around. Life as we know will not exist without carbon atom. Their unique valency give rise to further probabilities of arranging carbon atoms and the study of these probabilities and their effect on properties of synthesized product is nano-research. One particular probability Carbon Nano Tube, shows a rather promising future for technological advancement if perfected. This paper explains and briefs about many recent developments in the research field achieved by researchers.**

I. INTRODUCTION

Derived as a product from the trial and error method conducted in 1885, Carbon Nano Tubes are the next big thing in the technological advancement. Carbon Nano Tubes, as the name suggests are made primarily of Carbon atoms. These carbon atoms are derived from a graphene sheet and each layer has carbon atoms arranged in a way that looks like electrical fence only the grill is made of hexagons.

The series of events that led to the discovery of this substance may just be the most important chain of events because these structures that were discovered had so many properties which were not exhibited by any other substance all together at once. Carbon Nano tubes are famous for exhibiting contrasting abilities - along the axis, carbon Nano tubes have high tensile strength as well as hardness and show plastic deformation only after continued application of pressure beyond the 5% elongation limit while perpendicular to the axis, they act as elastic agents. Along the axis of the CNTs, they exhibit great thermal conduction properties but perpendicular to the axis, they do exactly the opposite – they act as great insulators. CNTs when treated appropriately also give total internal reflection easily and this property is used in making available high speed internet through optical fibres as well as has many other virtual properties – the properties that are not exhibited by CNT normally but are exhibited after certain procedure of treatments.

One CNT can be very long and as high as million is to 1 ratio for length is to diameter has been achieved over time. These stunning properties to the Carbon Nano Tubes provide a large number of experts on varied subjects an incentive to work on them. With continued research being done on the subject, this paper tries to describe a few applications of CNTs and provide detailed description of the applications.

CNTs can be broadly divided into two types – SWCNT (Single-Walled Carbon Nano Tubes) or MWNT (Multi Walled Nano Tubes). SWNTs, as the name would suggest, are made up of only a single layer of carbon structure in a solid sheet. Depending on how the sheet is wrapped, the resulting nanotube can be described similar to a vector (n,m), where n and m are unit vectors in two directions along the honeycomb structure of the sheet. If m=0, the nanotube is referred to as a "zigzag", as the exposed end of the tube will result in alternating points and dips. If m=n, the tube is called an "armchair", as the exposed end will show alternating high and low plateaus. Any other vector produces a tube that is referred to as "Chiral". Most SWNTs will have a diameter of about 1 nanometer but the tube length can be on the order of millimeters, millions of times longer than that of the diameter. They have unique electronic properties which can change significantly with the chiral vector, C = (n, m), the parameter that indicates how the graphene sheet is rolled to form a carbon nanotube.

MWNTs follow one of two models. In one model, multiple SWNTs of varying diameters are arranged concentrically within one another. In the other, a single sheet is rolled up on itself similar to a newspaper or an old scroll of parchment paper. In either case, the distance between layers is generally very small, about the same as that between layers of graphite in a pencil. MWNTs exhibit advantages over SWNTs, such as ease of mass production, low product cost per unit, and enhanced thermal and chemical stability. In general, the electrical and mechanical properties of SWNTs can change when functionalized, due to the structural defects occurred by C=C bond breakages during chemical processes. However, intrinsic properties of carbon nanotubes can be preserved by the surface modification of MWNTs, where the outer wall of MWNTs is exposed to chemical modifiers.

2. Applications

2.1 Electricity generation through body heat conversion

Based on an independent research conducted by four scientists from Japan, a new type of material was created by a team under the leadership of David Carrol which exhibits all the properties to be classified as fibre, feels like a fibre though acts like a charger. Cell phones or other small devices like MP3 players can be charged while on the go using nothing but your body heat.

These devices called as 'Power Felt', are basically made of 5 layers of Single Walled CNTs treated differently and arranged precisely over each other.

Figure 1: Power Felt Fibre

According to a research published by 4 scientists, they were able to generate electricity from CNT by altering Seebeck coefficient which was achieved by changing and reforming semiconducting ratios of 5 individual layers of CNT. These layers were individually subjected to different treatments and then placed one after other. Since all these sheets had a shift in their Van Hove Singularity point of density of states which is nothing but the Fermi energy level at which population inversion is experienced, they produced a charge release which is then collected and hence temperature gradient successfully results in production of electricity from these sheets which are nothing but one layer together.

2.2 Sound generation using CNT

Researchers in Tsinghua University and Beijing University developed a thin film based on carbon nanotubes (CNT) that could replace conventional magnetic loudspeakers and earphones.

Thermo-acoustic property of CNT was discovered as early as 1915, though work could never really be done on it only as late as until 2008, when the researchers tried to optimize the thermo-electric property of CNT by replacing the conventional magnetic speakers with a stretchable thin CNT film which when exposed to an audio frequency current, produces sound in wide frequency ranges as well as exhibiting very low total harmonic distortion and high sound pressure levels.

This research brings forth a promising and rather exciting technological advancement for sound instruments by offering an achievable benchmark of transparent speakers. The CNT films being employed in the next gen speakers exhibit a jaw dropping stretch ability of 200%.

Offering a flat transmittance of amazing 80% at natural state, and a heightened transmittance of 95% as a result of laser treatments or being stretched to their maximum states, these films are made of treated special cylindrical MWNTs exhibiting high heat radiation properties. The audio producing part consists of a thin layer of the discussed MWNTs and two electrodes that rely on positive and negative variations in an alternating current to produce a periodical temperature fluctuation around the film in air and thus pressure oscillation is created which produces the sound. Double frequency sound is generated because of double frequency oscillation produced in the air due to alternating current.

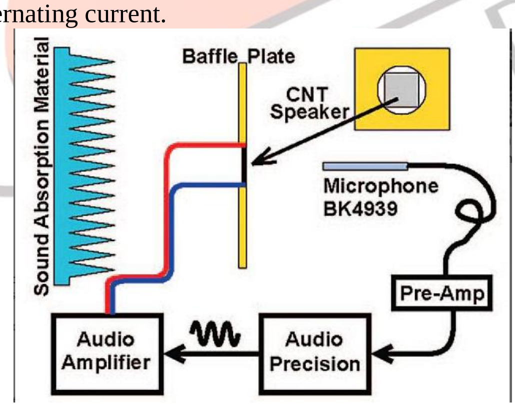

Figure 2: Electrical circuit demonstrating the working for CNT speaker.

As can be seen in the diagram, CNT speaker produces the sound, which is taken up by a sensitive microphone that further enhances the volume of sound using a general sound amplification circuit guided by an audio precision instrument that is in turn provided for sharper sound reproduction.

The only limit this system currently offers is the volume as a need for amplification is still present to make the sounds rich in the output.

2.3 CNT Based Solar Cells

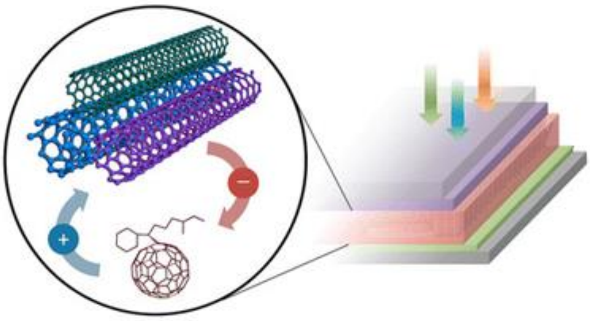

Figure 3: The new poly-chiral CNT based Solar Cell.

Solar cells are known for their high efficiency in conversion of solar energy to electricity. Though, they are costly and hence a cheaper solar cell with similar efficiency is the next step in revolutionizing the field of solar energy generation. CNTs, especially SWCNTs come in as perfect alternative for the otherwise expensive silicon solar cells more so because of their receptivity to a wide range of bandwidth variations in radiation but the problem with SWCNTs is that they exhibit really low conversion efficiency in current solar modules close to around only 1%.

The problem particularly magnifies because of the procedure usually followed while production of CNTs, wherein chirality which is nothing but the direction and plane along which repetitions are done while folding up a CNT molecule, is kept fixed and the entire module is made up of CNT that has just one chirality.

While rolling up a SWCNT, several thousand possibilities exist for chirality, each chirality lends an increased receptivity to the SWCNT molecule to a particular bandwidth of radiation. The new research is heavily based in the iterations to the perfect ratio of poly-chiral SWCNTs. By using these multiple chiralities, CNT solar cells absorb across a wider portion of the solar spectrum, which leads to higher currents and efficiencies.

2.4 Bulletproof Vests

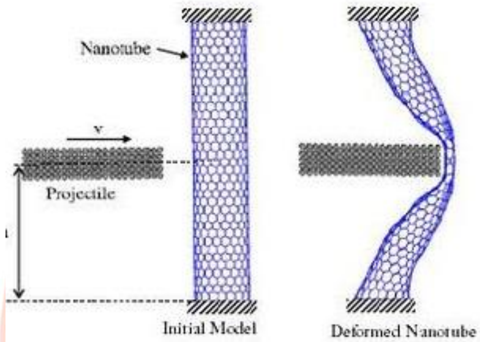

Figure 4: Bulletproof vest CNT depiction

Bullet kinematics highly rely on applying high pressure on one point. Concentrated high pressure when applied on one point, bullet can pierce the toughest of materials based on the strength of the material from which bullet is made of.

A bulletproof vest hence based on bullet's kinematic principle, dissipates the concentrated pressure on one area and dissipates it over a much larger area hence rebounding the bullet and preventing it from piercing the body of victim.

Current body vests are made of high performance fibers and yarns. Commonly used in practice today are S-glass, aramids (e.g., Kevlar 29, Kevlar 49, Kevlar 129, Kevlar KM2), highly oriented ultrahigh molecular weight polyethylene (e.g., Dyneema, Spectra), PBO (e.g., Zylon) which is a p-phenylene-2-6-benzobisoxazole, new polymeric fibers such as Polypyridobisimidazole (PIPD) (referred to as M5) etc. These fibers are characterized by low density, high tensile and compressive strength, high modulus, high rupture strain, resistance to thermal degradation and high-energy absorption capacity. Basically, ballistic protection is generated from high stiffness and toughness, woven or laminated, polymeric fibers stacked in a number of layers.

The main failure mechanisms in PMCs under ballistic impact are straining of fiber and its fracture, delamination and shear deformation in the resin matrix.

Carbon nanotube (CNT) is an ideal candidate material for bulletproof vests due to its unique combination of exceptionally high elastic modulus and high yield strain. A Young's modulus of about 1000 GPa, strength ranging between 13-53 GPa, and strain at tensile failure predicted to be as high as ~16% typically characterize SWCNTs14.

These SWCNTs can be used basically in three ways to create a bulletproof vest.

1) Incorporation of CNTs into vests, metals or ceramics to enhance their hardness or toughness and erosion resistance.
2) Use of neat or composite fibers of CNTs in the form of woven or non-woven fabric.
3) Reinforcing the armor grade fibers like Kevlar, UHMWPE or PBO with CNTs to improve their elastic modulus and energy absorption capacity.

CNTs, because of their unique combination of high elastic modulus and high strain to failure are capable of elastically storing an extreme amount of energy, which can cause the bullet to bounce off or be deflected. This attribute of carbon nanotubes can also provide the armor improved protection against blunt trauma effects. Based on their computational modeling studies, it can be seen that body armor comprising six layers of carbon nanotube yarns, each of 100 µm thickness, would have the capability of bouncing off a bullet with a muzzle energy of 320 J.

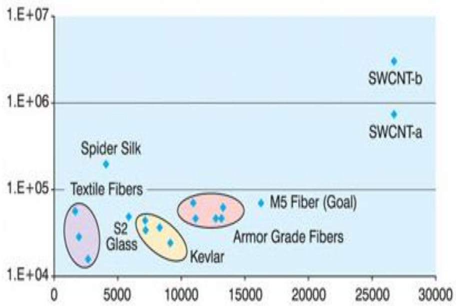

Figure 4: Specific Energy Absorption Capacity vs sonic velocity graph comparing current materials and SWCNT performance

3) Conclusion

Concluding, properties, procedure, effects and discussions of various recent benchmarks in the current research field of Carbon Nano Tubes have been presented.

4) Acknowledgement

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