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Recent Advances in the Development of Nanotechnology for Bio Medical Nano-Applications & Different Approaches

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Abstract:-- **This paper presents a brief review about the recent advances in the field of nano-technology. The word nano-technology means different to different people. For some, it conjures up images of fabulous new materials, lighter and stronger than steel. Others envision microscopic robots that clean plague from our arteries and tartar from our teeth. Nanotechnology has captured the attention of the scientific community, the media and now, the public. In the purest sense, Nanotechnology is the science of small…very small things measured in units called nanometers, which is one-billionth of a meter. Nanotechnology, better known as Molecular Nanotechnology, uses well-known physical properties of atoms and molecules to make novel devices with extraordinary properties. The technology completely abides by the laws of physics. This review paper would introduce you to the world of Nanotechnology in an exorbitant manner. The theory behind this extraordinary technology is Molecular Building Blocks. These blocks manipulate matter on nano-scale and this is an inevitable consequence of continued advancement in the fields of chip manufacture, biology, chemistry, computers and several major scientific disciplines. The future with nanotechnology is quite promising and sure to effect the present technology dynamically. This review paper definitely gives a total grip on the basic of nano-technology, especially those who want to purse a career in this exciting & dynamic field.**

Keywords- **Genetics, Swarms, Nanotubes, Molecules.**

I. INTRODUCTION

The invention of germanium transistor way back in June 1946 was the starting point of the microelectronics technology. In the late 1940s, a thinking that integrated circuits can act as brain to different products gained ground resulting in the birth of microprocessor 4004 in the year 1971. The late 1990s saw system on chip at 0.18 microns to 180 nanometres. Thus, between 1940 and 1950, the semiconductor technology emerged from R&D laboratories. Nanotechnology involves the manipulation and manufacture of objects on an atomic scale. One nanometer is roughly the length of three atoms in a row, or 1/10,000th of the diameter of a human hair.

Objects created using molecular nanotechnology will be precise to within the size of a molecule. Machined components will no longer abrade one another because they will fit together with molecular precision. Moreover, they will have been made with virtually no waste or pollution. They will have been made one atom at a time with readily available components like carbon, oxygen and nitrogen as their building blocks

Medical science will be able to create devices small enough to enter the body's bloodstream to repair damage and treat diseases at the cellular level. For example, instead of treating cancer using chemotherapy that weakens the entire body, nanotechnology will one day produce medical devices that can identify cancer cells and repair or destroy them with no damage to healthy tissue.

This manufacturing revolution will also give rise to startling advances in material science. Instead of steel or aluminum being mined from the ground, new materials will be made from carbon atoms in the form of nanotubes and related structures. A single-walled, carbon nanotube is a strawlike structure with a one atom thick wall of carbon atoms. Lighter, stronger and more flexible than steel, carbon nanotubes are believed by many to be the most promising of all nanomaterials [1].

While carbon nanotubes are still too expensive to use in everyday construction materials, the cost of producing them has decreased twenty fold over the past five years. As they continue to get cheaper to produce, manufacturers will develop innovative uses for them in a wide array manufacturing applications. The presence of carbon nanotubes today doesn't prove we'll one day be able to produce tiny medical devices that enter the body and cure cancer. Scientists believe this sort of thing will be possible because of the nature. Living cells are perfect examples of nanoscale devices that assemble structures one atom or molecule at a time [2].

II. MOLECULAR BUILDING BLOCKS

Making a self replicating diamonded able to manufacture a wide range of products is likely to require several major stages, as its direct manufacture using existing technology seems quite difficult. For example, existing proposals call for the use of highly reactive tools in a vacuum or noble gas environment. This requires an extremely clean environment and very precise & reliable positional control of the reactive tools. While these should be available in the future, they are not available today. Self-replication has also been proposed as an important way to achieve low cost.

A more attractive approach as a target for the near term experimental efforts are the use of molecular building blocks (MBBs). Such building blocks would be made from dozens to thousands of atoms (or more). Such relatively large building blocks would reduce the positional accuracy required for their assembly. Because this approach uses positional assembly at the molecular scale, and because positional assembly of molecules was, until recently, not a possibility that had been considered seriously, there has been remarkably little research in this area [3].

Strength and stiffness are the most desirable qualities in both individual MBBs and in the structures built from them. Intuitively, building things from marshmallows is usually less desirable than building them from wood or steel. More specifically, we can expect to use the intermediate systems we build from MBBs to make more advanced systems, including assemblers. The manufacturing techniques that have been proposed for advanced systems rely heavily on positional assembly. Positional assembly, in its turn, depends on the ability to position molecular parts with high precision despite thermal noise. To do this requires stiff materials from which to make the positional devices that are needed for positional assembly.

The immediate effect of using building blocks is to move us farther away from our objective. There must be strong compensating advantages before we will restrict ourselves to any particular building block. The advantage of building blocks are [4]:

1) Larger size.
2) More links between MBBs.
3) Greater tolerance of contaminants.
4) More accessible experimentally.
5) Ease of synthesis.
6) A larger design space.

MBBs can be characterized by a large number of linking groups. More linking groups are generally better, as they more easily let us make stiff three–dimensional structures. On the other hand, more linking groups tend to make the MBB harder to synthesize. MBBs with two linking groups form three-dimensional structures only with difficulty and only by using indirect and complex methods. MBBs with three linking groups readily form planar structures, which are strong and stiff in the plane but bend easily, like a sheet of paper, unless rolled into tabular structures to improve stiffness. They can also be used (although somewhat less naturally) to directly form three-dimensional solids with a unit cell having four MBBs.

MBBs with four linking groups quite naturally form strong, stiff three-dimensional solids in which the unit cell is composed of two MBBs (as in diamond). MBBs with five linking groups can readily form strong, stiff three-dimensional solids in which the unit cell is composed of six MBBs. MBBs with six linking groups readily form strong, stiff three-dimensional solids in which the unit cell is composed of a single MBB. They can also form very stiff sheets if all linkage groups are in plane, though this arrangement sacrifices stiffness out-of-plane. MBBs with

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twelve linking groups can form very strong and stiff three-dimensional solids.

Fig 1 MBB

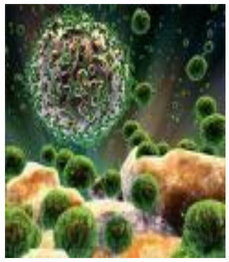

Fig 2 Wet nanotechnology

While MBBs can have any number of linkage groups, MBBs with fewer linkage groups are usually (though not always) more readily synthesized. If we seek an MBB with the least number of linkage groups that can still readily form strong, stiff three-dimensional structures, then MBBs with four linkage groups are quite attractive. A high symmetry structure with four linkage groups will have tetrahedral symmetry (with an inter-linkage angle of approximately 109 degrees).

III. TYPES OF NANOTECHNOLOGY

The different types of nanotechnology are the wet nano-technology, dry nano-technology & the computational nano-technology. These in turn are explained briefly one below the other as follows [5].

Wet nanotechnology : It is the study of biological systems that exist primarily in a water environment. The functional nanometer scale structures of interest here are genetic material, membranes, enzymes and other cellular components. The success of this nanotechnology is amply demonstrated by the existence of living organisms whose form, function and evolution are governed by the interactions of the nanometer scale structures.

Dry nanotechnology : This derives from science and physical chemistry. It mainly focuses on the fabrication of structures in carbon (e.g., fullerenes and nanotubes), silicon and other inorganic materials. Unlike the Wet technology, the Dry techniques admit use of metals and semiconductors. The active conduction electrons of these materials make them too reactive to operate in a 'wet' environment, but these same electrons provide the physical properties that make 'dry' nanostructures promising as electronic, magnetic and optical devices. Another objective is to develop 'dry' structures that possess some of the same attributes of the self-assembly that the wet ones exhibit [6].

Computational nanotechnology : This permits the modeling and simulation of complex nanometer scale structures. This predictive and analytical power of computation is critical to success in nanotechnology: nature required several hundred million years to evolve functional 'wet' technology; the insight provided by computation should a low us to reduce the development time of a working 'dry' nanotechnology to few decades, and it will have a major impact on the 'wet' side as well.

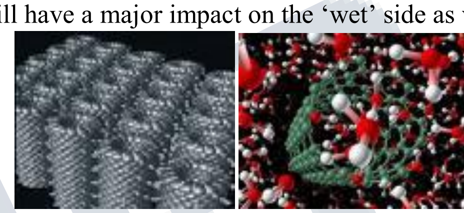

Figure 3. : Dry nanotechnology

Figure 4: Computational nanotechnology

IV. APPLICATIONS OF NANOTECHNOLOGY

Nanoparticles offer radical breakthrough in areas such as materials and manufacturing, electronics, medicine and healthcare, environment and energy, chemical and pharmaceutical, biotechnology and agriculture, computation and information technology, and national security. Scientists are discovering how to custom design exotic nanoparticles and processes with almost limitless potential.

Some of the possibilities we might see in the next decade include: polymer-based paints that defy scratching and corrosion, iron polymer batteries that generate twice as much power, resilient metal-composite car body panels that pop back into place, light-weight composites that boost jet-engine performance etc… Let us consider a few important applications briefly, Nanocomputers, The field of medicine, Space science, Nanocomputers [7].

Figure 5: Nano Computer

In the computer industry, the ability to shrink the size of transistors on the silicon microprocessor will soon reach its limits. Nanotechnology will be needed to create a new generation of computer components. Molecular computers could contain storage devices capable of storing trillions of bytes of information in a structure the size of a sugar cube.

While making a microprocessor, we handle big groups of semiconductor molecules and structure them into the form we need. This form of handling matter produces severe limitations as how small these circuits can be made. Present day lithographic technologies are at 0.13 microns. After the 0.13micron limit, it is very difficult to etch the circuits precisely and effectively on the silicon substrate. This is where nanotechnology steps in.

Computer giant IBM has come with a new kind of memory called ‘millipede technology’, which makes use of an array of atomic force microscope probes to make marks on polymer surface for storing data. Each tip writes a ‘bit’ of 50 nanometer on the polymer, which stores data. Reading and erasing of data is done by the same arrays. Today’s best storage devices are capable of memory capacity of 2 gigabits per square cm, where as this technology has made possible densities go up to 80 gigabits per square cm. This is about 40 times greater than memory devices available today.

Figure 6.: Liquid Nano Computer

Computers back in 1990’s used microelectronics. With nanotechnology, computers are built from molecular electronics. Presently, there are two types of molecules that have been demonstrated and are proposed for use as the potential basis or a backbone for the current carrying molecular scale electronic devices [8].

Nanotechnology in the field of medicine : It is intended for the treatment and/or the elimination of medical problems where accumulation of undesirable organic substances interferes with the normal bodily function. It describes a mobile robot that can be created and that can be used to seek out and destroy the unwanted tissues within the human body that cannot be accessed by other means.

It provides either cures or at least a means of controlling or reducing the effects of a no. of ailments, but it will also provide valuable empirical data for the improvement and further development of such machines. Practical data garnered from such operations at the microscopic level will allow the elimination of a no. of false trials and point the way to more effective methods of dealing with the problems inherent in operation at that level [10].

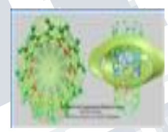

Figure 7: Nano Crystalline silver

Nanotechnology can be used for the treatment of kidney stones, liver stones, burn and wound debriding, parasitic removal. Nanotechnology applied to space science: Space science has long played a role in the research and developing of technologies. Spacecraft are being launched, with the hulls that are imposed of carbon fibers, a lightweight high tensile strength material. Combine that with smaller onboard computers that perform hundreds of times faster than computers used on spacecraft just a decade ago and one can see the way of incredible advances in space exploration in just the past few years. The advancements in material science and computer science have allowed the building, launching and deploying of systems that continually do more and more as they become smaller and lighter [11].

Some of the latest avenues being explored, that are far more in the nano realm, in space science, include smart materials for the hulls of the spacecraft. These materials along with being even lighter will also be far stronger too. To equalize the surface temperature now, a spacecraft must be kept rotating and although a slight spin

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is good in maintaining the altitude of a craft sometimes it interferes with the mission plan, like when a spacecraft is taking photographs or is in the process of docking with another craft. And heat shielding, on a spacecraft now, doesn't allow for any changes in mission design.

Another avenue being investigated is a concept of nano robotics called "Swarms". Swarms are nano robots that act in unison like bees. They theoretically, will act as a flexible cloth like material and being composed of what's called Bucky tubes, this cloth will be as strong as diamond. This smart cloth could be used to keep astronauts from bouncing around inside their spacecraft while they sleep; a problem that arises when the auto pilot computer fires the course correction rockets. The cloth like material will be able to offset the sudden movements and slowly move the sleeping astronaut back into position. Still another application for the nano robot swarms, being considered, is that the smart cloth could be used in the astronaut's space suits. This material will also be capable of mending it very quickly.

V. FUTURE WITH NANOTECHNOLOGY

Eric Drexler, popularly known as the father of nanotechnology, says, "A short summary of what molecular nanotechnology will mean is thorough and inexpensive control of the structure of matter. Pollution, physical disease, and material poverty all stem from poor control of the structure of matter. Strip mines, clear-cutting, refineries, paper mils, and oil wells are some of the crude 20th century technologies that will be replaced. Dental drills and toxic chemotherapies are others. I would add the gasoline engine, electrical power generation facilities, glass, metal, and plastic material manufacturing, intravenous injection and surgery, and agriculture as we know it. If nanotechnology works as envisioned, it will change everything."

Research in nanoscience is literally exploding, both because of the intellectual allure of constructing matter and molecules one atom at a time and because the technical capabilities permit creation of materials and devices with the significant societal impact. The rapid evolution of this new science and the opportunities for its application promises that nanotechnology will become one of the dominant technologies of the 21st century. Nanotechnology represents a central direction for the future of chemistry that is increasingly interdisciplinary and economical in application. If we had the ability to manufacture things on atom at a time, we could build with a precision that would be as close to flawless as human beings may ever get.

Pollution will be thing of the past with the dawn of this technology. The present plundering of the planet's resources only to release harmful by-products back into the biosphere will be seen as a shameful part of human history. Today's approach of manufacturing from the top-down (i.e., cutting down of trees for wood, or mining to obtain metals) will be replaced with molecular manufacturing, the idea that we can build an object from its component molecules. Since we understand the molecular building blocks of most materials, such as wood and steel, we can manufacture them molecule-by-molecule, but make the even stronger and lighter than their counterparts in nature. With the power to control matter, molecular manufacturing will make materials with a strength-to-weight ratio of a hundred times as that of steel [12].

The future of computing technologies lies in nanotechnology. There are five areas that hold promise : Nano Fabrication: Carbon nanotubes are an exotic variation of common graphite having super strength, low weight, stability, flexibility, large surface area, etc. Potential applications include transistors and diodes, field emitter for flat-panel displays, cellular-phone signal amplifier, ion storage for batteries and material strengthener. Nano electro mechanical systems are being developed for heterogeneous assemblies, telecommunications, consumer electronics, micro fluids, defense and space needs. Chemically assembled electronic nanotechnology is another emerging area. This uses self-alignment to construct electronic circuits out of nanometer scale devices that take advantage of quantum-mechanical effects.

Biocomputing : cross-fertilization of biotechnology with the information technology reveals the inherent formation theories of natural life sciences with high-end computational techniques. Efforts have been made to compile full genetic information stored in nucleus and the mitochondria as digital repositories of information.

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Figure 8. Carbon nanotubes   Figure 8a : Genetic material

Molecular computing : researchers have built an electronic switch consisting of a layer of several million molecules of an organic substance called rotaxane. By linking a number of switches, the researchers produced a rudimentary version of an AND gate. One of the simplest active devices was a molecular based on a string of 3 benzene rings in which orbitals overlapped throughout.

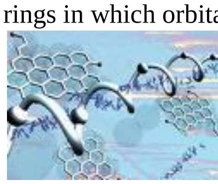


Figure 9: Molecular computing   Figure 10. : Optical comp. instr.

Optical computing : in optical computers electrons are replaced by photons. Thus, it is possible to fabricate closely packed nanostructures. Researchers are using new conducting polymers to make transistor-like switches smaller and 1000 times faster than silicon transistors. There are a number of proteins, which are sensitive to light and change their structures/orientation depending on the wavelength of the light. This emerging can revolutionize information processing, providing novel methods of securing, processing, storing, retrieving and transmitting information. Practical applications could include super fast computers operating at the sub-atomic scale, and fully secure information transmission.

VI. THREATS OF MISUSE

It is on the side of caution where more of the weight should be felt. Molecular nanotechnology, if developed in secret and without the strictest controls possible, can be dangerous beyond precedent. Self-replicating systems pose two major risks. One risk is that a self-replicating system will continue to replicate unchecked. The other is that during replication there will be changes or alterations in the self-replicating system that will allow mutations that lead to some sort of evolutionary process. This could result in a system that does things that you don't expect – possibly quite unpleasant things that you don't expect.

Molecular manufacturing makes it possible to build weapons at a much faster rate than is now possible, but a more frightening prospect is the development of dangerous programmable "germ" nano-machines for warfare. The possibility of accidental world destruction also exists, if one thinks about the implications of the escaped replicating machines eating organic materials throughout the earth. Indeed nanotechnology in the wrong hands could have disastrous consequences, but even those responsible for its beneficial use must be wary of the potential dangers.

VII. CONCLUSION

This paper presented just a brief review about the basic fundamental concepts of nano-technology & its vast and diversified applications in the modern day world. Molecular nanotechnology is predicted to be the most powerful technology yet developed by mankind. It will lead to major changes in our civilization. Three key breakthroughs are necessary : nanomanipulation, mechanochemistry and system design. There is an immense amount of work to be done. There is no question that will see major steps towards the goal of creating molecular nanotechnology in the next decade. In the future, nanotechnology will let us take off the boxing gloves. We'll be able to snap together the fundamental building blocks of nature easily, inexpensively and in most of the ways permitted by the laws of physics. This will be essential if we are to continue the revolution in computer hardware beyond the next decade, and will also let us fabricate an entire new generation of products that are cleaner, stronger, lighter and more precise. Momentum towards this technology is fast building up as researchers, private companies and government agencies all over the world rush to be leaders in this very exciting race. Every body goes from nano to macro, but now the world is going in the reverse way, i.e., from the macro to the nano. The future is small, but it promises to benefit us all !!!!!

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