CHAPTER-1
INTRODUCTION

"Invisible things are most powerful." so the Nano.

The study of assembling, controlling or/and manipulating matter on molecular or atomic size is called Nanotechnology in brief known as Nano [1-3]. Very commonly, nanotechnology is the study of material of lesser than size 100 nm or smaller in one dimension at least, which comprises of constructing devices or materials of that size [4]. Nanotechnology is extensively wide phenomenon starting from classical device-physics to foremost new methodologies based upon self-assembly of molecules, evolving materials with nano-dimensions, investigation of methods that can directly control matter on atomic scale.

Nano-(symbol n) is prefix means 10^{-9}, denoting a factor in metric system. This is a derivative of Greek word νᾶνος, meaning *dwarf*, and is officially established as standard in 1960. In 1965, Gordon Moore, head of Intel Corporation, predicted that the number of transistors that could be fit in a given area would be double in number for every one and half years in next decade [5]. This came to be reality and this phenomenon is popularly known as Moore's Law. To this day, the phenomenon according to above law continued for the past decade. We have witnessed the fact that there is a significant increase in housing the transistors from couple of thousand transistors in 4004 processors in the year 1971 to over 7 lacks of

transistors in the Core-2-duo computer mother board. It is noted that significant decrease in the size of individual electronic elements, going from millimeters to nanometers in modern circuitry. At the same time, the chemistry, biochemistry and molecular genetics communities are moving in the same direction with the same pace.

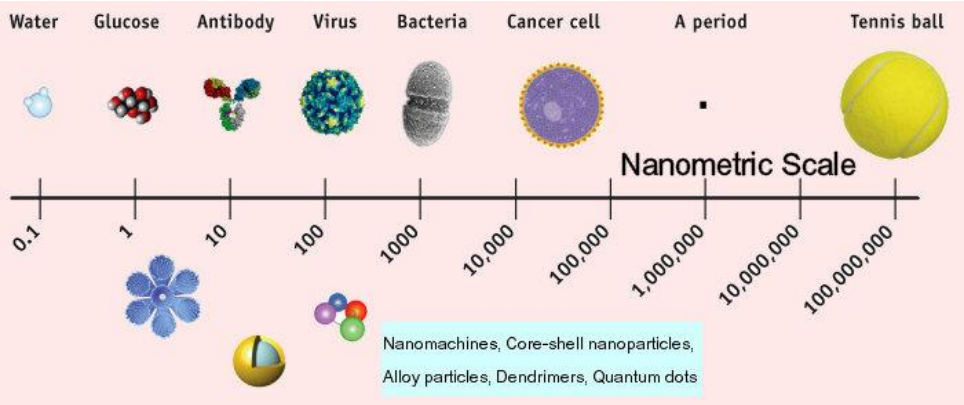

Fig. 1.1 Nanometric scale

In the beginning of a new digital era, the different powerful technologies have met the nanoscale with the promise of transforming both the fields of and biology of electronics. This upcoming field of molecular bio-nanotechnology opens new avenues from basic research in bio-physics and molecular-biology to biosensing, biolabelling, bioinformatics, pharma and medicine, genomics, information storage and energy conversion applications and also in computing [6-11].

We refer to a talk given by physicist Richard Feynman, a Noble laureate at an American physical society meeting on December 29, 1959, "There is plenty of room at the bottom," [12]. The term "nanotechnology" was first defined by a well-known scientist 'Norio Taniguchi' of Science University, Tokyo in a 1974 paper. In early 80s, the research of nanotechnology was stochastic than deterministic. A

Nano-scale phenomenon was up-held by Dr. K. Eric Drexler for precise handling of individual atoms and molecules theoretically [13, 14]. Academic knowledge of nanotechnology in life was given by R. Jones in a book published; 'Soft Machines' (nanotechnology and life) [15]. The concept of DNA nanotechnology was invented by a crystallographer, Seeman in 1980 who demonstrated that a three-*dimensional* DNA lattice could be used to orient target molecules. In 1991, Seeman's laboratory published the synthesis of DNA cube, the first three-dimensional nanoscale object, for which he was awarded Feynman Prize in Nanotechnology in 1995 [16].

Although nanotechnology has wonderful future applications, at the other face it raises many issues as in the case of introduction of a new technology, which includes concern about the toxic impact of nano-residues on the environment, and their global-economic effects, which predicted many doomsday scenarios. These created apprehensions for the governments and the intellectuals to debate on the necessity of brining a special regulation for nanotechnology [17].

Nanobiotechnology is an amalgamation of the researches made in nanotechnology and biology. The specialty of this branch is the study of biological phenomenon at nanosize level. Nanobiotechnology includes methods of synthesis, characterization, pharmacological screening and the other possible applications of nanoparticles. These comprise of using experimental tools like visual inspection, imaging, analysis via, AFM, FESEM, TEM /optical tweezers. This is dependent on different properties of nanomaterials which are extensively studied

for optical (photochemistry, luminescence, absorption phenomenon), mechanical (adhesion, deformation), thermal (thermal management in hyperthermia treatment of cancer) and biological properties (cell-particle interaction, biosensing, biological mechanisms, thermomutability) [18, 19].

In pharmacy and medicine, emphasizes are laid on the research applications of basic sciences to nanoscience and nanotechnology. Nano-bio-science is studied for the application of the bio-functionalized nanoparticles to different types of diseased cells along with the knowledge of mechanism of their action to prevent and cure the particular disease [20-22].

1.1 Green Chemistry approach of nanoparticle biosynthesis

Green chemistry is an innovative method of research which includes application part for design and development enabling efficient production of the goods that can bring the health hazardous substances to a minimum. The green chemistry in relation to bio, organic, inorganic, analytical, and even physical chemistry emphasizes only on large-scale applications [23]. This new green nanotechnology projects aim at minimizing the human as well as the environmental health hazards. The production and applications of nanomaterials in turn require a replacement of newer nano based products that can prove to be useful in this respect [24]. What we need to know is about exposure and toxicity of these nanomaterials so that we can find out the measures that can prevent the risk in the usage of these nanomaterials. This nano research is at its infancy, but

we need to put much effort to stay in touch with this technology as it is brought up.

1.2 Biofunctionalized noble nanoparticles as drug delivery systems

Highest level of attention is paid to nanoscience and technology with a zeal never witnessed before, because of its budding prospect that can virtually transform every subject wherever it is applied. As such, only recently this field has attracted researchers to use bio-functionalized noble metal nanoparticles in the systems of drug delivery [25]. The recent vibrant development of nanotechnology based drug delivery is creating the smart and novel approach; the functionalized noble nanoparticles can themselves act as drugs or drug vehicles and can also be employed for many applications in pharmaceutical and medical research [26]. In this noble metal based drug delivery systems, the foremost thing of considerations is to manufacture a material on a safe and sophisticated modus. Using green chemistry principles i.e., synthesis of medicinally useful functionalized metal nanoparticles through bio-route is an excellent idea; which in practice is seldom found [27]. The problems with the current physical and chemical methods are: poor ability, short time stability and safety problem in usage of these particles and such problems can be satisfactorily solved by biosynthetic processes. The ultimate aim of manufacturing these functionalized noble nanoparticles through bio-route is to develop drug delivery system

and become useful for formulations for treating patients with high level of specificity and also the safety [28].

Looking in to safety parameters, the pharma and biotech industries take high level care in using these new drug delivery systems if included as active ingredients or components or excipients. Hence it becomes quite essential to study thoroughly on the systemic safety parameters in the usage of the new bio-synthesized nanomaterials. Only marginal improvement in the parameters of the drugs or the delivery systems as is done classically will not make worth formulations for the future. But surely, nanotechnology has a prospective which can positively reverse the situation for it increases the efficacy and provides safety by orders of magnitude [29]. To quote an example, functionalized gold nanoparticles are effectively used as contrast agent for diagnosis, treatment, carrier for other drug from site of injection to site of action. In drug delivery systems, nanotechnology has proved to have many prospects which can be of a great help. The nanotechnology oriented drug delivery system will grow fast in comparison to conventional methods when we stress upon manufacturing and fabrication of materials with a right approach [30].

1.3 Nanotoxicology

The study of toxicity of nanomaterials is known as nanotoxicology which is a branch of nano-bio-science. Owing to their high surface area, nanomaterials show distinctive properties when compared with bulk materials. Even the inert noble metals like gold

and silver become highly active when they are reduced to nanoscale [31]. These properties of nanoparticles may also affect and pose problems to the health of human beings and to the atmosphere for controlling their ultra activities. E.g., ultrafine particulate matter harms the cardiovascular system and lung cells in a human model [32].

1.4 References

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