Introduction

1.1 Background

In contemporary time nanotechnology has emerged as significant and sensational subject in pure science as well as applied science and engineering. It has potential to lead us in the future full of advancements in technology and applications. The focus of scientific improvement is always for lighter, speedier, and economical devices with more end applications using minimal raw materials and energy (Schmid et at., 2003). The Fig. 1.1 depicts the growth phenomenon of nano system in the past 20 years time span (Bhattacharyya et al., 2009).

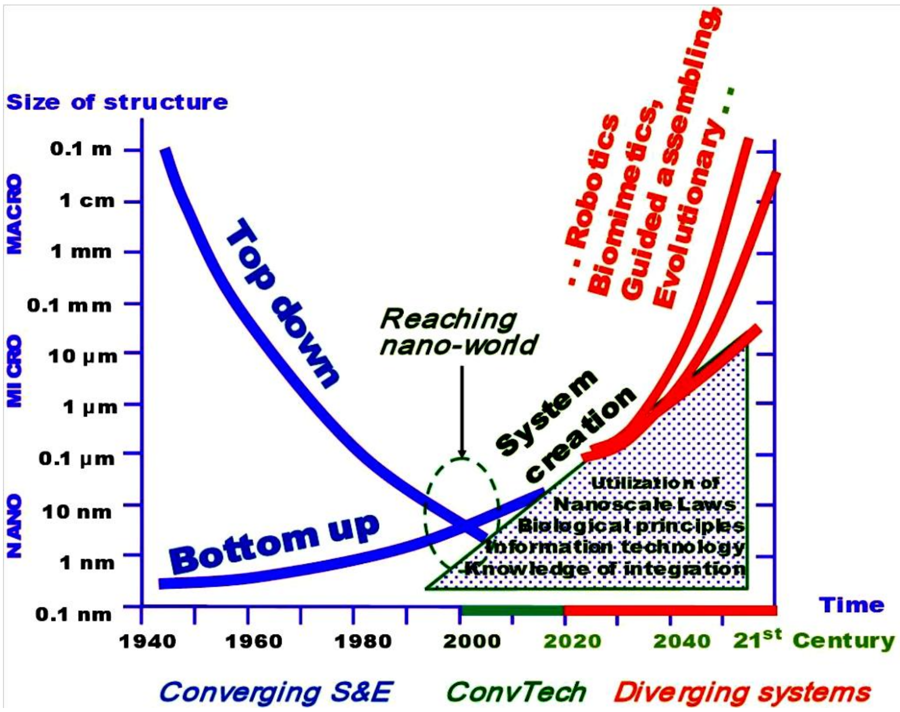


Fig. 1.1 Reaching at the nanoworld (Bhattacharyya et. al., 2009)

The technological race is edged only by pace of development in science and engineering, amalgamation of science and characteristics of nature at the nanoscale leads to contribution of new knowledge in the form of innovation and integration of technology (Taylor et al., 2007). The mixing and separation are a major component in many processes of science and engineering. According to Nanotechnology White Paper published as an External Review Draft on December 2, 2005 by U.S. Environmental Protection Agency, the figure 1.2 shows perceived stages of Nanotechnology Development based on increasing technological complexity.

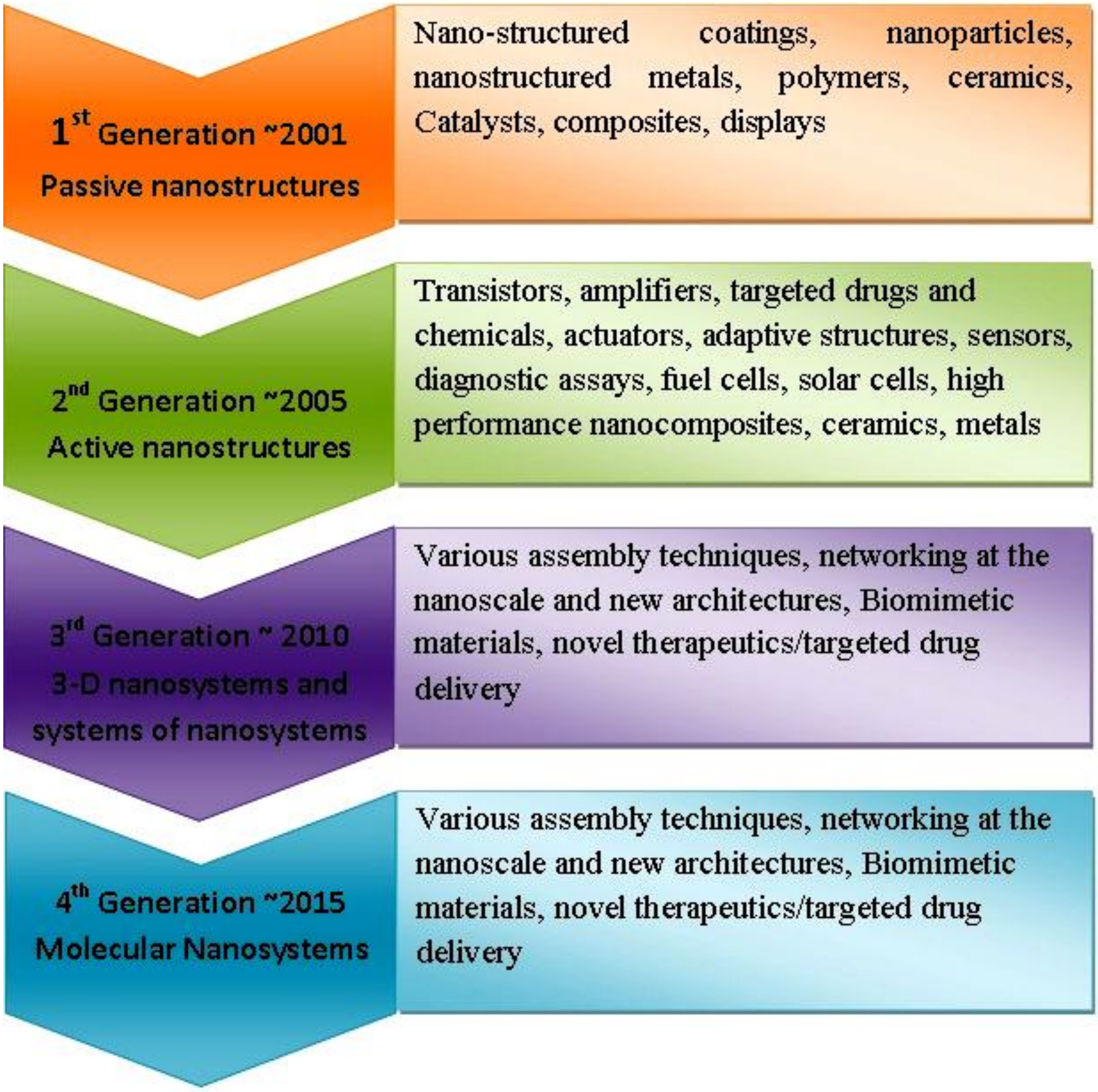


Fig. 1.2 Perceived stages of nanotechnology development based on increasing technological complexity

Considering the present large requirement and projected for future, nanoparticle researchers are enthusiastic for formation of new materials starting the design at the atomic and molecular level. The challenge is to provide genuine, commercial methods without compromising the energy and environment standards (Bhattacharyya et al., 2009).

1.2 Nanotechnology

Nanoscience is the study of matter at nanometer scale, and developing academic perceptions and principles for them. Nanotechnology deals with engineering, operation at nanoscale matters. Nanotechnology uses the knowledge of nanoscience for applications.

Nanotechnology is at center stage for researchers. The term nano coins from the Greek and it means “dwarf.” The term is indicator of physical dimensions in the range of one-billionth of a meter. This is nanoscale. Two hydrogen atoms are about one nanometer long. Generally the materials whose constituent structures are up to 100 nm in size are believed to be of nanoscale. The electrical, optical, and magnetic properties of the matter as well as structural behavior are affected at nanoscale. The most popular example is computer chips. The fundamental properties of materials can be controlled while maintaining chemical status at nanoscale.

Nori Taniguchi introduced the term nanotechnology at the Tokyo International Conference on Production Engineering in 1974. He was refereeing the word to explain the process of a material to nanoscale precision. His focus was to study the mechanisms of machining hard and brittle materials through ultrasonic machining. American Physicist and Nobel Laureate Richard Feynman had visualized that the scanning electron microscope would be able to “see” atoms with design modification (Ajayan et al., 2003). K. E. Drexler pushed the concept of “molecular nanotechnology” where he anticipated the technology where atom by atom and molecule by molecule are capable of building whatsoever is desired (Muataz Ali Atieh et al., 2008). Fig. 1.3 illustrates the scale of objects in the nanometer range.

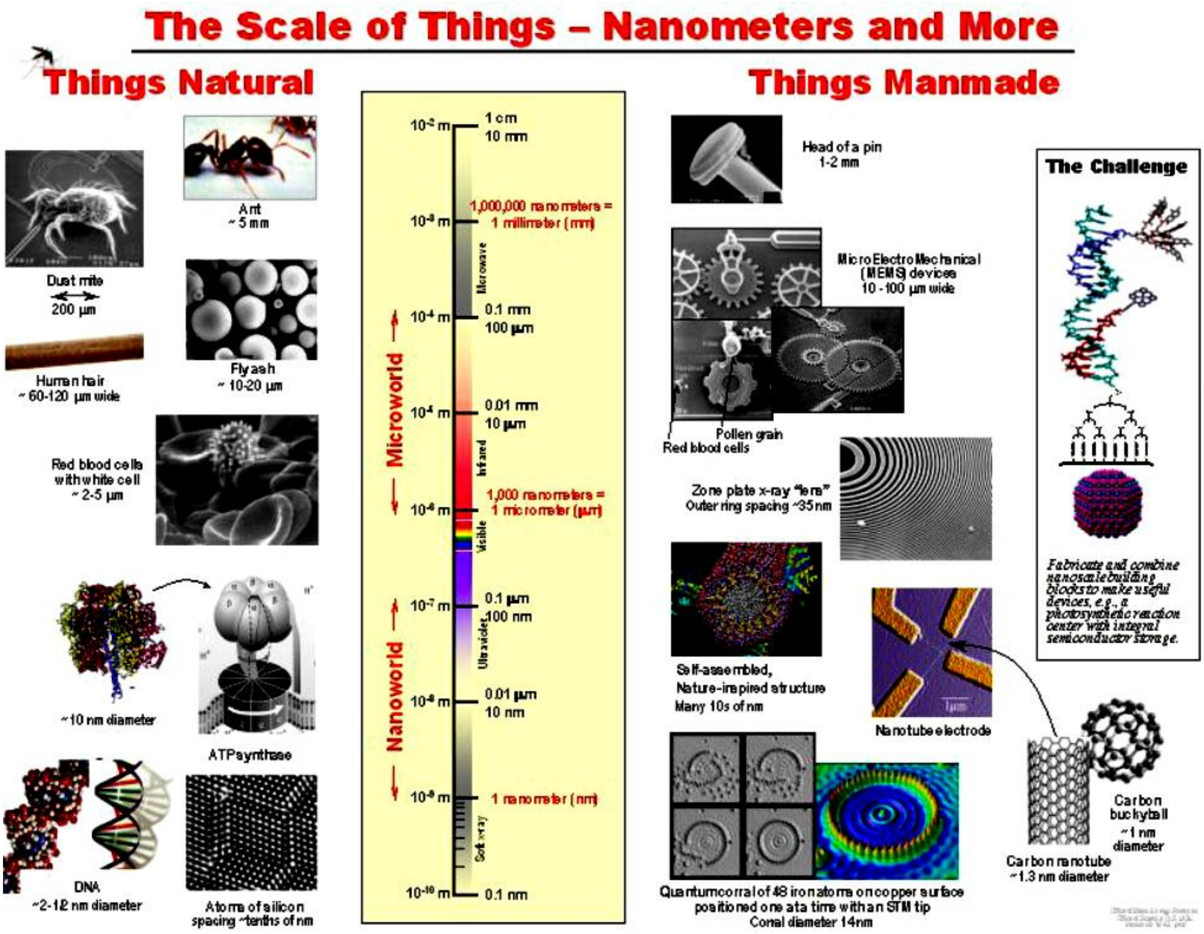


Fig. 1.3 Diagram indicating relative scale of nano-sized objects

(http://www.epa.gov/osainter/pdfs/EPA_nanotechnology_white_paper_ external_ review_ draft_12-02-2005.pdf)

1.3 Nanoparticles

Revisiting the history one come across the fact that artisans used nanoparticles for glittering effect on the surface of pots (Reiss et al., 2010, Khan et al., 2012). Nanoparticles are connecting link of bulk materials and corresponding atomic or molecular structures. In absence of internationally accepted definition of a nanoparticle, the new PAS71 document developed in the UK defines as: "A particle having one or more dimensions of the order of 100nm or less and Novel properties that differentiate nanoparticles from the bulk material typically develop at a critical length scale of under 100nm".

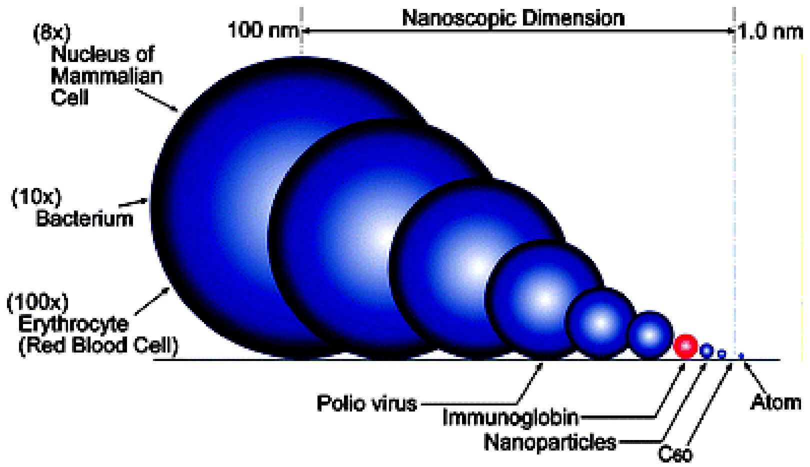
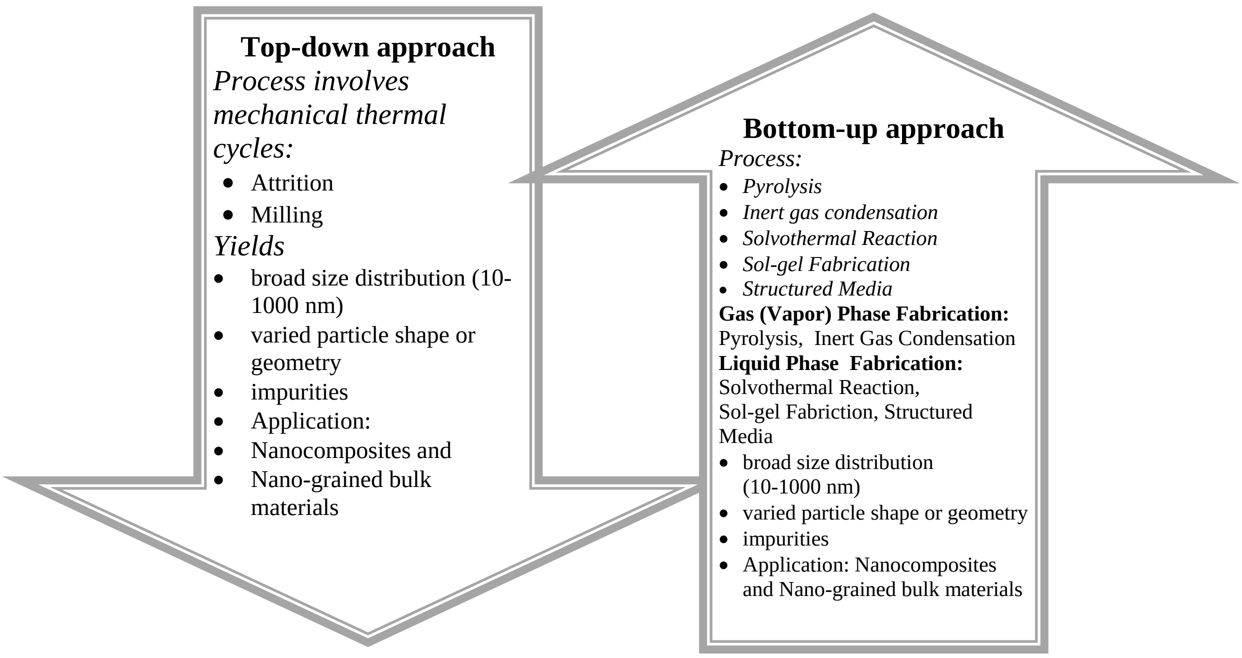


Fig. 1.4 Size comparison of nanoparticles with bacteria, viruses and molecules
(Gu et al., 2006)

Most of the nanomaterials are prepared straight as dry powders with assumption that these stored powders will stay in the same state. On the contrary, aggregation takes place in a few seconds. The effect of the aggregates is related to application of the nanomaterial. Fig. 1.4 illustrates typical biological objects where particles of 1 to 100 nm can be found.

1.3.1 Nanoparticle synthesis

The synthesis of nanomaterials can be achieved by employing one of the two general approaches. The schematic figures in Fig. 1.5 are for illustration.



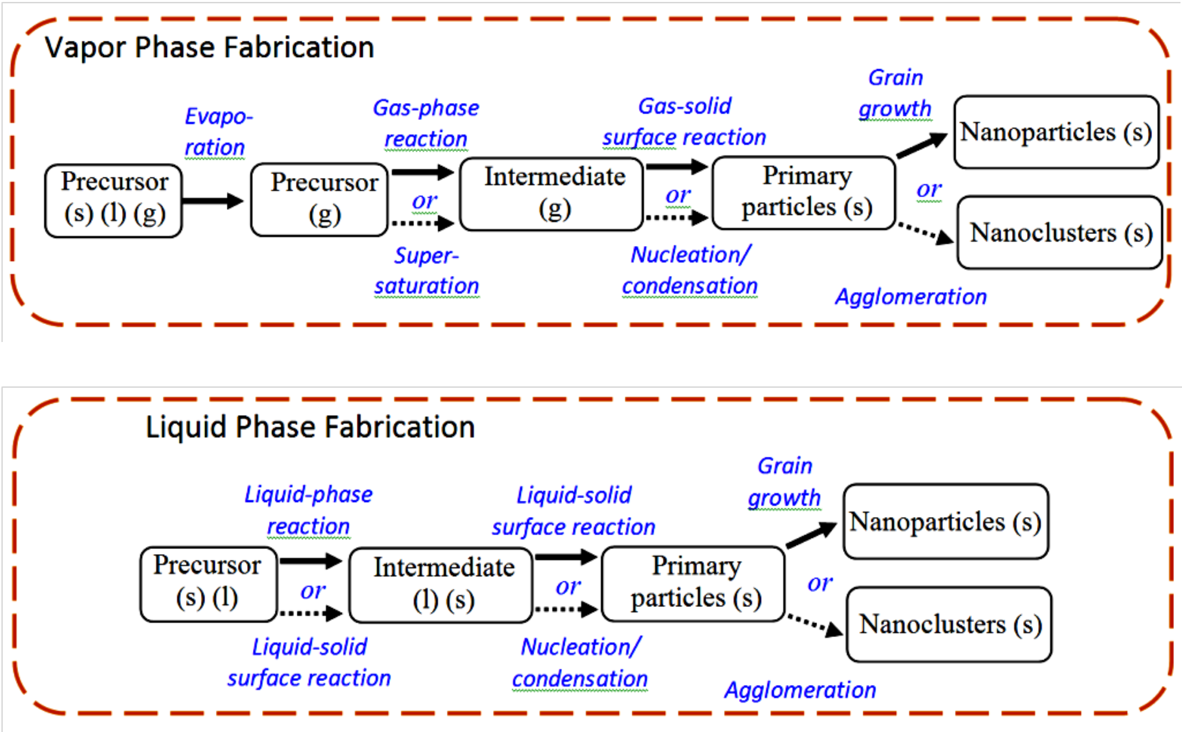


Fig. 1.5 Nano particle synthesis

(http://www.learningace.com/doc/1969627/55894ed0b784fee939009b47156bc639/lecture4-overney-np-synthesis)

Vapor phase synthesis of nonmaterial's are extensively used for depositions to prepare semiconductors for device making, it is the liquid phase synthesis that has attracted considerable attention to get materials that may or may not be semiconducting and used for device making but could be used for multitude of other applications such as catalysis, coatings, drugs, tracers, fillers etc.

In the attempt to synthesize materials in the liquid phase the major hurdle encountered by investigators is the difficulty encountered in keeping the particles small. All the forces of nature conspire to help particles grow; they grow due to surface energies, surface charge, Oswald ripening etc. As a consequence, to arrest this growth investigators have attempted unique techniques from surface charge neutralization, capping, shrinking reactor sizes, precipitation at interfaces, precipitation in pores etc.

Quite some attempt has been done to synthesize nanoparticles in micro heterogeneous media such as emulsions and Micro emulsions where in the phase heterogeneity itself contributes to restriction of size of particles and a lesser degree of aggregation during the course of synthesis.

1.4 Thesis Outline

This thesis was planned with focus on the synthesis of nanoparticles /aggregates of nanoparticles in diverse micro heterogeneous systems such as Micro emulsions, sol-gel systems and compares the same with classical hydrolysis and hydrothermal methods. To investigate the effect of space confinement on particle synthesis, we also had in mind to use the material for device making. During the investigation it was realized that the materials obtained by the micro emulsion method was not pure in phase as a result building a solar cell type device was pointless. Moreover, the yield of material was very low, even for characterization, product from a number of runs were needed to be collected therefore application of this type of material beyond a concept development was not attempted.

At this juncture our attention was attracted by nano clay which is a naturally occurring micro heterogeneous material extensively used as fillers in the rubber industry. The application of nanoclay to prepare rubber nanocomposites for tire inner liners seemed an attractive proposition as a result a second phase of work was undertaken to achieve property enhancement of rubber composites in the presence of porous nano clays as fillers and to characterize such composites in terms of mechanical properties so as to explore the possibility of reduction or elimination of conventional carbon black fillers from rubber composites that are potential environmental hazards. Since this work was slightly out of tune with the main theme of the thesis hence it was decided to retain this part of the work as a total unit in a separate chapter.

The Thesis is presented in six chapters. Chapter 1: ***Introduction*** outlines the scope of the study. Chapter 2: ***Literature Survey*** provides a general review on the synthesis of nanoparticles in micro heterogeneous media. Experimental procedures and characterization techniques are detailed in Chapter 3: ***Materials and methods*** Chapter 4: ***Synthesis of nanoparticles in microheterogenous media*** discusses the results of experimental synthesis of particles in different microheterogeneous systems. Chapter 5: ***Application of nanoparticles in synthesis of rubber nanocomposites*** details the methods, results and discussion pertaining to property changes sustained by composites in the presence of nanoclay. Finally Chapter 6: ***Conclusions*** sums up the results of the investigation and provides direction to future work.

1.5 References

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