

# Chapter 11

## Nano World

### ABSTRACT

*This part of the book provides information and projects for the readers about the omnipresence of nanoscale objects – soft matter, colloids, liquid crystals, carbon nanotubes, nanoshells, and the developments in nanoscale and molecular-scale technologies involving these small structures. Nanotechnology concerns structures measuring between 1 and 100 nanometers and allows manipulating individual atoms and molecules. Since Norio Taniguchi of Tokyo Science University first used the term nanotechnology in 1974, the governments, corporations, and venture capitalists invest every year billions of dollars in nanotechnology and more than a half of advanced technologies incorporate nanotechnology products in different ways. In addition, developments in nanotechnology demand hiring in millions of trained nanotechnology workforce (Nano.gov, 2012).*

### INTRODUCTION

The developments in nanoscale and molecular-scale technologies let us study the nanoscale objects: liquid crystals, soft matter, nanoshells, and carbon nanotubes. We may learn about structures and actions going in the nanoscale and how can we use nanoparticles and nanotechnology. These technologies make a background for progress in energy conservation in micro and nano scale. Nanotechnology can impact cancer treatment, clinical neuroscience, tissue engineering, drug delivery, and diagnostics.

Nanoparticles can be made “top down” by chopping a bulk material into nanosize bits or

“bottom up” by growing molecules like crystals in controlled conditions. Nanoshells, nanoparticles covered with metal, e.g., gold nanoshells are used for biomedical imaging and serve therapeutic applications. Nanoceramic filters allow water purification pushing water through nanotubes or a  $10^{-9}$  m to  $10^{-11}$  m membranes. Themes discussed here comprise early nano applications and technologies, soft matter, nanoscale metric measures, tools for examining nanostructures, graphene, nanofabrication, size dependent properties of nanoparticles, colloids, nanoshells, viruses, liquid crystals, fullerenes: carbon nanotubes and buckyballs, structures in a human cell, and visualization of biological data: DNA.

## EARLY NANO APPLICATIONS AND TECHNOLOGIES

Nano applications had preceded nano technologies. Before the time when nanoparticles became the object of thorough investigation people were not fully aware of the omnipresence of nano structures functioning as the nanoscale building blocks in nature and as our makeup. The prehistoric, ancient, and medieval people did not know about the nanoscale domain because they could not see it; however, they did make use of its potential in the past by applying specific techniques without knowing why their action were effective. People applied molds on wounds without knowledge about the antibiotic properties of penicillin, and used cultured molds to produce cheese, bread, or soy sauce. Long before the advent of nanotechnology, the Upper Paleolithic inhabitants of the Altamira caves in Spain, 13,000 B.C. created cave drawings and polychrome rock paintings of wild mammals and human hands using painting materials: charcoal and pigments. Charcoal contains nano material graphene, a two-dimensional allotrope of carbon. Pigments are micro- and nano-powders; by mixing with water they can be converted in colloidal or clay form. Many pigments change the color of reflected or transmitted light because they selectively absorb certain wavelengths of light (Cave of Altamira and Paleolithic Cave Art of Northern Spain, 2012; Orfescu, 2012).

2,000 years ago Romans used the gold and silver nanoparticles in their artwork not knowing they are so minuscule. Dated from fourth century AD base of the Lycurgus cup (now in the British Museum, London) changes color from green (when illuminated from outside) to red (when illuminated from within) because it contains nanoparticles of gold and silver; followers couldn't recreate this effect (Cook, 2005).

Medieval artists from the 500–1450 period used to add nanoparticles of gold to create stained glass windows; they produced colors from yellow-

orange (with silver nanoparticles) to ruby red (with gold nanoparticles). The Renaissance (15<sup>th</sup>-16<sup>th</sup> centuries) Italian pottery makers from Deruta (2012), Umbria produced iridescent or metallic glazes using copper and silver particles: light bounces off the particles' surface at different wavelengths giving metallic or iridescent effect. Irish stain glass designers and the Damascene masters of sword making also applied nanoparticles materials (PennState modules, 2009, Goodsell, 2006).

Thomas Wedgewood and Sir Humphry Davy used silver nitrate and chloride to produce impermanent images. Photographic film is covered with gelatin containing silver halides and a base of transparent cellulose acetate. Light decomposes the silver halides producing nanoparticles of silver – the pixels of the photographic image. In 1827 Joseph Niépce used material that hardened when exposed to light. Louis Daguerre (1839) continued this work after Niépce died. Michael Faraday prepared first metallic (gold) colloids in 1857. As described below, colloidal systems have now numerous applications. Gustav Mie's developed in 1908 a theory about why light scatters from particles more efficiently at short wavelengths. Thus scientists learned why the size of particles would determine the visible colors. For example, air particles scatter blue light more efficiently than red light (blue light has a shorter wavelength than red light), and so the sky is blue.

In 1960, Charles Plank and Edward Rosinski developed a process to use zeolites to speed up chemical reactions when breaking down petroleum into gasoline. A zeolite is either natural or synthetic porous material that works as a sieve. In order to use fossil fuels more efficiently, researchers are now working on discovering or inventing zeolites and designing zeolite catalysts at the nanoscale. By adjusting the size of the zeolite pores on the nanoscale, they can control the size and shape of molecules that can enter. In the case of gasoline production, this technique could produce more and cleaner gasoline and provide new ways to gener-

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