علم النانو في الفيزياء الطبية

Nanoscience in Medical Physics

CHAPTER THREE

TYPES OF NANOSTRUCTURES

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Types of nanostructures

Nano-scale materials can be found in multiple situations and different shapes and dimensions. **In general the <u>nano-materials</u> can be divided into:**

(i) Nano-particle (powder and liquid), as shown in Fig. 2.1 (a, b).

(ii) Nano-structures (semiconductor, oxide semiconductor), as shown in Fig. 2.2.

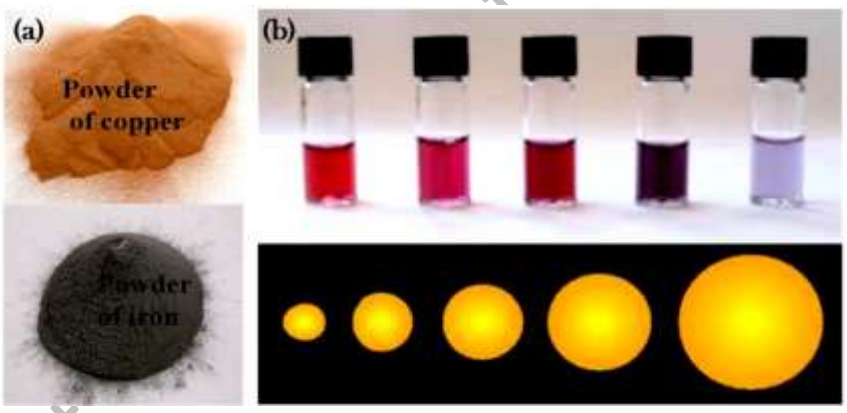
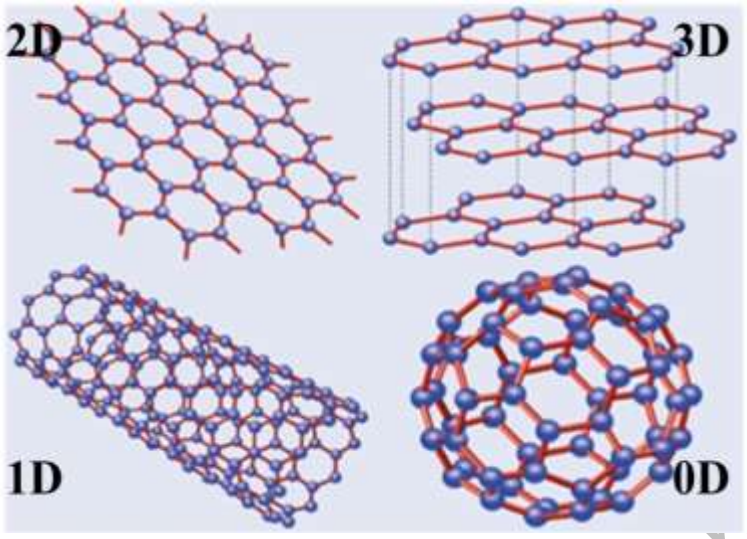


Figure 2.1: Nano-particle as nano-powder and nano-liquid.

The nano-structures could be classified into; (as shown in Fig 2.2)

i) Zero-dimensional (0D) (such as quantum dot, and nano-partical)
ii) One-dimensional (1D) (such as nano-wires, nano-needle, nano-rod, nano-tube)
iii) Two-dimensional (2D) (such as nano-flak, nano-leave, nano-sheet)
iv) Three-dimensional (3D) (such as tetrapod, and nano-sphere)



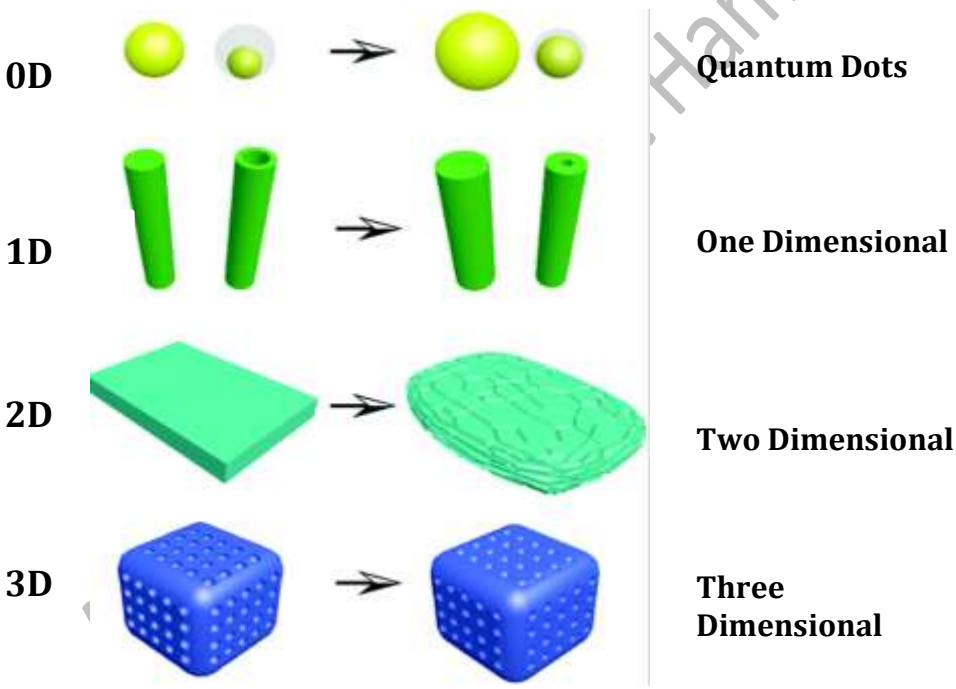


Figure 2.2: Schematic illustration of the nano-structures types.

Quantum-dot (0D) nanostructures are interesting objects for fundamental as well as practical reasons. Fundamentally, they can form the basis of systems in which to study the quantum mechanics of electrons confined in zero-dimensional

space. In practice, the dots can be embedded in the active regions of a new class of electronic and optoelectronic devices with novel functionalities. Diameters of the quantum dots can range from about $2-10$ nm such as nano-spherical or nano-balls, as shown in Fig. 2.3.

Properties of 0D nano-structures;

i) 0D diameters can range from about $2-10$ nm.

ii) 0D represent the smallest type of nano-structures.

iii) The changing of material properties with 0D, represents the biggest compared with other types.

iv) They are mostly nano-spherical or nano-balls shaped.

v) Use to synthesize nano-particles for various applications.

Question: The changing of material properties with 0D represents the biggest compared with other types of nano-structures ?

Answer: Due to the size and surface state of 0D represented the smallest compared with other types of nano-structures, where the dimensions and sizes of materials play an important role to determine their properties.

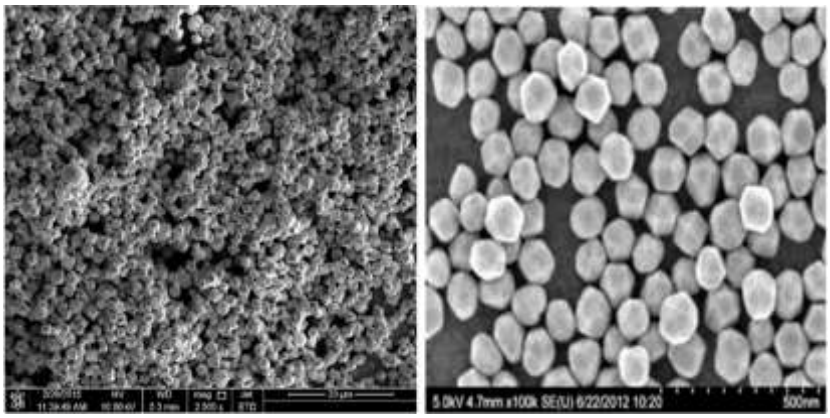


Figure 2.3: Quantum-dot (0D) nanostructures

One-dimensional (1D) nanostructures such as nanowires, nano-needle, nano-rod , and nano-tube (Fig. 2.4) have attracted growing interest for different applications and are promising candidates for preparation of advanced devices. In addition, the sensors based on 1D nanostructures attracted a great deal of attention and showed higher sensitivity and improvement capability compared with the other film materials, all of these properties of 1D nanostructures because of their;

Properties of 1D nanostructures;

(a) Large surface-to-volume ratio

(b) Electron confinement properties

(c) Polar nature of the 1D nanostructure

(d) 1D nanostructures can be useful for electron transport and can decrease the ratio of probability of charge recombination

(e) Can be find the 1D nano-structures as nano-rods, nano-needles, and nano-wires.

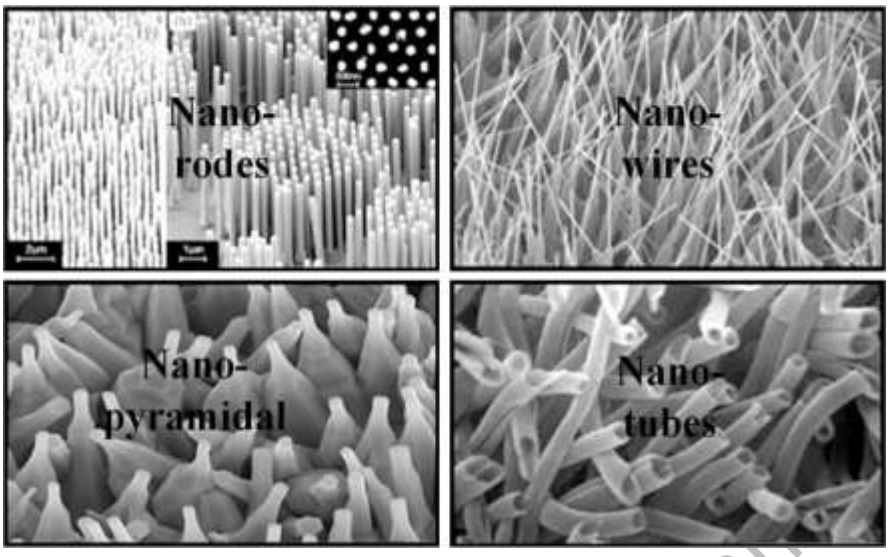


Figure 2.4: Real images of different types of 1D nanostructures

2D Materials, sometimes referred to as single layer materials, are crystalline materials consisting of a single layer of atoms. These materials have found use in applications such as photovoltaics, semiconductors, electrodes and water purification. 2D materials can generally be categorised as either 2D allotropes of various elements or compounds (consisting of two or more covalently bonding elements)

Properties of 2D nano-structures;

i) Can be find the 2D nano-structures as nano-leaves, nano-flags, and nano-sheet, as shown in Fig. 2.5

ii) 2D represent single layer materials

iii) 2D consisting of a single layer of atoms

iv) The unique 2D nano-structure facilitates easy tuning of the molecular in the crystal

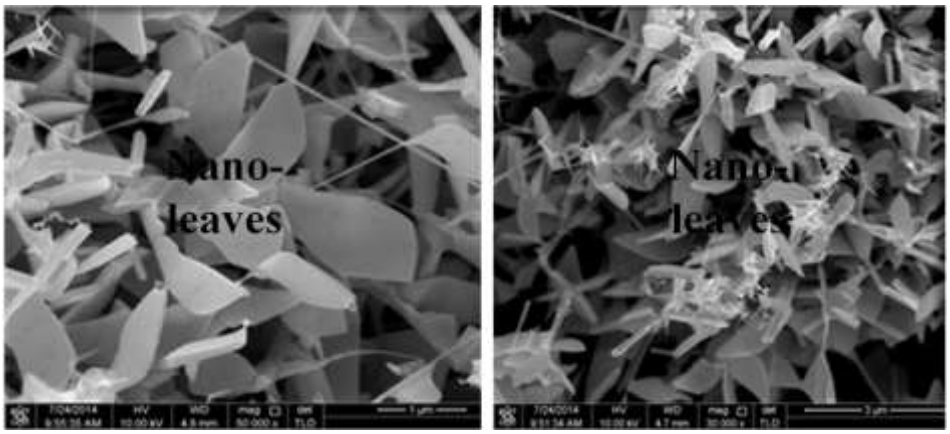


Figure 2.5: Real images of different types of 2D nanostructures.

3D tetrapods (Ts) exhibited potential applications, as novel multi-terminal devices. The difference between the angles of the arms of tetrapods and its perfect geometry (Fig. 2.6) is caused by compensating the stresses generated as a result of dislocations in the core of the seed particles. The junctions of the arms of tetrapods appear in different forms, such as nanorod–nanowire junction, nanorod–nanoneedle junction, and nanoleaf–nanowire junction. The diversity of synthesized Ts, with different size ranges, morphologies, and properties makes them important for various applications. In general, the controlled synthesis of tetrapods with regard to their size and shape has been of significant interest and has led to novel applications that can be investigated depending on their structural properties.

Properties of tetrapods structure (3D) ;

i) The structure of tetrapods appear four arms at 109.5° angle with each other.

ii) The sensors based on tetrapods can give multiple responses to a single signal at the same time.

iii) The tetrapods could be designed as multi-terminal sensors for enhancing response.

iv) The junctions in the arms of tetrapods play a critical role in the electrical properties.

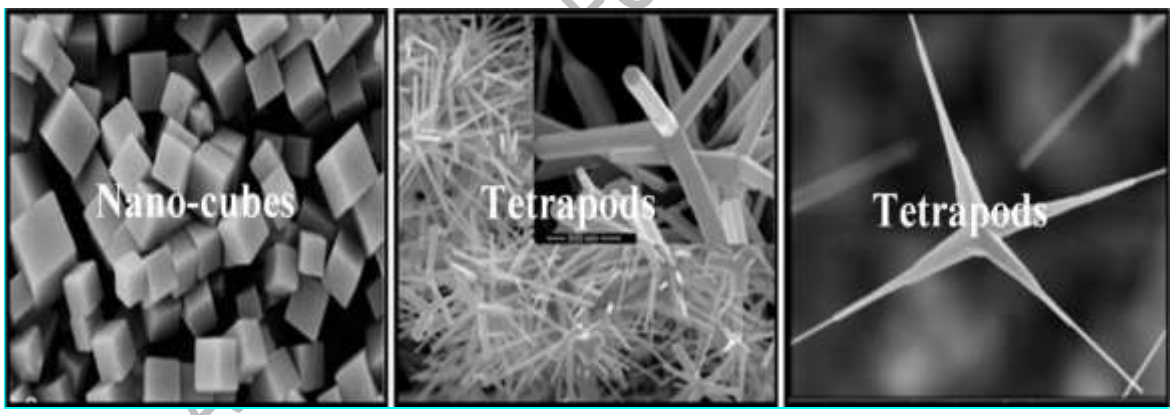


Figure 2.6: Real images of 3D Nano-cubes and Tetrapods