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Molecules in Nanoworld: how does nanotechnology affect the world?

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Nanoscience and technology has become a fascinating area of contemporary science from both research as well as education perspectives. In spite of its higher impact on scientific community and society, it is beyond the reach of general audience or common students. The motivation behind this article is to provide a flavor of nanoscience to non-experts and general audiences. The article mainly focuses on 'How does nanotechnology affect the world?' through some beautiful examples of water and boric acid molecules confined to nano-region. Some facts are included in order to make the idea more demonstrative, at the same time, technical details are avoided to make it digestive. The present article will properly introduce non-experts and students to the world of future-nanoworld.

Einstein's theory of relativity tells us that none is allowed to predict the future. In fact, nobody even can exactly interpret the events in the present. The theory beautifully explains the underlying reason. However, there are some other things that no more follow this principle of relativity. One of such things is the imagination- a scientific imagination. The scientific imagination was mentioned and discussed by Richard P. Feynman in one of his world famous lectures [1]. Of course, Feynman knows how to imagine scientifically! This is reflected in his 1959's talk 'There's Plenty of Room at the Bottom' [2] in which he better used his scientific imagination and introduced the audiences to a world of the future- a nanoworld.

Nanoworld, as the term suggests, refers to a region limited to a very small scale equivalent to the nanometer (10^{-9} m or 10 A^o) range. The things confined to such a trivial region must be looked different but to be frank, they must not be looked. As Feynman invited the audiences to imagine the complete set of encyclopedia brittanica placed on the head of a pin. None can say it will still be that brittanica which contains a set of 24 volumes bundled with a waterproof cover. So, one can only imagine that it must be more or less different. But science is something that must go beyond imagination because it has its own ways of perception. It is that perception which allows the scientists to play with atoms having size of 1 A^o. The nanoworld is, still, about 10 times larger than these atoms!

Atoms bind together to form a molecule with a specific geometrical arrangement which is specified by bond-lengths, angles, torsions etc. The geometry of molecule is one of the most important factors deciding its physical as well as chemical interactions and properties. For instance, hydrogen-bonding interaction between O and H becomes effective within a distance of 3.2 A^o but not for 3.4 A^o [3]. Everyone knows how important this interaction is! It is the interaction which is responsible for the structure and properties of water, an indispensable compound for life, as a solvent and in its various phases. In case of a water dimer (combination of two water molecules), there exists a hydrogen bonding interaction between O of one water molecule and H of the other such that the geometry of a water dimer is linear!

What happens to a water dimer when confined to a nano-region? And/or how does nano-environment affect the structure of a water dimer? Before addressing this issue, we must know how to confine something to a nano-region? To put it another way, how can one prepare nano-materials? The preparation of nano-materials is not so difficult than their characterization and utilization in meaningful ways. The latter jobs are still a challenge to scientists as well as technologists. Nano-materials can be prepared either by the 'top-down' or by the 'bottom-up' approach. The latter approach has become possible due to progresses made in ultrahigh vacuum, molecular beam and laser techniques. The former approach has been known since long time and can be easily followed from theoretical point of view. In this approach, theoreticians use atoms and molecules as building blocks and form supramolecules that constitute nano-materials, just analogous to building atoms from fundamental particles and molecules from atoms.

Now, let's return to our previous question. A study has revealed some interesting facts. In this study, a water dimer was confined to a fullerene cage of nano-dimension. In fullerenes, the covalent bonds linking atoms provide it enormous stability as well as a rigid structure. It was found that water dimer inside fullerene cage assumes unusual geometry. It is no longer a linear but bent appreciably! In case of increase in the number of water molecules, nature and strength of interaction is greatly influenced. For an interesting account, the readers are referred to Ref. [4].

Not only water, many other molecules has been found to be affected by confinement to nanoworld. As another example, one can consider graphite like structure of solid boric acid in which boric acid molecules are arranged in a network of hexagons in a plane and several such planes are stacked on top of each other. However, if boric acid molecules could be made sufficiently close together, the large number of molecules tends to curl up and form bowls and eventually balls like fullerenes [5].

Thus, the manipulation of molecules into nano-regime brings unusual characteristics. The interesting properties of molecular systems at nano-scale make nanoscience and nanotechnology a fascinating area of research and development. The scope of

nanoscience and technology is continuously expanding and expected to cover all aspects of science undoubtedly.

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Notes and References

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1. R.P. Feynman, R.B. Leighton and L.S. Matthew *The Feynman lectures on Physics* vol. 2 (**1964**).
2. R.P. Feynman *There is plenty of room at the bottom* Annual meeting of APS, Caltech, California (**1959**).
3. T. Steiner *Angewante Chemistry International Edition* 41 (**2002**) 48.
4. C.N. Ramachandran and N. Sathyamurthy *Chemical Physics Letters* 410 (**2005**) 348.
5. M. Elango, R. Parthasarathi, V. Subramanian and N. Sathyamurthy *Journal of Physical Chemistry A* 109 (**2005**) 8587.

