Nano-cars: the enabling technology for building buckyball pyramids

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Abstract

One of the most interesting and challenging goals of nano-technology in the coming years will be construction of 'Buckyball Pyramids'. Rationale for their creation is given and scientific requirements and sociological implications are discussed. Technologically, transportation of large number of buckyballs pose a serious problem. To address it the construction of the smallest possible car, a nano-car, is proposed. The size of this engineering artifact (as the name suggests) would be $\sim 10^{-9}$m. This is billion times smaller than so popular street machines. Applications in very large scale ($\sim 10^6$ cars) Intelligent Vehicle Systems and big cities traffic simulators are also proposed.

Motto: If it was easy we would not attempt to do it.
Marek T. Michalewicz

1 The need for 'Buckyball Pyramids'

Each civilisation leaves behind the pyramid fit to its greatness. Examples abound: Egypt, Aztec and Maya civilisations, the Pompidou Centre (Paris), the Parliment House in Canberra, Australia. Huge and monumental things were done and do not pose the original challange - XXI century has to be celebrated with *Very Small Pyramids*. It is chemically and aestetically convincing that the best building block for tiny pyramids would be C_{60} molecule, commonly known as 'Buckyball'.

Buckyball pyramids will find wide use in a range of areas: from a Christmas season novelty, a collector item (collect them all?), to its use in SETI search and communication with alien civilizations (proving our Civilisation's superior intelligence and ability to controll matter) and finally to extensive studies of paranormal claims of pyramid 'energy' (through orientation, scale ratios, *etc.*).

But now we are confronted with a serious technological issue: How can we efficiently cart around tiny buckyballs? To help solve this problem, in this paper we propose all construction elements necessary to build a nano-car. The idea of a tiny little car first surfaced in the original Feynman's paper [1]. However Feynman speculated on a micro-car, a car approximately only 4 000 times smaller than an automobile. In the present work we push the limit as far as 'molecularly possible' and propose construction of a nano-car, with linear dimensions of the order $\sim 30\mathring{A} \times 20\mathring{A} \times 20\mathring{A}$. We strive to adhere to the basic laws of physics so this tiny engineering artifact can indeed be build one day.

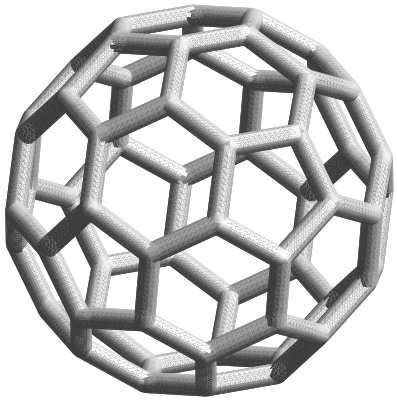

Figure 1. Buckyball molecule C_{60}

In the following sections we list all required melecular 'sub-parts', touch upon the construction process and cost analysis and propose other uses of a nano-car. We conclude with some general remarks on a sociological impact of this engineering feat.

2 Molecular Ingredients

The necessary structural elements are: four 'Ferric wheels', 'staffenes', graphitic sheets and as a reinforcing elements – buckytubes. The novel feature of this design is the propelling system: it is embedded in the (antiferromagnetic) wheels which interact magnetically with the 'road', or atomic substrate. There would be no car, nor a cart without a wheel. The wheels of a nano-car will be four molecules $[Fe(OMe)_2(O_2CCH_2Cl)]_{10}$, affectionately called "a molecular ferric wheel" [2].

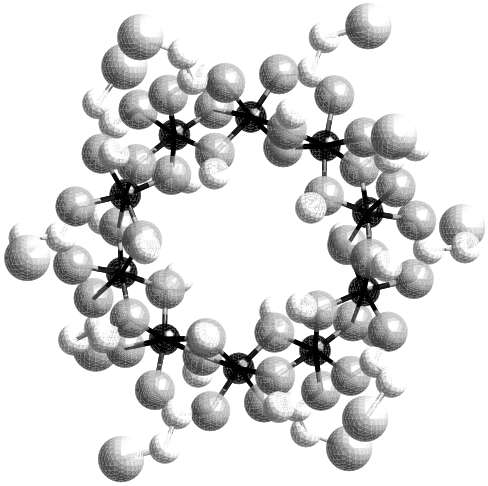

Figure 2. A ball and stick representation of a "Molecular Ferric Wheel". Black balls are Fe ions.

The axles will be conviniently obtained from $[n]Staffenes$, a molecular-size tinkertoys synthesized and described in detail by J. Michl, his co-workers and others [3-10].

The remaining elements of nano-car construction set will be a graphitic sheet forming $2D$ analogue of metal-sheet joining two axles together, and perhaps some nanotubes which would provide greater structural rigidity and strength. The assambly of a nano-car is an issue which is best left to technologists and engineers to sort out. Suffice it to say that the use of abstraction molecular tools [11] could be the preferred choice of a fabrication technique.

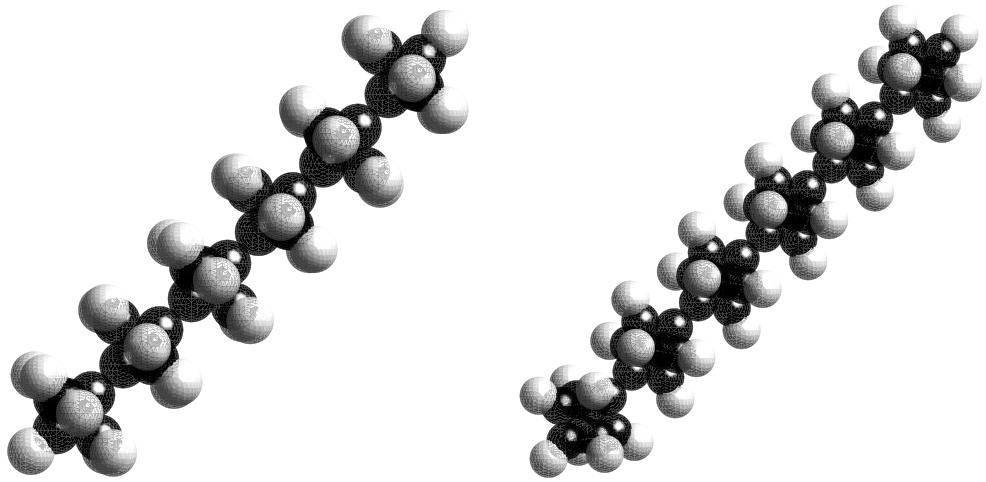

Figure 3. A ball representation of two $[n]Staffenes$: (a) oligomer of $[1.1.1]propellane, n = 6$ (left) and (b) [6]cubane (right).

3 Drive System

One of the most intriguing features of a nano-car is its drive system. The 'engine' is hidden in the wheels. Taft *et al.* [2] reported the first study of magnetic properties of anti-ferromagnetic 'ferric wheel'. By changing various time- and length- dependent characteristics of an external magnetic field a nano-car will be accelerated, deccelerated or manouvered on its path. The details of these interactions are crucial and await more detailed studies.

4 Other applications of nano-car

The applications of a nano-car are many and exhaustive exploration of all possibilities would take us outside the main topic of this paper which is building 'Buckyball Pyramids' and the construction and feasibility study of a nano-car. However some of the most obvious other applications of a nano-car are:
- testing the road rules,
- accident prevention,
- large number of cars models of Intelligent Vehicle Systems,
- traffic simulators of the whole cities (e.g. Mexico City traffic)
- accurate drug delivery
- nano-couriers

5 Conclusions

The concept of miniaturisation played an important role in development of the modern technological society. We are just on the verge of scientific and technological breakthroughs which will bring the ultimate limit of miniaturisation. Building a nano-car will enable building of 'Buckyball Pyramids' but it is an enterprise without a doubt worth persuing in its own right. It also constitutes the ultimate challange to Automotive Industry.

Philosophical and social implications of this invention are hard to predict. We may only speculate that its size and mass scale of manufacture will make global civilisation more egalitarian and just: perhaps we will see a day when there is one Buckyball Pyramid and one nano-car for each and every person. Humankind faces constant challange and desire to 'out-do' earlier generations and contemporaries. The race of nations to dominate the World, so beneficial in bringing about Space exploration, landing of humans on the Moon, or collapse of Communism and the end of The Cold War, is still on. The nation that wins in microscopic world might very well be the nation to win the Globe.

6 Acknowledgements

I thank Prof. Diana Guenzburger for bringing the 'Molecular Ferric Wheel' to my attention. Ferric wheel molecule was built using Cerius2 program with input parameters from Ref.[2]. All other molecules and molecular fragments were built and optimised using the UniChem suite of Quantum Chemistry programs.

7 References

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