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Saving Space from Buildings by Nanotechnology

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Abstract: - The population goes on increasing algebraically increasing the need for space and housing. Since it will continue to grow for ever (till the end of the universe) there will always be the need for more spacing for buildings. The haphazard growth building and now multi-storey buildings has created more risks than safety and comfort. We have no alternative than to provide least space occupying buildings if we have to spare space for natural growth with new materials. Best new materials for buildings are nano-carbon coated hardened plastics or clays. Clays are at present used as construction materials, clay particle based composites-containing plastics. Coating & surfaces are used in catalytically active and chemically functional surfaces. Self cleaning windows are coated in highly activated titanium dioxide as water repellent and anti-bacterial. Breathable, waterproof, scratch & stain resisting hard coatings are used in polymers, in-organics and fabrics. These materials will occupy negligible space and can be safely tried out as new building matrials.

I. INTRODUCTION

Gone are the days when the greenery spread all around the world. Concrete jungles of buildings are now dominating the green grassy lands. Cities are spreading their jaws to eat away farm lands; greenery is vanishing fast. As the population goes on increasing algebraically the need for space and housing too grows accordingly. It will continue to grow for ever till the end of the universe provided something is done to check the growing population. The haphazard growth of multi-storey buildings has created more risks than safety and comfort. We have no alternative than to provide least space occupying buildings if we have to spare space for natural growth.

The materials in use for construction of buildings at present are bricks, concrete blocks, wood, stones, lime, sand, cement and steel. These materials occupy large space, are very bulky, not transportable as a unit, labor intensive and time consuming to construct, prone to occasional shortages, not easily modifiable, costly, have limited life, unable to protect from all weather, prone to natural calamities and abnormal changes in weather conditions, not fully safe from hazards and pollution creators. Even the availability of these materials is fast receding. Despite of heavy construction costs, and the best of the available material, they do not guarantee total safety. The recent trend of multistory buildings has created more complication than solutions. The bigger the building; the greater is the risk.

We will have to look for compact, light, cheap, quick to construct with least labour; least space occupying; strong to withstand natural calamities including fire, floods, earthquakes and tsunamis and abnormal weather conditions; and providing soothing environment year around. If possible it should be easily transportable and foldable for easy carriage. It should have filters to stop unwanted air entering the buildings keeping these away from the effects of pollution.

How do we find the alternative which could stop this haphazard occupation of land, destruction of greenery, reducing available land for tilling and prevent the drawbacks of the existing materials and meeting the above stated requirements? Nanotechnology has the answer. Building construction with nano-materials will not only save space, but also the transportation cost; construction costs and time and will have more strength, longer life, better space and better security and protection.

What type of buildings can be constructed and what materials can be used by nanotechnology which might provide space, strength, quality, affordability, least cost, safety and time saving? Answer to such like questions are conceptualized in this paper.

The nano-materials have the promise of providing strength many times more than steel; are flexible and portable; occupying negligible space; near nil transportable costs, construction costs and time; assuring safety and strength and causing no pollution.

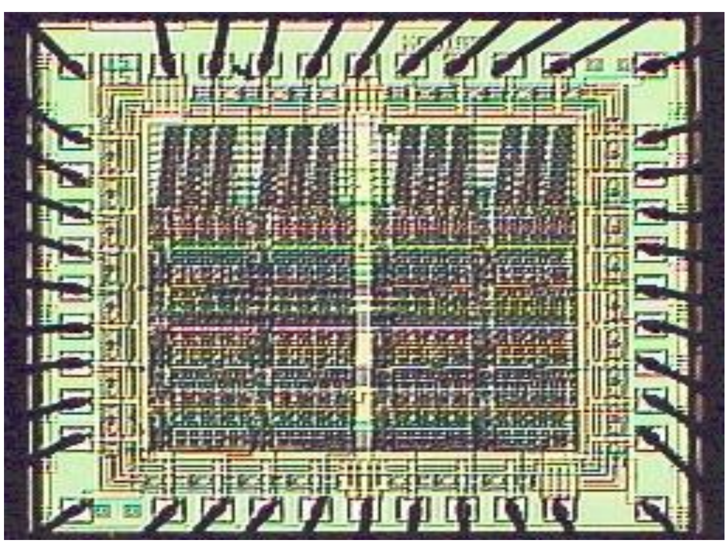
For construction of nano-materials there is no dearth of atoms and molecules in universe. The only requirement is of assembling these atoms with required qualities. Broadly speaking, nano-technology is the act of purposefully manipulating matter at the atomic scale i.e., nano-scale. Nano is a Greek word midget meaning a metric prefix indicating a billionth part (10-9). Basic unit of measure is 'nanometer' (nm). One billion nm=meter. Each nm is only 3 to 5 atoms wide. Really small; ~40,000 times smaller than the width of an average human hair. It uses working mechanism using components with nano-scale dimensions and is also termed as Molecular Technology (MNT).

USA is presently leading the world in this field and spending maximum on research on nano-technology. Introducing a bill for sanction of 3 billion Dollars for nano-technology Initiative (NNI) Bill Clinton, the then President of USA remarked, "Imagine the possibilities: materials with ten times the strength of steel and only a small fraction of the weight -- shrinking all the information housed at the Library of Congress into a device the size of a sugar cube." Other nations cannot afford to wait and watch.

How can the required material be created? Material creation may involve all or some of the following steps: (a) Listing out characteristic requirements for the particular material (b) Identifying or Planning for innovating materials with the above characteristics (c) Adopting methods and approaches for material preparation (d) Organizing construction process and equipment (e) Construction, testing and try out and modification (f) Bulk production and (g) Using the materials for construction

The characteristic requirements for building construction are security, strength, easy and cheap transportability and flexibility, less labour and easy availability at affordable costs. The alternative materials providing these qualities are; diamond & steel that provide security and strength; plastics, silicon, cardboard, paper and ply that provide easy transportability and flexibility, cheaper costs and less labor.

None of the materials in the world at present meets all the above needed qualities. Hence there is a need for innovation of such materials which contain all or almost all these qualities. One type of such novel material at the threshold or being developed is through nano-materials. Nano-materials are the materials with structured components with at least one dimension less than 100 nm. Overall properties of all materials are determined by their structure at the micro & nano-scale. Novel materials can be created by rearranging atomic structures.



Arranging Atoms to make nano-materials

Variations in the arrangement of atoms have distinguished the cheap from the cherished and the light from heavy. Arranged one-way, atoms make up soil, air, and water; arranged another way, they make up ripe strawberries. Arranged one way, they make up homes and fresh air; arranged another way, they make up ash and smoke. Nature which created coal, diamonds, sand and dust is the best guide to provide the suitable alternative materials for construction purposes as well. Nano-materials are prepared from nano-particles taking a queue from the nature. At the nano-scale, the bulk approximations of Newtonian physics are revealed for their inaccuracy, and give way to quantum physics.

Nano-technology is more than a linear improvement with scale; everything changes every second. Quantum entanglement, tunneling, ballistic transport, frictionless rotation of super-fluids, and several other phenomena have been regarded as "spooky" by many of the smartest scientists, even Einstein, upon first exposure. For a simple example of nano-tech's discontinuous divergence from the "bulk" sciences, consider the simple aluminum coke-can. If you take the inert aluminum metal in that can and grind it down into a powder of 20-30nm particles, it will spontaneously explode in air. It becomes a rocket fuel catalyst. The energetic properties of matter change at that scale. The surface area to volume ratios become relevant, and even the inter-atomic distances in a metal lattice change from surface effects. Nano-technology explores and gets benefit from quantum phenomenology in the ultimate limit of miniaturization.

Materials in this size range exhibit some remarkable specific properties: a transition from atom or molecules to bulk form takes place in this size range. For example, crystals in the nanometer scale have a low melting point (the difference can be as large as 1000 deg c) and reduces lattice constants, since the number of surface atoms or ions become a significant fraction of the total number of atoms and the surface energy plays a significant role in the thermal stability. Au nano-crystal demonstrates to be an excellent low temperature catalyst.

Best materials for buildings are nano-carbon coated hardened plastics or clays. Clays are at present used as construction materials, clay particle based composites-containing plastics. Coating & surfaces are used in catalytically active and chemically functional surfaces. Self cleaning windows are coated in highly activated titanium dioxide as water repellent and anti-bacterial. Breathable, waterproof, scratch & stain resisting hard coatings are used in polymers, in-organics and fabrics.

Properties of Carbon coated nanostructures are: (a) High Tensile Strength (b) Physical stability (c) Chemically reactive with free radicals so that (i) Derivatives can be framed (ii) More hydrophilic than fullerenes (iii) New organic molecules can be generated. Other atoms can be placed inside its “cage” (doping with alkali metals) for (i) Superconducting properties (ii) and Optical Properties (endohedral fullerenes). Carbon coated plastics provide strength, less costs in long run, transportability and flexibility. Nano-carbon coatings provide strength, security & long life and plastics provide transportability and lower costs.

Various approaches used for making these nano-materials bottom up or top down approaches. Bottom up approach is building up from nano building blocs and top down approach is cutting, etching etc., from top to bottom.

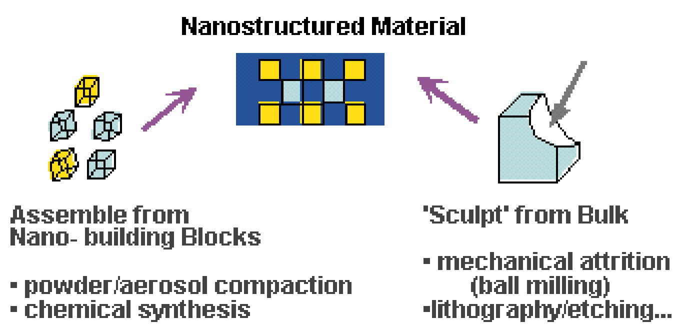


Fig 1. Approaches for making nano-materials

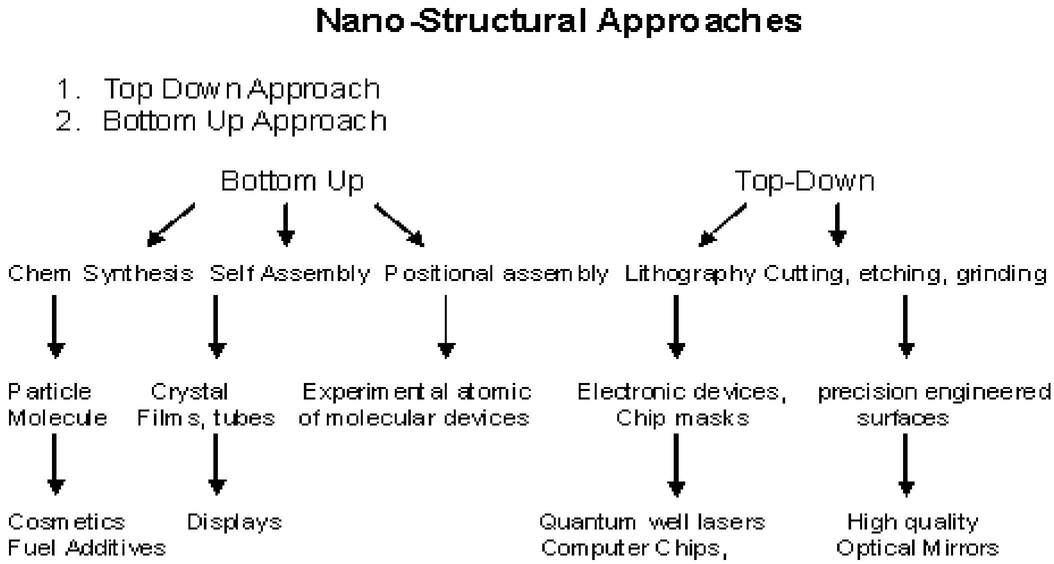


Fig 2. Bottom up and Top down approaches

Bottom up approach by chemical synthesis is the best approach for preparing nano-carbon coated plastics for buildings.

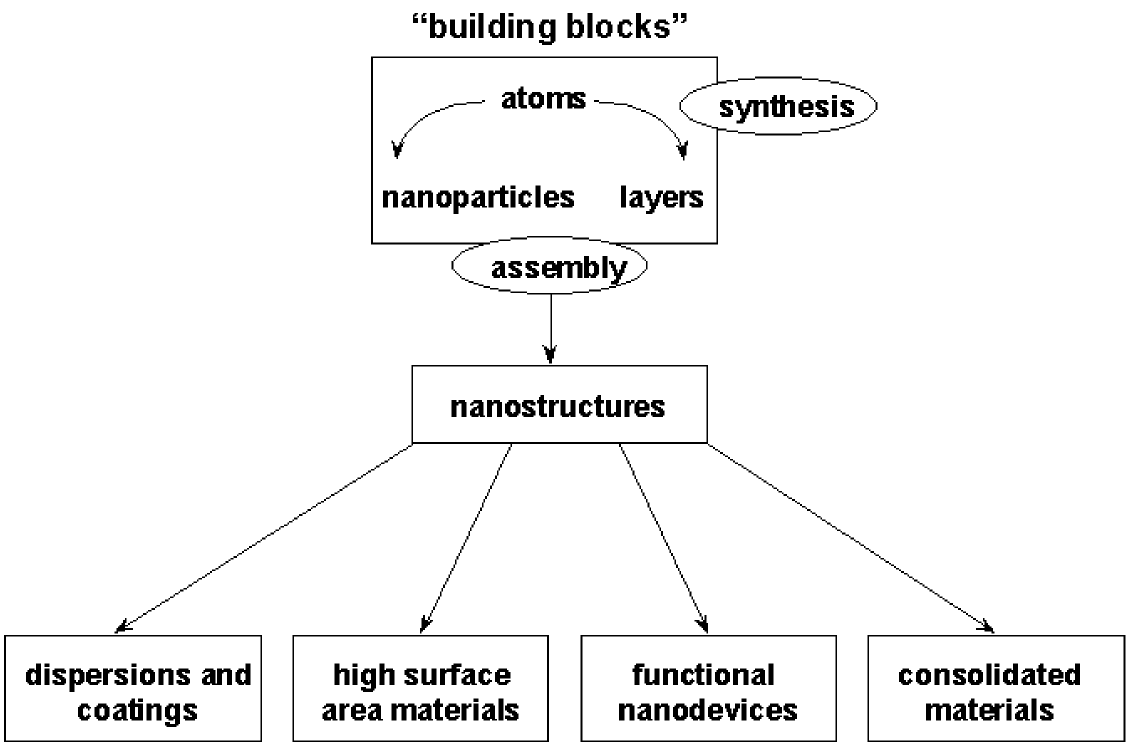
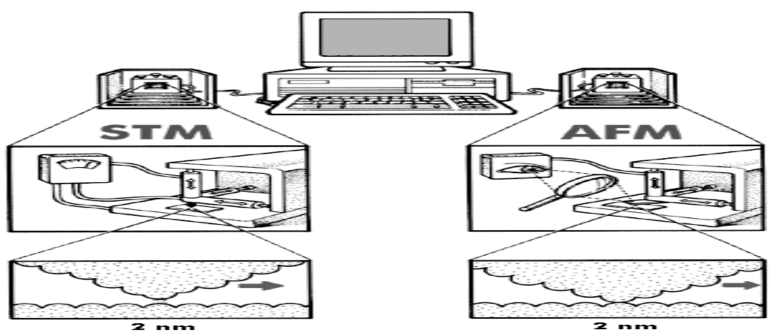


Fig 3. Material Preparation Processes att nano scale

In the process we must first design a set of nano-building blocks, and then assemble the building blocks by the use of positional control. The building blocks are nano-particles linked together through synthesis process. Positional and orientational control over the building blocks can be converted to three dimensional from the one dimensional (relying on linear structures that spontaneously fold into a particular shape to achieve a degree of control in three dimensions). Relatively rigid bricks can be formed that can be bonded to each other in a stiff three-dimensional framework. Many bricks can be assembled in more conventional environments (solution), and so we can eliminate the need for vacuum. This greatly simplifies the system. Indeed, with brick-based nanotechnology one can relatively easily envision the synthesis of a set of bricks that can, with the addition of positional control, be assembled into a wide range of structures with the stiffness.

"Nanosize" powder particles (a few nano-metres in diameter, also called nano-particles) are potentially important. These are zero dimensional. The characteristics of nano-particles are that they have a much greater surface area per unit mass compared with larger particles. As a particle decreases in size, a greater proportion of atoms are found at the surface compared to those inside, e.g., a particle of size 30nm has 5% of its atoms on its surface, at 10 nm 20% of its atoms and 3nm 50% of its atoms. Nano-particles have a much greater surface area per unit mass compared with larger particles. These characteristics can change or enhance properties as reactivity and strength. Scanning probe microscopy is an important technique both for characterization and synthesis of nano-materials.

The laboratory work can be done by The Scanning Tunneling Microscope (STM) and Atomic Force Microscope (AFM). STM images surfaces well enough to show individual atoms, sensing surface contours by monitoring the current jumping the gap between tip and surface. AFM senses surface contours by mechanical contact, drawing a tip over the surface & optically sensing its motion as it passes over single-atom bumps.



STM AFM

Fig 4. Atomic Force Microscopes and Scanning Tunneling Microscopes

Atomic Force Microscopes and Scanning Tunneling Microscopes can be used to look at surfaces and to move atoms around. By designing different tips for these microscopes, they can be used for carving out structures on surfaces and to help guide self-assembling structures.

Atoms can be moved around on a surface with scanning probe microscopy techniques, but it is cumbersome, expensive and very time-consuming, and for these reasons it is quite simply not feasible to construct nano-scaled devices atom by atom. You don't want to assemble a billion transistors into a microchip by taking an hour to place each transistor, but these techniques can be used for things like helping guide self-assembling systems. These microscopes are thus used now primarily in laboratories for probing. Natural or man-made particles or artifacts often have qualities and capabilities quite different from their macroscopic counterparts. Gold, for example, which is chemically inert at normal scales, can serve as a potent chemical catalyst at nano-scales mass compared with larger particles.

Major efforts in nanoparticle synthesis can be by (a) Gas Phase Synthesis (b) Sol-Gel Processing (c) Cavitation processing, (d) Microemulsion processing, and (e) High-energy ball milling

Nanoparticles with diameters ranging from 1 to 10 nm with consistent crystal structure, surface derivation, and a high degree of mono-dispersity have been processed by both gas-phase and sol-gel techniques. Typical size variances are about 20%; however, for measurable enhancement of the quantum effect, this must be reduced to less than 5% Initial development of new crystalline materials was based on nanoparticles generated by evaporation and condensation (nucleation and growth) in a subatmospheric inert-gas environment. Various aerosol processing techniques have been reported to improve the production yield of nanoparticles. These include synthesis by combustion flame, plasma laser ablation; chemical vapor condensation; spray pyrolysis; electrospray; and plasma spray. Sol-gel processing is a wet chemical synthesis approach that can be used to generate nanoparticles by gelation, precipitation, and hydrothermal treatment. In sonochemistry, an acoustic cavitation process can generate a transient localized hot zone with extremely high temperature gradient and pressure. Such sudden changes in temperature and pressure assist the destruction of the sonochemical precursor (e.g., organometallic solution) and the formation of nanoparticles. The technique can be used to produce a large volume of material for building applications.

In hydrodynamic cavitation, nanoparticles are generated through creation and release of gas bubbles inside the sol-gel solution By rapidly pressurizing in a supercritical drying chamber and exposing to cavitational disturbance and high temperature heating, the sol-gel solution is mixed. The erupted hydrodynamic bubbles are responsible for nucleation, growth, and quenching of the nanoparticles. Particle size can be controlled by adjusting the pressure and the solution retention time in the cavitation chamber. Microemulsions have been used for synthesis of metallic, semiconductor, silica, barium sulfate, magnetic, and superconductor nanoparticles. By controlling the very low interfacial tension ($\sim 10^{-3}$ mN/m) through the addition of a cosurfactant (e.g., an alcohol of intermediate chain length), these microemulsions are produced spontaneously without the need for significant mechanical agitation. The technique is useful for large-scale production of nanoparticles using relatively simple and inexpensive hardware.

The only top-down approach for nanoparticle synthesis, has been used for the generation of structural nanoparticles. The technique, which is already a commercial technology, has been considered dirty because of contamination problems from ball-milling processes. However, the availability of tungsten carbide components and the use of inert atmosphere and/or high vacuum processes have reduced impurities to acceptable levels for many building applications. Common drawbacks include the low surface area, the highly polydisperse size distributions, and the partially amorphous state of the as-prepared powders.

One of the most challenging problems in synthesis is the controlled generation of mono-dispersed nano-particles with size variance so small that size selection by centrifugal precipitation or mobility classification is not necessary. Among all the synthesis techniques discussed above, gas-phase synthesis is one of the best techniques with respect to size mono-dispersity, typically achieved by using a combination of rigorous control of nucleation-condensation growth and avoidance of coagulation by diffusion and turbulence as well as by the effective collection of nano-particles and their handling afterwards. The stability of the collected nanoparticle powders against agglomeration, sintering, and compositional changes can be ensured by collecting the nanoparticles in liquid suspension. For semiconducting particles, stabilization of the liquid suspension has been demonstrated by the addition of polar solvent; surfactant molecules have been used to stabilize the liquid suspension of metallic nanoparticles. Alternatively, inert silica encapsulation of nanoparticles by gas-phase reaction and by oxidation in colloidal solution has been shown to be effective for metallic nanoparticles. New approaches need to be developed for the generation of monodisperse nanoparticles that do not require the use of a size classification procedure.

Scale-up production is of great interest for nano-particle synthesis. High energy ball milling, already a commercial high-volume process, as mentioned above, has been instrumental in generating nano-particles for the preparation of structural materials. However, the process produces poly-dispersed amorphous powder, which requires subsequent partial re-crystallization before the powder is consolidated into nano-structured materials. Although gas-phase synthesis is generally a low production rate process (typically in the 100 milligrams per hour range) in research laboratories, higher rates of production (about 20 grams per hour) are being demonstrated at Ångström Laboratory at Uppsala University in Sweden. Even higher production rates (about 1 kg per hour) are now being achieved commercially. For sol-gel processing, the development of continuous processing techniques based on present knowledge of batch processing has yet to be addressed for economical scale-up production of nano-particles. Other related sol-gel issues concern the cost of precursors and the recycling of solvent. Overall, sol-gel processing is attractive for commercial scale-up production.

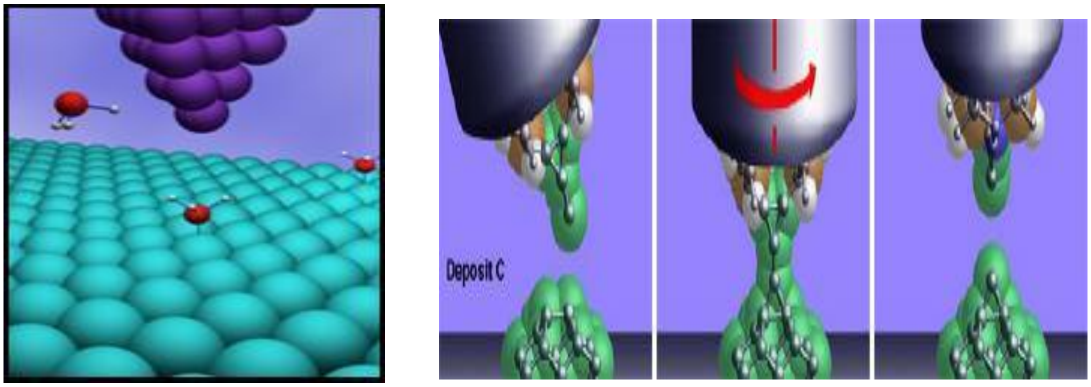
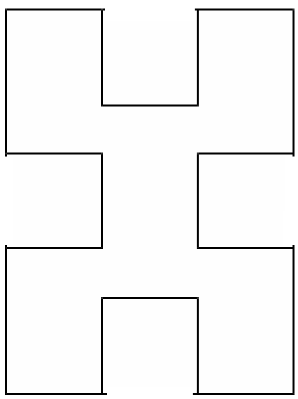
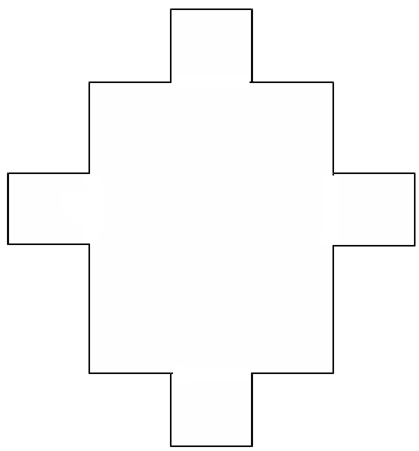


Fig 5. Mechanosynthetic Reactions Based on quantum chemistry



Block 1



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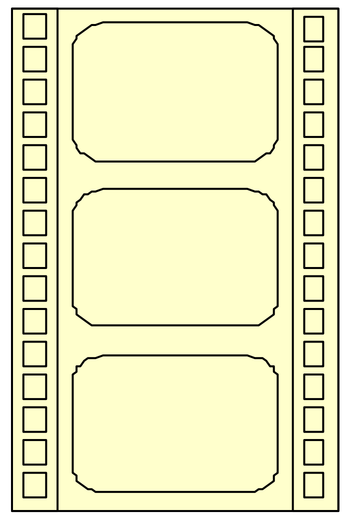

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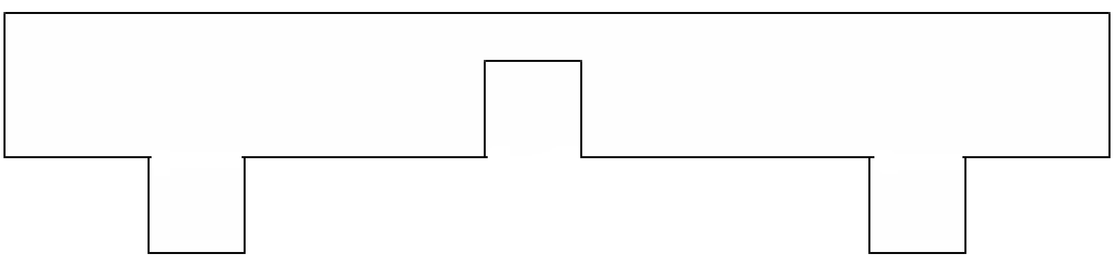


Block 4

Fig 6-9: Block types 1 to 4

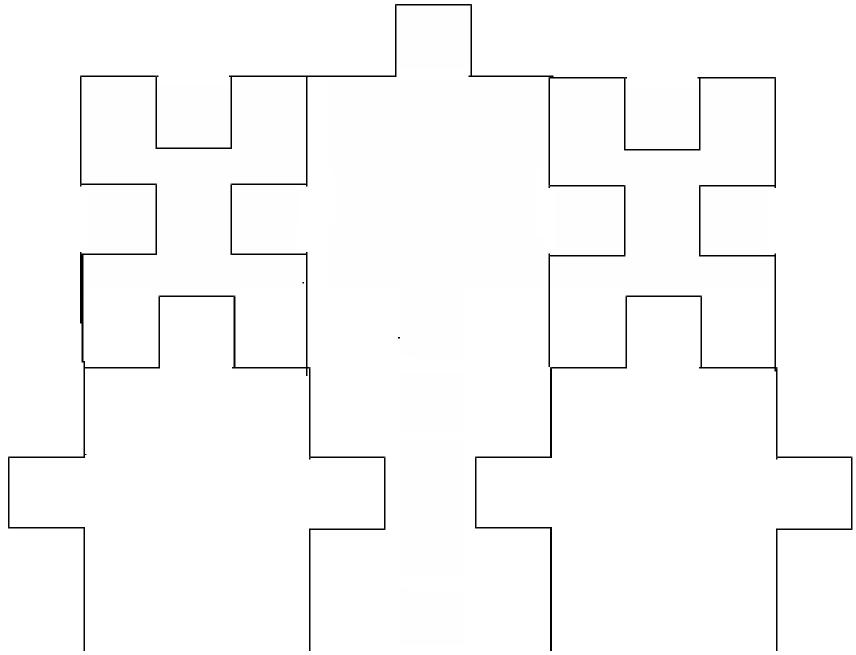


Fig 10. Block Making- Stage 1

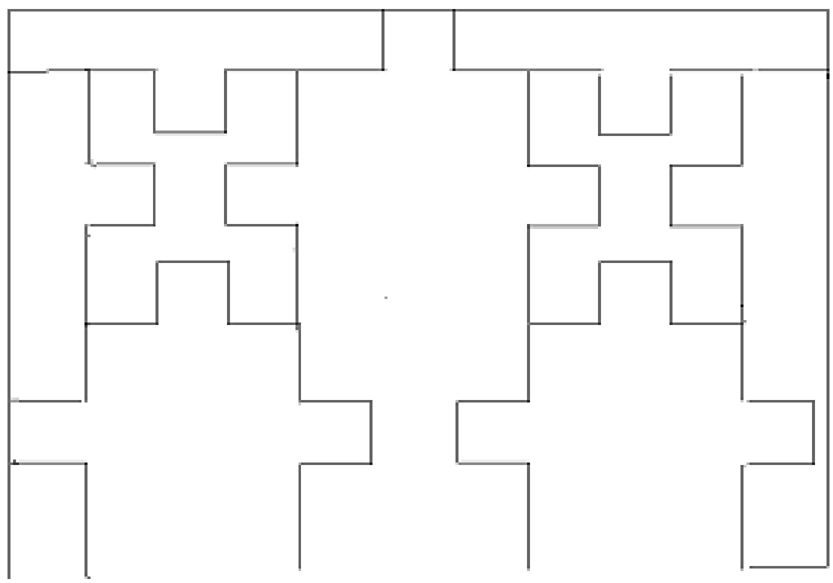


Fig. 11 Block Making Stage 2- Wall 1

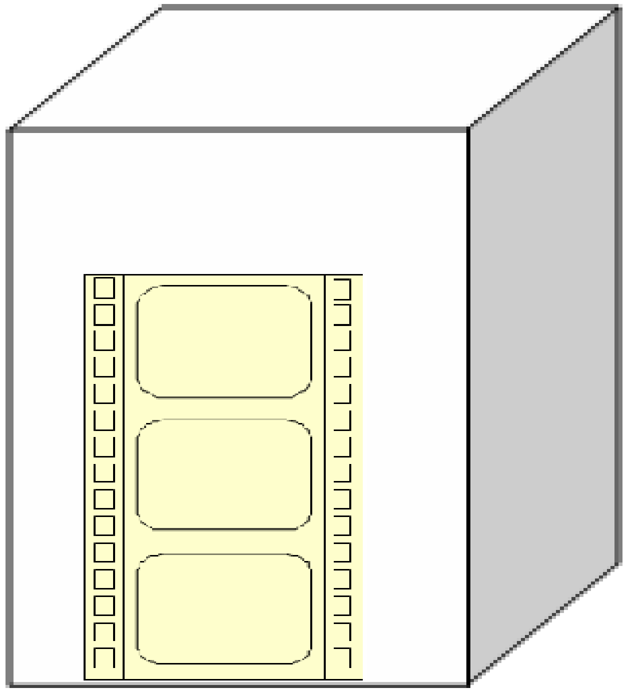
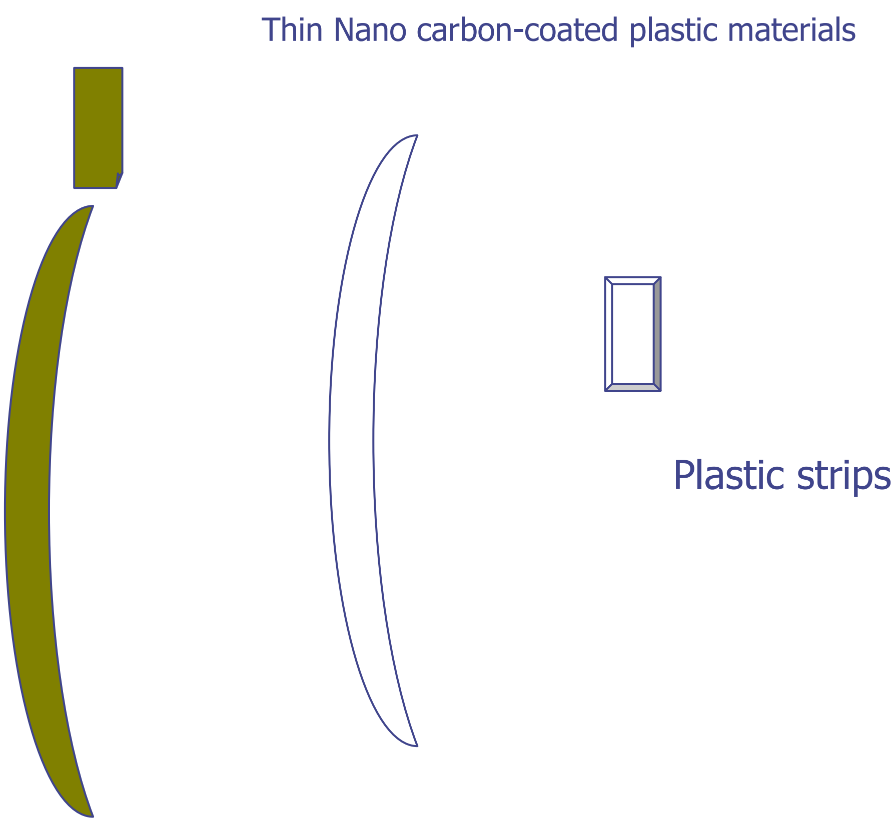


Fig. 12 Built House

Another sample is of making an igloo type house as shown in Fig 13 below.



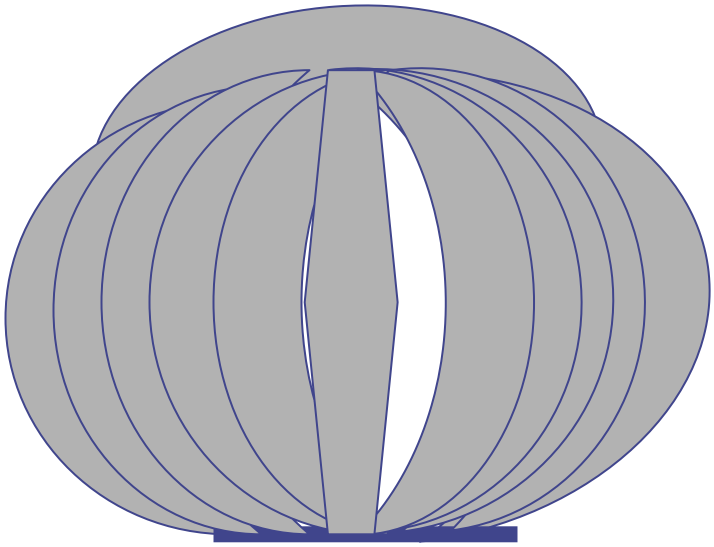


Fig 14. Igloo House

The size of the blocks may vary from 6" x 6" x 0.25". To build a house of size 10' x 12' you will require 2400 strips of size 6" x 6" x 0.25".weighing about one kg which can be safely carried by even a child. Assembling with practice may take at the most 2 to 3 minutes. Strength of these strips will be enough to withstand the impact of an atom bomb. The materials used may be nano carbon coated plastic materials.

Advantages of nano-carbon coated plastic materials are that these are hard & strong, easy to construct, transportable, less time to construct, no extra labor to construct, cheaper in the long run, occupy least space/ no permanent space, hermatically sealed hence safe from all round pollution. Disadvantages of carbon coated plastics are that these are still at conceptual stage, require heavy costs of research, heavy initial construction costs and time factor for initial induction. The concept needs to be put into research and the result are certainly expected to be positive.

To save space we must find items, other than the nature, now covering major space of the earth. We have producing units (factories and fields) buildings (dwelling and storing units) and communicating units (roads, airports, rails and bridges) as the major space occupying units. If we do away or reduce the sizes of these major units from the earth, we shall be provided pollution free sufficient space on earth to easily survive.

The laws of nature leave plenty of room for progress, and the pressures of world competition are even now pushing us forward. For better or for worse, the greatest technological breakthrough in history is still to come. The ancient style of technology handles atoms and molecules in bulk; call it *bulk technology*. The new technology will handle individual atoms with control and precision; call it *nanotechnology*. It will change our world in more ways than we can imagine. It will provide us the answer for new materials for construction