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An Overview of Nanotechnology

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Abstract: **This paper provides an overview of nanotechnology and its multiple applications. This includes its extension to medicine, the military, even to the food industry and other areas of daily civilian lives. In addition, this paper traces the growth and evolution of nanotechnology over the last few years and a comparison of the various forms of the technology over the same period.**

Keywords: **Analysis of Nanotechnology, Number of products, Yearly analysis.**

I. INTRODUCTION

Nanotechnology may be defined as the micro / molecular level application of engineering systems. This is however the conventional definition. A more contemporary definition would be the extension of engineering techniques and tools in the creation of new products with manifold functionalities using a 'bottoms up' approach.

Everything in nature, including manufactured products is made up of molecules and atoms. It is these atoms and their molecular arrangements therefore that dictate the peculiar properties of a particular product. For example, a particular arrangements of coal atoms result in the formation of a diamond. A combination of atoms of silica, found in sand, and other trace element particles result in the formation of computer chips. Similarly, everything, right down to the food that is consumed is made of atoms. In conventional manufacturing, products are manufactured through processes of casting, milling and grinding. These are additive and subtractive processes that result in the formation of products with desired functionalities. Nevertheless, they have been described as crude and requiring much effort and alteration for obtaining the necessary functionalities.

Nanotechnology offers an alternate solution to create products with the necessary utility and functionalities. Rather than the conventional top down approach, this technology proposes a bottoms up approach where products are manufactured by the differential arrangement of microparticle atoms. This is much cheaper and in accordance with the principles of natural sciences. The biggest extension of nanotechnology is in computer hardware and technologies, which is purported to create a new generation of highly efficient and avante garde computer systems over the next decade.

II. CURRENT APPLICATIONS

According to Uldrich and Newberry (2012), the next big things will come in small sizes in their references to nanotechnology. These researchers say that nanotechnology is not something that is going to occur in the future. Rather it is already gaining traction in a wide variety of applications all of which are explored below:

A. Nanotechnology in Everyday Applications:

Nanotechnology finds application in the clothing industry. Nanoparticles embedded in cotton materials renders them stain proof. This process is already being used extensively in manufacture of stain repellant khaki clothes. While this simple application of nanotechnology in its most basic form will create a small revolution of sorts in the apparel and textile industry, affiliated industries will be threatened. These include dry cleaners, manufacturers of detergents and makers of stain removal agents. The inference here is clear. Nanotechnology promises to be a revolutionary new technology that creates new products and at the same time render old ones completely redundant.

That nanotechnology is increasingly being use even in everyday products may be made out from the statistics that the number of products incorporating nanotechnology has increased from 212 to 475 in the one had half years since the Project on Emerging Nanotechnologies brought out the world's first ever online catalogue of nanotechnology manufactured products in 2006. There are 77 items of clothing and 75 items of cosmetics. Other products include bedding, items of personal care, food and beverage items, sporting items as well as jewellery. In the food and beverages category, containers as well as diet supplements manufactured using nanotechnology doubled from 30 products in 2012 to 61 products in 2013. Moreover, 20% of the entire online inventory (or 95 items) contains nanoscale silver which is the most common of nano particle elements. The other most commonly used element is carbon where carbon nanotubes and fullerenes is the second most commonly used nanoparticle material. Nor are such items confined to countries such as the USA or the UK. Merchandise on the inventory is source from as many as 20 countries. While the most number of products comes from the United States (52% or 247 consumer products), East Asian countries account for 123 products which is an almost 60% increase over 2012. The inventory boasts of some new products as well. These include the Corsa Nanotech Ice Axe. This item contains a steel alloy called Sandvik Nanoflex manufactured using nanotechnology that is 20% less heavy than conventional steel and has upto 60% more tensility. Another product is the Maatshop Crystal Nano Silver which is a dietary supplement, that comes in liquid form, with provides the body with dramatically enhanced levels of resistance to common cold, flue as well as several other dangerous diseases including anthrax and cholera.

B. Application of Nanotechnology to the Military:

The main applications of nanotechnology in military also indicate the harmful side effects of the technology. These need to be worked upon for the more widespread use of the technology in arenas of combat. Nanotechnology is currently extensively used in the manufacture of uniforms and equipment which has the dual effect of making them stronger as well as lighter. However, the possibility of nano-fibres coming loose from the uniforms and equipment and entering the bloodstream and the environment cannot be ruled out. Nanoparticles are used in the manufacture of surface coverings in order to make them both hard and smooth. Here again, any erosion of the surface can result in the inhalation of particulate matter by the militia and the general population as well with consequent harmful effects. Nanomaterials are routinely used in the military and on the field to eliminate impurities from fluids. These filters are very low in cost, but the risk of harmful, toxic substances entering the human bloodstream is very real. Nano particles such as respirocytes used in the manufacture of artificial blood can lead to the saving of many human lives. However, there have been several reported cases of overheating of the body, breakdown of biomaterials within the body etc. Possibly the greatest threat of nanotechnology is its newness and the novelty it affords which can make their handling difficult and complicated. Miniature, robotic weapons as well as such systems are intelligent, self-target seeking ammunition rifles etc can lead to unexpected and unintentional injuries and even death of military personnel, civilian population and even threaten the infrastructure and environment surrounding the military camps.

C. Application of Nanotechnology in Food:

The application of technology in food has many forms. It may be used to preserve the food for extended shelf lives, detection of harmful bacteria and even impart more flavor and taste. These only touch upon possible application of nanotechnology to food and beverages sectors. This is because the application of this technology to the food industry is still little understood and under wraps with many companies working on these applications in secret.

As things stand however, nanotechnology offers one of the best possible solutions to protect the quality and safety of foods. They are used in the manufacture of contamination sensors where just a flash of light is required to detect the presence of harmful bacteria. It is used in the production of antibacterial packaging where common edible items are coated with nano particles of zinc and calcium that kills harmful pathogens. They are used to produce barriers that keep oxygen away from foods that are easily oxidized. Nanotechnology can be used to increase the nutritional content of foodstuffs. These include preserving water soluble vitamins, antioxidants, preservation of delicate omega and fatty acids and other nutraceutical food materials. They are used to use natural materials such as shells of marine creatures and corn hubs to create packaging that is environmentally friendly and biodegradable. They are used in the disbursement of pesticides into the environment. This reduces the need for additional spraying of harmful pesticides and chemicals into the environment and reduces the leakages of harmful chemicals into the water supply. Nanotechnology is used in the creation of nanobarcoding which is used to track, trace and protect materials and goods during transit more efficiently than current mechanisms. The application of nano crystals to lipids and fats improves their texture, their spreadibility and their stability as well. They can be used to create new flavors as well as enhance existing flavours. They can be used to create particles that bind with atomic pathogens which upon detection, can then get eliminated.

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All of these may be achieved without the very controversial technique of genetic manipulation. Nevertheless the shroud of secrecy surrounding application of nanotechnology to the food industry means that it is difficult to create laws and regulations to contain risks inherent in this technology.

III. ANALYSIS

As of October 2013, the nanotechnology consumer products inventory contains 1628 products or product lines. Products were grouped according to relevant main categories (Figure 1) that are loosely based on publicly available consumer product classification systems. The largest main category is Health and Fitness, with a total of 788 products. This includes products like cosmetics and sunscreens. In the analysis, product grouping was done according to the most relevant, primary categories as indicated in figure 1. The grouping was done according to data that is freely available to the public regarding classification of products. The most number of items are grouped under the Health & Fitness section consisting of 788 products including cosmetics and sunscreen lotions.

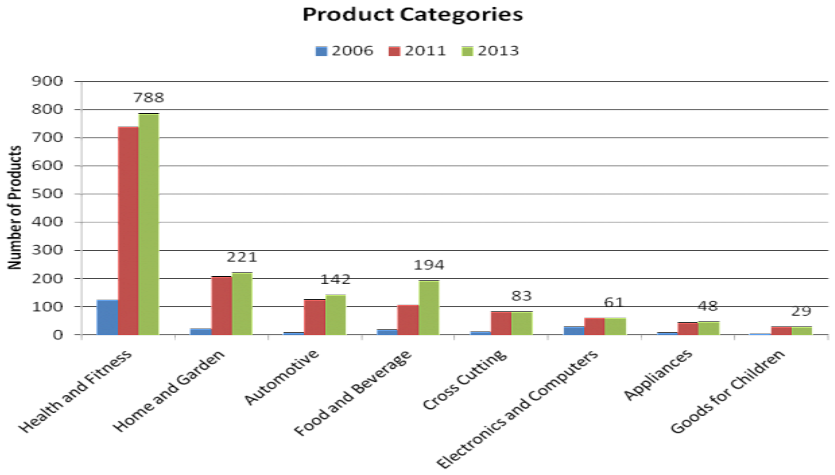

Fig.1 Category Grouping

Products with relevance to multiple categories have been accounted for multiple times in Figure 1. Associated with each category are a number of appropriate sub-categories that allow for further organization of the products. For example, Paint is a sub-category under Home and Garden, while Display is a sub-category under Electronics and Computers. The Cross-Cutting category was included as a grouping of products that are multi-functional. Currently, the only sub-category under Cross-Cutting is Coatings. In addition, 88 products have a "generic" designation, indicating that they are commercial technologies that will be used in, or are currently appearing in, consumer products.

Figure 2 indicates products that are related to multiple categories.

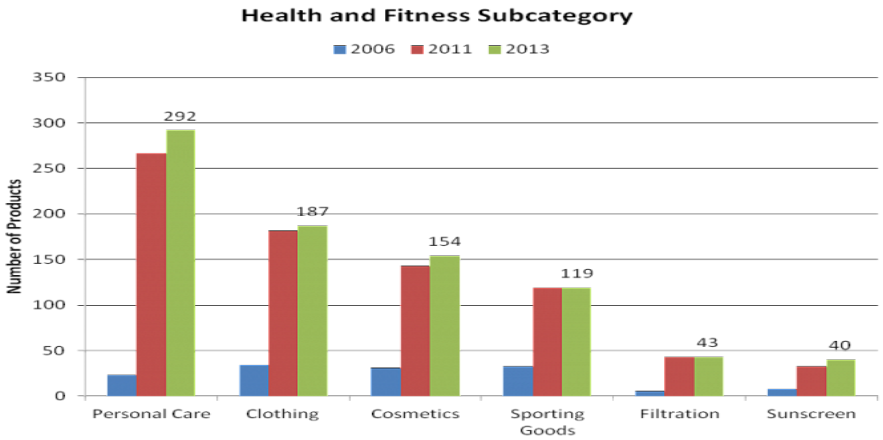

Fig. 2 Category Association

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In figure 2, the only such cross cutting category is called 'Coatings'. This indicates that these are commercial technologies and can be used in products meant for the mass consumer markets. Figure 2 illustrates the sub-categories associated with the largest main category, Health and Fitness. It includes Cosmetics (154 products), Clothing (187), Personal Care (292), Sporting Goods (119), Sunscreen (40), and Filtration (43). Again, products with relevance to multiple categories have been accounted for multiple times. The Cosmetics, Clothing and Personal Care sub-categories are now the largest in the inventory.

Figure 3 indicates the region wise distribution of products. The inventory now includes products from 30 different countries. Figure 3 illustrates the breakdown of products by region (when identified) and indicates that companies based in the United States have the most products, with a total

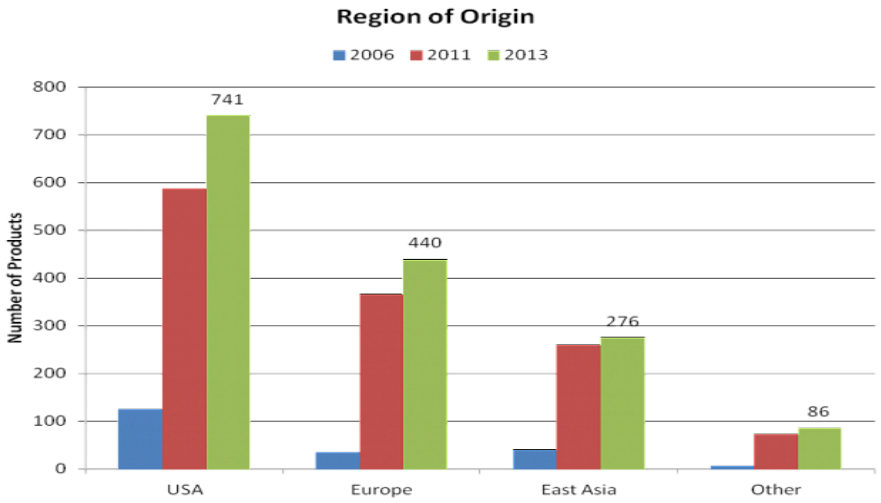

Fig. 3 Region Wise sourcing

of 741, followed by companies in Europe (UK, France, Germany, Finland, Switzerland, Italy, Sweden, Denmark, The Netherlands) (440), East Asia (including China, Taiwan, Korea, Japan) (276), and elsewhere around the world (Australia, Canada, Mexico, Israel, New Zealand, Malaysia, Thailand, Singapore, The Philippines, Malaysia) (86).

Figure 4 indicates the numbers of products and the associated materials they are made up of. As Figure 4 indicates, there is a small set of nanomaterials explicitly referenced in consumer products. The most common material mentioned in the product descriptions is now silver (383 products). Titanium (179), which includes titanium dioxide, has surpassed Carbon (87), which includes fullerenes, followed by silica (52), zinc (including zinc oxide) (36), and gold (19).

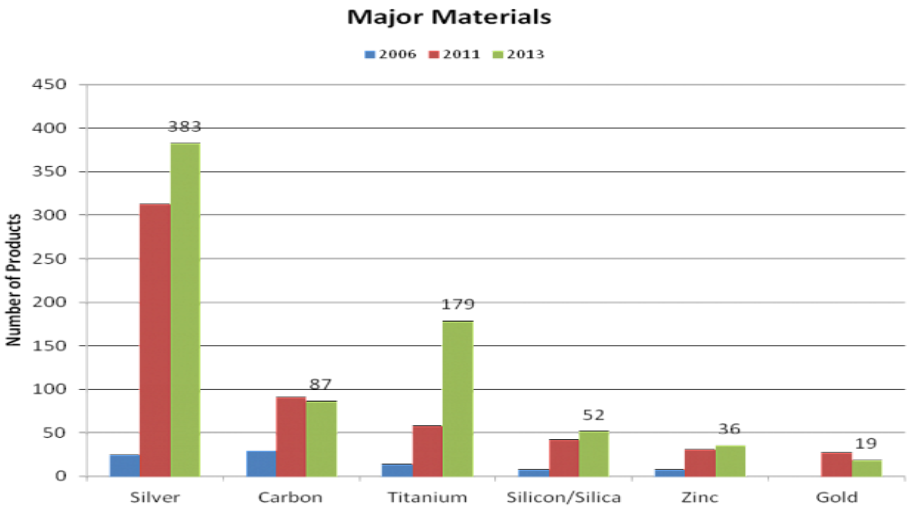

Fig. 4 Material Composition

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IV. CONCLUSION

It may be inferred from the above that while nanotechnology might seem to be exotic technology to the uninitiated, in reality it is already prevalent in various facets of daily lives as well as more esoteric applications. It has the potential to change the way current products are constructed and function as well as render moribund, seemingly indispensible products. It increases the functionality of various products, reduces costs and is used mostly in foods and in health care items. It is definitely a technology to look out for in future.

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