Nanomaterials for Economic Development

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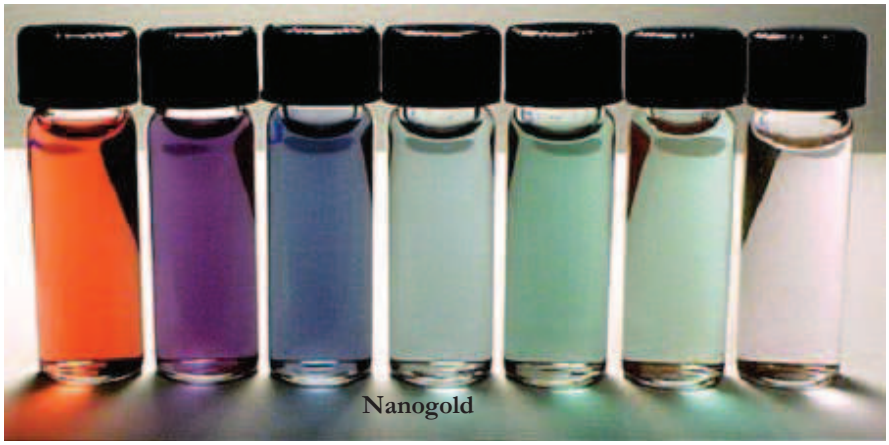
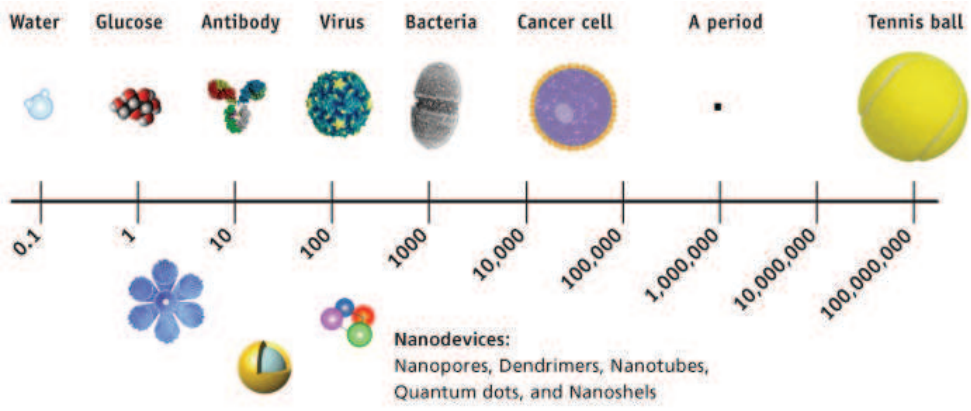
Sri Lanka, though a small island, is geographically rich in mineral resources. Typical nature of mineral resources is that the ores eventually will exhaust specially in the case of over-mining. Currently, most of our mineral resources are mined and consumed internally or externally without addition of much value to the raw form. Nanotechnology developments have presented an ideal space to add value to mineral resources in a sustainable manner. In the value chain of nanomaterials, nano-intermediates and nano-enabled products, it has to be noted that though nano-materials present the lowest value addition to raw materials, yet they are the building block of the nano-intermediates and nano-enabled products.



Nanogold

Nanomaterials are defined through their characteristics, usually in the size range between 1 and 100 nm at least in one of the dimensions. Chemical and physical characteristics of the materials take drastic changes due to surface to volume ratio increase and the quantum confinement effects when the 100 nm size is reached. Some of the properties such as optical, electrical, and magnetic aspect ratio effects can be exploited to create useful nano-intermediate and nano-enabled products. Most importantly, some of these useful changes in properties could be achieved by adding nanomaterials up to around 5% by weight of the bulk materials. Some such enabled products are already available in the market.



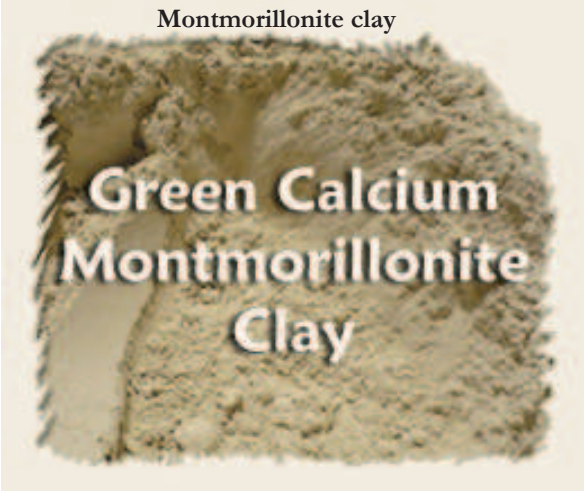
The web site http://www.nanotechproject.org/inventories/consumer/ lists 1317 nano-enabled consumer products registered with them from 30 countries around the world (visited 23rd November, 2012). Among these the incorporation of the antibacterial properties of Silver nanoparticles into fabrics, the use of non-scattering (thus transparent) UV blocking sun screen in lotions, and making tennis rackets which are lighter like a feather but stronger than steel with carbon

nanotube composites, are some examples of such products with enhancements via novel properties of nanomaterials. According to Lux Research Inc., nanotechnology will account for $2.4 trillion of revenue by the year 2015. Out of that, Nanomaterials will account for $3 billion and nano-intermediates will account for nearly $500 billion. This provides a fabulous opportunity for a country like Sri Lanka where non-renewable mineral resources are abundant in a smaller land mass. Let's look at some of the sustainable utilization possibilities for Sri Lanka's main minerals with the new technology developments.

Beach sands

North-eastern beaches in Pulmoddai are covered with black sands where 70 – 80% of it is in the form of Ilmenite. Ilmenite is the main source of Titanium products (mainly titanium dioxide and the metallic Titanium). In the past half a century, Sri Lanka has surface mined the beach sand and exported Ilmenite and Rutile after a minimal separation. Sri Lankan Ilmenite has over 55% of titanium dioxide content. The ore is estimated to be around 4 million metric tons, which gets replenished during the monsoon season. It is estimated to last 25 years at the mining rate of 150,000 MT annually (http://sundaytimes.lk/051002/ft/4.html). In 2012, the average price of Ilmenite was around $200 per MT whereas titanium dioxide at around $4200 per MT, metallic Titanium at $13,000 pet MT and nano-titanium dioxide was around $10,000 per MT. Nano-titanium dioxide has good transparency because the particle size is less than the wavelength of visible light but has excellent UV-A and UV-B absorbance. In usual formulations these properties could be achieved between 0.5 – 8% doping of nano-titanium dioxide depending on the application. At the Sri Lanka Institute of Nanotechnology (SLINTEC), the technology to extract pigment titanium dioxide and nano-titanium dioxide from Ilmenite is currently undergoing scale up, while the technology to extract metallic titanium is being investigated. SLINTEC is seeking investors to take all these technologies to commercial production.

Montmorillonite clay



Nano-titanium dioxide

Clay minerals

Not all clays fall within the nomenclature of "nano-clays". Montmorillonite (Bentonite) is a clay mineral with nanoscale gallery spaces. In north western Murunkan area, the clay deposit contains about 40% of Montmorillonite (MMT). Due to the nano size gallery spaces they could be used in many composite applications. Market prices of MMT clays vary depending on composition as well as the purity and percent composition. Two major types

of nano-clays based on composition would be Sodium-MMT and Calcium-MMT.

Organoclays are produced using Sodium-MMT as the base. Organics are reacted with high exchange capacity Sodium-MMT where organics are exchanged with Sodium. They are used in oil based paints, high temperature grease, in oil based drilling mud and several other niche markets. Prices vary from $1500 - $4000 per MT. Calcium-MMT is acid activated to produce bleaching clays which are used to clarify edible oils and beverages. Total volume of the bleaching clay market is estimated to be 850,000 tons priced at $250 - $600 per ton.

Currently there is no industry for producing nano-clays and nano-clay composites in Sri Lanka. SLINTEC has developed extraction and purification methods for MMT from Murunkan clays. Currently the technology is being developed for organic clays.

Estimated market size by 2009

Technology/application	Estimated market size*(by 2009)
Polymer/clay nanocomposites	Over 1 billion pounds
Packaging	367 million pounds
Automotive	345 million pounds
Building and construction	151 million pounds
Coatings	63 million pounds
Industrial	48 million pounds
Others	67 million pounds

Graphite

Graphite based nano-structures are the most talked about nanomaterials in the world. Since graphene won the Nobel Prize for Physics in 2010, electronics industry has invested considerable amounts of money and time in graphite based nanomaterials (nanocarbons). Nanocarbon products include single-walled carbon nanotubes (SWNT) and multi-walled carbon nanotubes (MWNT), fullerenes, graphene, carbon nanofiber and nanodiamonds.

Production capacity for all products increased from 996 metric tons in 2008 to more than 2190 tons in 2009, and to 4065 tons in 2010, and is expected to exceed 12,300 tons in 2015, a compound annual growth rate of 24.8% a year. Total production value is expected to reach about $435 million in 2010 and reach a value of $1.3 billion in 2015 (http://www.innoresearch.net). Sri Lanka has been a graphite producer since the year 1675.

Most of Sri Lankan graphite is mined underground as vein graphite. Sri Lanka is the only country where vein graphite is mined and it is the purest form (reaching 99.5%) available in nature (Simon Moores, Industrial Minerals, 2012). Currently Sri Lanka is a graphite-exporter in the raw form without value addition. Though Sri Lankan miners may be making a profit, the opportunity provided by new markets for nano-graphite is not going to last for a long time. SLINTEC is waiting for graphite producers of Sri Lank to join hands to explore these new opportunities.

There are other minerals such as apatite, quartz, magnetite, silica sand, feldspar, monazite, serpentinite, mica and gem minerals where nanotechnology could provide sustainable ways to develop mineral resources of Sri Lanka. SLINTEC has provided an opportunity for Sri Lankan industrialists to take a leap of faith into the world of nanotechnology.

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