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ANTI-CORROSION Nanotech protects

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Nanotech Magazine
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Tel +44 (0) 131 478 0921
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Welcome to the second issue of Nanotech magazine. The magazine is brought to you by Future Markets (www.futuremarketsinc.com), the world’s leading provider of nanotechnology and nanomaterials market information. Nanotech magazine will provide you with all the latest industry relevant news, views, features and opinion. This unique industry focus will allow us to cut through all the hype surrounding nanotechnology.

This month we focus on quantum dots, which are finding their way into TVs and displays and are also causing a stir in the lighting industry. We take a look at all the main players. We also take a look at nanotechnology in cleantech, an industry that will only continue to grow in the coming years as technologists seek solutions to a global problem that seems to be beyond most governments, as they pursue policies of self-interest rather than tackle a critical future challenge. Also covered in this issue are the latest developments in nanotechnology and science and technology policy in the United States, specifically the National Nanotechnology Initiative, which is now in its second decade. Zinc oxide nanopowders are another key industry we will be exploring in this issue, as well as taking a look at how nanotechnology is being deployed in the frontline in the military.

The magazine has proved an instant success and will continue to meet the needs of those with a keen interest in nanotech and how it is being applied across all business sectors. Next month will see us look at regulatory aspects of nanotechnology. We will endeavour to keep you informed of all that is happening in nanotech.

Andy Garland, Editor, Nanotech Magazine
In France, a pilot plant run by Centre Technique du Papier and Institut Technologique FCBA has been established with a capacity of 100 kg/day of NFC or MFC.

The wood forestry chain is a marvelous source of materials, products, molecules and derivatives for many industrial sectors (pulp and paper, wood building, furniture, agro-food, pharmaceuticals...). To valorize this potential, innovation in new technologies and products is always required. This is the reason why CTP and FCBA have decided to invest in the micro/nano fibrils of cellulose, a natural component of the lignocellulosic fibres wall.

Cellulose is the most abundant natural, renewable and recyclable resource on Earth with nearly 75 milliard tons produced yearly. This is a natural polymer of glucose and the component the most abundant in the plants. Wood, one of the lignocellulosic materials, is a natural, porous composite, hydrated and tridimensional composed of an interconnected network of fibres/tracheids, vessels and cells, mainly constituted of cellulose, hemicelluloses and lignin. The fibres/tracheids have a cell wall structured in different layers of which the secondary layer is rich in microfibrils of cellulose with a width of 100 to 300 Å. These microfibrils are an interesting material presenting exceptional properties (Young modulus comparable to steel).

The manufacture of micro/nanofibrils of cellulose (MFC/NFC) is based on the liberation of these microfibrils from the cell walls of the fibres produced by the pulp industry, through mechanical, biotechnological or chemical ways. Depending on the size of the generated particles, it will be possible to produce micro fibrils or nano-fibrils, the latter corresponding to the elementary component of the cellulose chains.

**THE AIM**

In the frame of the InTechFibres partnership, CTP and institut Technologique FCBA have chose the “Bottom down” technology for the manufacture of MFC/NFC at pilot scale, i.e. the way of deconstructing the cellulosic fibres to liberate the micro/nanofibrils of cellulose present and naturally produced by the plants. The homogeneising technology at high
pressure (1500 bars) has been selected for the final step of the manufacturing process.

**THE TOOLS**

For this, a pilot platform of production of MFC/NFC was installed in 2011 in CTP’s buildings, composed of the following elements:
- A pilot unit for refining the cellulosic fibres with a capacity of 5 kg constituted of a pulper, storage chests and two single disc refiners in series running at 4-5% pulp consistency.
- A pilot unit for refining the cellulosic fibres with a capacity of 75 to 100 kg constituted of a pulper, storage chest, a double disc refiner and a conical refiner,
- An homogenizer from GEA Niro Soavi, Ariete model, with a capacity of 1000 L/h at 1500 bars and a power of 55 kW
- An homogenizer from GEA Niro Soavi – Panther model, with a capacity of 50 L/h at 1500 bars and a power of 5 kW for the manufacture of laboratory batches,
- Two storage chest for the Ariete equipment.

This platform allows to produce batches of MFC/NFC of different quality depending on the origin of the pulp used and the selected process (biomechanical or chemical one) for the evaluation at laboratory, on pilot at a the semi-industrial scale. Batches of 50 g up to 70 kg of o.d. MFC/NFC can be produced on request, depending on the selected quality and process.

**APPLICATIONS POSSIBILITIES**

- Development of barrier papers for packaging
- Use as additives in panelboards, on wood products, in wood painting and preservatives to reinforce their strength and resistance
- Reinforcement of papers and boards, panelboards, furniture surface layers, composites,
- Use in highly technical products: battery, organic LED, heath displays, ...
- Replacement of glass fibres in some technical products
- Use as molecule carriers for diverse applications: (antimicrobial, antibacterial, ...)

**KEY RESULTS**

To date, they have:
- created an operational platform to study and produce MFC/NFC gels
- validated two technologies for the MFC/NFC production at laboratory and pilot scales
- produced pilot MFC/NFC batches for semi-industrial evaluation
- developed protocol to produce MFC/NFC films
- studied different potential applications in paper industry for packaging
- initiated different research projects for the MFC/NFC production characterisation and use....

**CTP**

CTP is an industrial partner for Applied Research, Consultancy, Testing Laboratories and Training Courses... CTP is independent and impartial, with high level of Scientific Expertise in:
- Lignocellulosic chemistry
- Biobased materials
- Health and safety applications
- Packaging of the future
- Printed electronics – Smart paper
- New value for Recovered Paper&Board
- Water – Energy
- Printed Communication
- Industrial Performance

CTP helps innovate products & processes at lab, pilot and industrial scale; develops knowledge and makes you more competitive!

**FCBA IN IN 100 WORDS**

FCBA is the technological institute for Forestry, Cellulose, Construction with Timber and Furniture, since 1952. Teams of engineers, technicians, researchers and experts, in total more than 350 employees build the strong competence of FCBA. Our mission is to promote technical progress and to improve the output, as well as to guarantee high quality in industry. This is accompanied by encouraging a comprehensive approach and emphasizing areas of synergy. FCBA’s distinctive feature resides in the diversity of trade professionals whom we act for, covering: silviculture, forestry and sawmills, pulp, packaging and miscellaneous products, timber in the construction industry, furniture, finishing, wood treatment and preservation, environment, health, energy, economics, and sustainable development.
NanoPCC

Our definitive guide to nanotechnology in the construction and architecture industry from protective coatings to insulation.

Nano materials are particularly suited to protecting the surface of various construction materials such as glass, concrete, sand limestone or marble from environmental influences like water staining, moss, algae as well as soot and oil stains; and can also function as corrosion inhibitors for reinforced steel. Nano additive paints and surface coatings are commercially available that create a low energy facing thus rendering a building surface highly hydro- and oleophobic, thereby helping to prolong maintenance cycles and reduce cleaning.

Dirt repellent protective paints and photocatalytic coatings are the most prominent applications in the construction and exterior protection industry. Dirt collection (accumulation) in building exteriors poses considerable problems for building maintenance. Cleaning such building surfaces is generally done by using detergents accompanied with scrubbing, wiping and high-pressure water jets. These processes have several shortcomings such as use of chemical detergents, high consumption of energy and labour cost. These naturally lead to high maintenance cost; therefore, an effective self-cleaning coating is desirable. Nanoparticle TiO2 self-cleaning coating technology is applicable for use on surfaces. Such coatings greatly benefit building maintenance, especially for skyscrapers, as they reduce the need for costly surface cleaning. Photocatalyst coatings are also used to improve indoor air quality by reducing the amount of volatile organic compound and other toxic chemicals people are exposed to. Other applications utilising nano materials in the construction industry include nanoporous aerogel insulation, nanocomposite additives to steel, fire retardant materials, and environmentally sustainable materials.

**CURRENT MARKET SIZE FOR NANOMATERIALS IN CONSTRUCTION**

$725 million

**POTENTIAL MARKET SIZE 2020**

$4.5 billion

**PROS/CONS**

- Reduced maintenance and repair costs
- Greater safety and comfort
- Cost of innovation in a depressed industry
- Robustness issues with certain nanomaterials

**MARKET POTENTIAL**

**THE GOOD**

The use of nanomaterials allows for reduced maintenance cost and efforts, especially on office buildings.

**THE BAD**

The robustness of protective coatings can be affected by certain factors.

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**THE BAD**

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**INTERIORS**

Nanomaterials have been applied to a variety of surfaces in the household including easy-clean and self-cleaning coatings for bathrooms and furniture.

**01 Coatings**

Anti-graffiti nanocoatings are on the market and are durable for up to 6 years due to strong chemical bonding and penetration

**02 Insulation**

Nanoporous aerogels are widely used for insulation in homes. These materials are up to five times more effective than other insulation materials.
Nanotechnology can facilitate developing high performance insulation materials / systems. Different forms of insulation solutions, like coatings, vacuum insulation glazing, and nanofoams can be realized. Nanoporous aerogels are used in construction materials as insulators. The percentage of open space within an aerogel structure is about 94%, giving a tortuous path for heat, and this leads to it having the lowest thermal conductivity value of any solid.

Nanopowders have been added to construction ceramics, which include floor and wall tiles, countertop ceramics and sanitary ware products. They have found a place on the market with self-cleaning, anti-bacterialism hygienic and scratch resistant features. Nanoparticles exhibit properties of water/dirt repellency, UV protection, antibacterial, anti-corrosion for application on glass. The coatings contain functionalized nanoparticles such as nano silver that impart a bacteria-free surface which is anti-fouling & anti-algae.

Nanomaterials affect cement and concrete in different ways including their processing conditions, released CO2 emissions, service life and functionalities. Addition of nanoparticles will lead to stronger, more durable, self-healing, air purifying, fire resistant, easy to clean and quick compacting concrete. Some of the nanoparticles that are being used are nano silica (silica fume), nanostructured metals, carbon nanotubes and carbon nanofibers.

Self-cleaning coatings incorporating photocatalytic Titanium Dioxide (TiO2) use UV light for strong oxidation power and super-hydrophilicity on windows. Strong oxidation power can be used to kill bacteria attached on the wall, or oxide/remove foul smell from stains in toilets (TiO2-coated tile and TiO2-coated glass are commercially available). Super-hydrophilic properties allow dirt and stains to be easily washed away with water or by rainfall when the coating is applied to exterior surfaces.

“Nanomaterials have been added to construction ceramics including floor and wall tiles, countertop ceramics and sanitary ware products”
Global revenues for nanofiber-enabled products were an estimated US$382.1 million in 2011, growing to around $852.3 million by 2017. Main markets for polymer nanofibers are in air and water filtration, composites and textiles. Polymeric nanofibers account for the main bulk of the current revenues for nanofibers, finding application across a number of sectors. Alumina nanofibers are mainly used in filtration applications. Carbon nanofibers are beginning to find application across a raft of industries including electronics (heat management, EMI shielding, conductors), composites (polymers, resins, glass, ceramics, plastics), energy (batteries, catalysts and fuel cells) and medicine and life sciences and carbon nanofibers represent the fastest growing market for nanofibers, especially in Li-ion battery applications. Cellulose nanofibers are also beginning to make an impact in composites and electronics applications. Nanofiber based composites with excellent physical and mechanical properties offer great potential for lightweight, wear-resistant, and high temperature applications in the aerospace and aviation industry. Alumina, polymer, carbon and cellulose fiber composites are found in a number of industrial applications including automotive, aerospace and civil engineering as a specialized-functional material with high strength and modulus, high thermal resistance and high elasticity etc. Due to its outstanding thermal conductivity and coefficient of thermal expansion (CTE) vapor grown carbon nanofibers (VGCNFs) are one of the most promising reinforcing materials of metal matrix composites (MMCs) for the thermal dissipation of future power electronics. Nanofiber-based polymeric battery separators boost the performance and safety of lithium ion batteries. Nanofibers find widespread application in automotive applications, allowing for lower curb weight, better fuel efficiency and reduced costs. Leading players in the market include Ahlstrom, Dupont, Donaldson, Hollingsworth & Vose, Johns Manville, Kuraray, Mitsubishi Rayon, Teijin and Toray. Innovative up and coming companies involved in both the production and application of nanofibers include Elmarco, Fibero Technology Corporation, Finetex and Nanoval. Leading application developers include NEC and Asahi Kasei.
The Company
Nanoco was founded in 2001 as a spin-out company from Manchester University’s Chemistry Department. The company currently operates facilities in the UK and Japan. Nanoco partners major R&D and blue-chip industrial organizations in the development of applications incorporating quantum dots.

Technology
Nanoco manufactures large quantities of quantum dots. The company’s molecular seeding process for the bespoke manufacture of these quantum dots on a commercial scale is protected by worldwide patents. Nanoco Technologies is presently able to supply production quantities of quantum dots which do not use a regulated heavy metal. The company has signed an agreement with a large lighting company to incorporate their quantum dots into LEDs.

Markets
Lighting, solar cells, and biological imaging. The company’s quantum dots can be combined into a wide range of materials including liquids, polymers and glass.

Bayer

The Company
Bayer Technology Services GmbH (BTS) is a Bayer subsidiary employing over 2,600 people worldwide. 2009 sales totaled approx. EUR 380 million.

Technology
Bayer Technology Services GmbH (BTS) is actively pursuing the development of nanomaterials such as Baytubes®, Baydots®, Bayink®, metallic and metal oxide nanoparticles (or nanorods, nanoshells, etc.). The company’s Baydot® quantum dots are in the range of 1-20nm. Their main application is in organic photovoltaic films.

Markets
Bayer is mainly focused on the optoelectronics, medical, catalytic, photovoltaics, security labelling and functional polymer composites sectors.
Lab21, Inc.

THE COMPANY
Lab21 Inc. was formerly known as Selah Technologies, LLC. As a result of acquisition of Selah Technologies, LLC by Lab21 Ltd. and Nexus Medical Partners, Selah Technologies, LLC’s name was changed in December 2009. The company was founded in 2006 and is based in Pendleton, South Carolina. As of December 17, 2009, Lab21 Inc. operates as a subsidiary of Lab21 Ltd.

TECHNOLOGY
Lab21 Inc. engages in developing and commercializing nanotechnology-enabled products for the biomedical industry. It offers Selah Dots, which are bio-sensing and bio-imaging contrast agents that replace fluorescent dyes/microbeads/heavy metal based quantum dots.

Markets
Selah Dots are used in security inks, as well as authenticity and anti-counterfeiting taggants.

Ocean NanoTech

THE COMPANY
The company’s product line includes quantum dots, core shell quantum dots in organic solvents, nanocrystals for LEDs and solar cells, water soluble biocompatible nanocrystals, reaction buffers for conjugating nanocrystals to biomolecules and conjugation kits. The company was founded in 2004 and is based in Fayetteville, Arkansas.

TECHNOLOGY
The company offers quantum dot powders, and quantum dots in organic solvents and water, as well as NIR quantum dots in water; metal nanocrystal powders and metal nanocrystals in water; and iron oxide magnetic nanoparticles in organic solvents and water. The company provides custom synthesis, contract research, and joint product development services.

Markets
Main application areas are fluorescent bio-labeling and optoelectronics and displays.
Nanosys, Inc.
www.nanosysinc.com

THE COMPANY
Based in Palo Alto, California and privately held, Nanosys collaborates with industry to develop QD products for computing, optoelectronics, communications, renewable energy, defense and the life sciences.

TECHNOLOGY
Currently, Nanosys is focused on commercializing its quantum dot and silicon composite anode materials for the LED LCD and lithium ion battery industries. QDEF™ and QuantumRail™ are composed of Nanosys’ proprietary, high efficiency quantum dot phosphors. They find application in LED displays. Nanosys Quantum Dot Enhancement Film, or QDEF, is an optical film component for LED driven LCD displays. Based on Nanosys’ proprietary high efficiency Quantum Dot Phosphors, QDEF enables a new level of LCD display performance by providing a high quality, tri-color white light from a standard blue LED light source.

Markets
LED backlighting, LED general lighting, power (batteries and fuel cells), medical applications, next generation NAND Flash memories, Solar, and Flat Panel Display driver transistors.

NN-Labs
www.nn-labs.com

THE COMPANY
NN-Labs LLC is a developer of advanced functional materials including semiconductor, noble metal and magnetic metal oxide nanocrystals.

TECHNOLOGY
The company produces indium phosphide-based quantum dots as a new environmentally-friendly, heavy metal-free, high performance alternative to cadmium selenide-based (CdSe) quantum dots. NN-Labs is offering InP/ZnS core-shell quantum dots in kits of five emission colors: Green (530 nm), Yellow (570 nm), Orange (600 nm), Red (630 nm), and Deep Red (650 nm). D-dots™ are doped semiconductor nanocrystals without the presence of any heavy metal ions, such as cadmium (Cd), mercury (Hg), or lead (Pb).

Markets
Biological and imaging applications. The company also license their technology to NNCrystal for use in the lighting industry.
Nanocoatings can significantly increase the cost/benefit ratio, providing cost effective solutions and improved performances. Moreover, nanotechnology implementing new functionalities, enable the possibility to achieve completely innovative characteristics and the possibility to achieve multifunctional coatings and smart coatings.

“One of the main goals is identifying national strategies able to minimize the impact at the same time of preventing its development. Nowadays, annual direct cost of metallic corrosion is estimated $300 billion and €200 billion in Europe.”
One of the main goals is identifying national strategies able to minimize the impact of corrosion protecting it at the same time of preventing its development. Nowadays, annual direct cost of metallic corrosion in U.S. economy is estimated $300 billion and €200 billion in Europe.

Corrosion is becoming a significant problem for owners of industrial equipment, installations, and plants. Being a slow process it can change assuming many forms and arising very rapidly since it is triggered by environmental factors, such as oxygen and water, which cannot be eliminated. It is possible, however, to prevent corrosion, thanks to increasingly innovative technologies that shift the focus of the problem from the protection against corrosion to its prevention.

The presence of corrosive chemicals and harsh operating and environmental conditions can result in structural failure or loss of containment, which can be costly in terms of repairs, lost or contaminated products, environmental damage, and potential risk to personnel. Corrosion factor is very costly and has a major impact on the economies of industrial nations companies. Fight against corrosion depends on technical expertise and has a wide variety of applications, one of which is coatings for corrosion resistance.

One of the main goals is identifying national strategies able to minimize the impact of corrosion protecting it at the same time of preventing its development. Nowadays, annual direct cost of metallic corrosion in U.S. economy is estimated $300 billion and €200 billion in Europe.

While there is an increasing need for more effective and less costly products, EU and government regulations are also driving demand for lower content of chemicals in coatings. The need for innovation is urgent.

A system that protects and prevents corrosion must have all these features:
- High insulation and almost no permeability to water and oxygen;
- Very high adhesion to the metal surface and absolute continuity of the coating film;
- High mechanical strength and psycho-chemical inertia with respect to environment in which it is applied.

One approach that is getting more and more important is the combination of traditional coating know-how and nanotechnology.
The outcomes of this mix are protective coatings with nanoparticles, that can be of different kind, as industrial protective coatings, corrosion protection coatings, thermal resistant, fire retardant coatings, water based anti-corrosion coatings and fire retardant polymers.

For this reason nanocomposites are more and more considered as the key technology. Nanocomposites are particular composites materials with at least a phase in the nanoscale size (between 0,1 and 100nm). This family of materials, often displays original properties in respect to their homologues without nanoscale features. This is due to the dramatic increase of the surface area and the associated interface phenomena. Advantages are expressed in terms of improvement of performances or in terms of implementation of innovative functionalities. Such advantages are transversal across practically all major market sectors: automotive, aerospace and defence, electronics, clean tech, biomed, constructions. Coating formulations incorporating nano-technology are a particular category of nanocomposites. Following the general trend described above, their use has increased a lot in recent years.

Nanocoatings can significantly increase the cost/benefit ratio, providing cost effective solutions and improved performances. Moreover, nanotechnology implementing new functionalities, enable the possibility to achieve completely innovative characteristics and the possibility to achieve multifunctional coatings and smart coatings.

Main market drivers are as follows:
- constantly increasing requirements on the performance of anti-corrosion coatings
- rising cost awareness
- increasing environmental attention related to the reduction of solvent content
- growing application of surface tolerant protective coatings systems or coatings providing universal adhesion
- replacement of toxic inhibitors such as hexavalent chromium

The following list shows sectors that can be positively affect by the use of anticorrosive coatings: Oil and Gas, Shipping and Shipyard sector, Energy, Infrastructures, Rolling Stock, Lift equipment, Port machinery and the Lighting sector.

The advantages of anticorrosive coating are clear and visible, that is the increase of the coating durability (longer time protection), with high effect on the coating barrier and a long term corrosion protection.

There are significant new developments occurring in the corrosion segment. Numerous companies - both large, well established corporations and small, entrepreneurial firms - have focussed on developing products for the coatings marketplace which aim to differentiate themselves with nanotechnology.

Global nanomaterial demand will rise 21 percent annually through 2013 and this trend is expected to be respected in the following years. Between 2010 and 2015 nanomaterials will no longer be novel and niche market materials, finding use not only as replacement materials but also as materials of choice for new products, allowing for broader use in various applications. For instance, global market estimate for paints is almost 70 bn €.

Paints and coatings serve as one of the key methods for protecting metal surfaces from corrosion. Global growth has been pegged at 3.5- 4% per year. This growth rate has been achieved despite several negative factors currently active in the paints and coatings marketplace. Rising raw material and energy prices, the introduction of new regulatory restrictions, and the potential for overcapacity in the near future are all impacting margins.

Our Company, Nanto Protective Coating, provides industrial innovative nano-coatings for the manufacture industry, marine, energy and lighting sectors and smart coating for cleantech sector. The NPC’s core know-how developed by the company can be used both as Industrial maintenance but also on new markets transferring and competing with major portfolio products in order to provide new products also to new structures.

Nanto Protective Coating was founded in April 2010 with the goal to develop products such as innovative coatings and polymers based on proprietary nanotechnology. According to Dr. Roberto Caflaga, Nanto Protective Coating’s CEO “NPC is engaged in R&D activities and product development, extending the existing product portfolio, mainly based on customer needs, joint projects and collaborations. Value is consequence-ly create from technology commercialization by means of production and distribution licensing agreements and direct sales of products supplied by manufacturing industrial partners”. The team has a proven track in technology start-up launch, together with business development and marketing expertise. In addition to the team of executives, who are continuously supporting company’s development, NPC has a very effective network of partners and collaborators that sustain R&D and product development activities, such as the Shkenar College of Engineering and Design in Ramat-Gan (Israel), the University of Bergamo (Department of Physics), the University of Trento (Department of Materials Engineering and Industrial Technologies) and dedicated Chemical Lab, such as NanoFab and Vega in Padoa (Nanotechnology Italian Cluster).

NPC targets the protective coating segment (37% - € 25,7 bn) which is the largest segment of global market for anti-corrosion paints and coatings. Overall, the market is nearly evenly split between North America, Asia, and Europe.

The patented NPC technology developed the effectiveness of nanoclays as barrier elements to corrosion (oxygen and humidity) and to thermal control. Nanoclay composites are currently generating a great deal of interest due to their potential cost effective advantages in barrier properties. Nanoclays are montmorillonite minerals which have been treated with compatibilizing agents, enabling them to disperse and orientate opportune into resins.

In the last two years, NPC has been conducting technology research and focussed its efforts on the development of nanocomposites and in particular of nanoclay containing thermosets and thermoplastics. Starting from base research performed by international research partners, NPC has gone through all the product development value chain up to the production and commercialization of highly efficient anticorrosion and fire retardant coatings and polymers. All these sectors offering a Cost effective approach have unique Anticorrosion Properties and have already had a huge result, that is getting up to + 30 % with extended lifetime against corrosion.

Professor Samuel Kenig, Dean of the Engineering Faculty at Shinhar University of Tel Aviv and currently NPC’s Technical Director for R&D and nanoclay functionalization of new production plant run the initial tests that, in an early technology stage showed an increased barrier...
The effect of epoxy protective coating following the use of functionalized nanoclay. Prof. Kenig confirmed also that “NPC supplies intelligent coatings which meet the highest standards of quality and add real value and benefits for a broad range of market sectors and various applications”.

NPC pipeline is constantly growing adapting to the need of the market and the exigencies of customers and of the environment. A continuous R&D activity and a customer based approach are the major selling points of the company, which is building on this innovation factor a strategy of a fast and sustainable penetration in the market.

A huge respect for the environment leads to stronger cleantech version of the line of products and to high interest into a greener technology. NPC strongly believe in a “Cleantech Style life” in order to innovate and create a diverse range of innovative products that optimize the use of natural resources or reduces the negative environmental impact of their use while creating value by lowering costs, improving efficiency or providing superior performance.

A first series of solvent based anticorrosion paint, called N.P.C. 100, is ready to market. This product can offer a unique cost effective solution to the problem of corrosion. N.P.C. 100, exploiting a patented proprietary nanotechnology, provides a barrier effect up to 30% higher than existing anticorrosion coatings. N.P.C. 100 series will soon be expanded to additional solvent system, water based system and powder based system.

A part from the anticorrosion coatings which have some products ready to market and other very close to market, NPC is also active on a set of R&D activities which will provide the next series of NPC high performance coatings. This is to expand the product pipeline in order to support a continuous, strong and sustainable growth of the company.

Author:
Paola Alessi
NANTO PROTECTIVE COATING SRL
www.nantopaint.com
Zinc oxide nanopowders find application across a raft of industries where they are used for their antibacterial, antifungal, anti-corrosion, catalytic, and UV-filtering properties. They are also suited to electronics applications such as capacitors, varistors, photocopying and electrophotography due to their extremely low levels of heavy metal impurities.

The main markets for nano ZnO are as UV-filters. They are chiefly used as cosmetic and sunscreen additives. They show excellent absorption in both the UV-B and UV-A region. Their larger surface area also makes their protection functionality much more effective. This same holds for UV-protection of e.g. lacquer films and polymer surfaces.

Other applications for nanoZnO include automotive composite additives for colour fastness, transparent conductive thin-films in blue laser diodes, solar cells and liquid crystal displays, ZnO nanocolumns that act both as optical amplification medium and as a laser resonator, an anti-bacterial agent in the medicine and health and textile sectors, disinfection and self-cleaning glass-ceramic materials, industry sterilization dressings, packaging films and UV-protective textiles.

Production estimates for nanoZnO is between 80,000-90,000 tons per annum and they are mainly sold to cosmetics and sunscreens producers. Main producers sell over 500 tons per month to these industries alone.

The main producers of nanoZnO are BASF, Antaria Ltd., Buhler Partec, Elementis Specialties, Haarmann and Reime, Nanophase, Sakai, Showa Denko, Sumitomo Cement, Sunjin Chemical Co. Ltd. and Tayca Corporation. Further information on the market is available in the Future Markets, Inc. report The World Market for Zinc Oxide Nanopowders.
Molybdenum Disulfide

Touted as both an alternative to and perfect partner for graphene, MoS₂ could be set to make a significant impact in the electronics industry. Two-dimensional (2D) nano-materials such as graphene, and molybdenum disulfide (MoS₂) have been attracting increasing research interest in the past few years due to their unique material properties that promise a raft of new applications in sectors ranging from electronics to composites.

MoS₂ is the inorganic compound with the formula MoS₂. It has typically been used in industrial lubricant applications but it could potentially lead to new applications in high-speed logic circuits-on its own or in combination with graphene. It is a semiconductor with large band-gap which allows its use for logic devices, where a high Ion/Ioff ratio is required. Researchers at MIT, EPFL and the University of Manchester have been developing electronic circuits out of MoS₂ where previously they sought to develop electronic applications for graphene.

Graphene has a major problem in alternative silicon electronics application as it lacks an energy gap between its conduction and valence bands, which makes it difficult to achieve low power dissipation in the OFF state, and it therefore requires extensive modification in order to create one, whereas MoS₂ naturally possesses one. Researchers have therefore been developing graphene heterostructure devices with nanoscale molybdenum disulfide acting as a vertical transport barrier. MoS₂ has also been integrated with carbon nanotubes for application in high performance logic circuits.

Figure 1: Structure of 2D molybdenum disulfide (Image: Wang et al. / MIT)

The lack of a reliable large-scale production method is viewed as an inhibiting issue at present for their practical applications. According to researchers however, the material is already widely produced as a lubricant and due to work in producing large sheets of the material in labs, scaling up production is likely to be easier than with other nanomaterials.

MIT

Large sheets of MoS₂ have been fabricated by Yi-Hsien Lee, a postdoc in associate professor Jing Kong’s group in the Department of Electrical Engineering and Computer Science at MIT, via a chemical vapor deposition (CVD) process. Palacios, Han Wang and Yu then produced building blocks of electronic circuits on the sheets, as well as on MoS₂ flakes produced by a mechanical method. Wang and Palacios were able to fabricate a variety of basic electronic devices on the material: an inverter, which switches an input voltage to its opposite; a NAND gate, a basic logic element that can be combined to carry out almost any kind of logic operation; a memory device, one of the key components of all computational devices; and a more complex circuit called a ring oscillator, made up of 12 interconnected transistors, which can produce a precisely tuned wave output. Web: http://www.rle.mit.edu/rleonline/People/JingKong.html

University of Manchester

Graphene pioneers at the University of Manchester have developed prototype devices based on graphene heterostructures with atomically thin boron nitride or molybdenum disulfide acting as a vertical transport barrier. They exhibit room-temperature switching ratios of ≈50 and ≈10,000, respectively. Such devices have potential for high-frequency operation and large-scale integration.

EPFL

The patented NPC technology developed the effectiveness of nanoclays as barrier elements to corrosion (oxygen and humidity) and to thermal control. Nanoclay composites are currently generating a great deal of interest due to their potential cost effective advantages in barrier properties. Nanoclays are montmorillonite minerals which have been treated with compatibilizing agents, enabling them to disperse and orientate opportunistically into resins.

Figure 2: Schematic of molybdenum disulfide incorporated into electronic circuit (MIT)
UK-based quantum dots producer Nanoco has signed a 12 month joint development agreement with a global lighting company to incorporate their nanomaterials into LED lighting products.

**P2i SIGNS LED CONTRACT**

UK-based company P2i is launching a product line of LED lights with SavWatt USA, Inc. Incorporating the company’s nanocoatings product to make the LEDs water, dirt, salt and fog resistant.

**ENVIRONMENT WATER FILTERS**

NanoH2O, a US-based start-up developing membranes for water desalination, has raised more than $14.8 million as part of a $30.6 million fundraising effort. The technology has received several industry awards, most recently last month when it won the 2011 Aquatech Innovation Award in the “water supply” category.

**SOLAR START-UP SEEKS FACILITY**

New US-based start-up Camel City Solar is using nanotechnology patented at Wake Forest University to create third-generation solar cells, called FiberCells. The company is seeking to build a manufacturing facility for production of their cells.

**NANOCOATINGS NEW COATINGS FOR MACHINERY**

Russian company Rusal Irkaz, an aluminium smelter based in Irkutsk, has successfully finished testing Nanocomp Metcast, nanocoatings developed by Rusnano’s project company ITN Nanovation AG of Germany. The coatings will be applied to casting machinery to extend the service life of molds and lengthen the intervals for maintenance of casting conveyors. Rusnano acquired a 29.9% stake in ITN Nanovation AG in May 2011.

**US AIR FORCE COATINGS**

Alexium International Group has signed a new Cooperative Research and Development Agreement with the U.S. Air Force Research Laboratory in Florida to continue to develop and commercialise the company’s Reactive Surface Treatment (RST) technology. The technology provides function such as water and oil repellency, anti-microbialism and UV-protection.

**GRAPHENE KNIGHTHOODS FOR GRAPHENE INVENTORS**

Two Nobel laureates involved in the creation of graphene have received knighthoods in the New Year Honours. Professors Andre Geim and Konstantin Novoselov, from the University of Manchester, won the physics Nobel Prize in 2010 for their pioneering research.

**FDA LAWSUIT**

The Food and Drug Administration (FDA) has had a lawsuit filed against it by a coalition of consumer advocacy groups, after it failed to respond to a 2006 calling for labelling of nanotech ingredients in consumer goods. The coalition is led they the International Center for Technology Assessment on behalf of a number of groups who have released negative reports regarding nanotech including Friends of the Earth and the ETC Group.

**PATENTS NANO PATENTS 2011**

US PTO granted 977 nanotech patents in 2011. This is an increase from 780 in 2010, and 532 in 2009, 432 in 2008 and 352 in 2007. The total number nanotech patents now stands at 7,464.
**INVESTMENT**

**DSM INVEST IN NANOCOMPANY**

Dutch company Royal DSM, a multinational life sciences and materials company, has made an investment in NanoHoldings, a company specialising in breakthrough nanotechnology discoveries in the field of energy.

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**RISKS**

**NIH INVESTIGATE HEALTH RISKS**

The National Institute of Environmental Health Sciences has awarded Tomowave Laboratories a small business innovation research (SBIR) phase I grant to evaluate the health risks caused due to nanotechnology applications in medicine and industry. The company will utilize adjustable near-infrared laser pulses to determine nanoparticle characteristics all through the body of the animal by changing absorbed optical energy into ultrasound sources.

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**INVESTMENT**

**NEW NANO BIO-FUELS**

Sriya Innovations, a developer of nanotechnology for refining biofuels, has raised $50 million in venture capital. The company is seeking to produce nano-enabled low cost biofuels and biochemicals using a Nano-Solvo-Thermal Platform technology to convert biomass to bio-crude.

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**ENERGY**

**SMART BATTERY PROTOTYPE**

mPhase Technologies, a nanobattery developer, has refined a prototype for a new automotive and marine product featuring its Smart NanoBattery technology with a European automotive manufacturer. The company will be demonstrating the product in the first quarter of 2012.

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**FUNDING**

Venture capital companies I2BF Global Ventures and VTB Capital have announced a US$100 million nanotechnology venture fund with backing from RusNano and Kazyna Capital Management, the sovereign wealth fund of the Republic of Kazakhstan. The 10-year fund will focus on technology transfer into Russia and Kazakhstan as well as domestic nanotech investment

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**GRAPHENE**

Graphene producer Vorbeck Materials Corp. has announced that it has completed a fully subscribed series 3 financing, raising $10 million. Black Powder, LLC and Fairbridge Venture Partners, LP led the round, which included 15 additional investors. Vorbeck will use the financing to expand sales of Vor-ink™, Vorbeck’s graphene-based conductive ink for printed electronics.

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**MEDICINE**

**NEW PNEUMONIA VACCING UNDER DEVELOPMENT**

Liquidia Technologies is partnering with non-profit organization PATH to develop a new pneumonia vaccine. They are conducting preclinical studies. Liquidia’s proprietary “PRINT” technology can control the size and shape of a nanoparticle, which optimizes the delivery of a therapeutic to the cells of the human body.

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**MEDICINE**

**OBESITY DRUG TO TRIAL**

Arrowhead Research Corporation, a nanomedicine company with development programs in oncology and obesity, has announced that the Investigational New Drug Application (IND) for its first obesity drug candidate, Adipotide™, has been accepted by the U.S. Food and Drug Administration allowing the initiation of a clinical trial to test the safety of the compound.

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**MORE INFORMATION:** www.arrowres.com

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**MEDICINE**

**NANOBIOSCIENCE**

NanoBio Corporation has announced a preclinical collaboration with a subsidiary of Merck & Co., Inc., focused on the development of a vaccine for Respiratory Syncytial Virus (RSV). The studies will evaluate the combination of Merck’s proprietary RSV antigen with NanoBio’s NanoStat® adjuvant technology for use as an intranasal vaccine. As part of the agreement, Merck has the option to negotiate a non-exclusive license to the NanoStat® adjuvant for development of a commercial RSV vaccine.

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**NANOFSURFACES**

Metal Estalki, which produces coatings to improve the performance of industrial tools and components, is developing nanomaterials based products for greater strength, hardness and wear-resistance to industrial tools. The company, which sub-contracts part of its nanomaterials research to the Basque technology corporations IK4 and Tecnalia, uses nanocomposites formed from hard ceramic nanoparticles embedded in a more strongly binding ceramic material.
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ELECTRONICS

NANOELECTRONICS LAWSUIT FILED

NVE Corp., a nanoelectronics company that makes magnetic nanotechnology products for computer memory, has filed a lawsuit charging a competitor with infringing on three of its patents. NVE alleges that Everspin Technologies Inc. of Chandler, Ariz., used three of NVE’s patents to produce Magnetoresistive Random Access Memory products.

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MORE INFORMATION:
www.nanothecmag.com