

Scientific and technological developments sometimes seem remote from the day-to-day life of the European citizen; many people think that the work of white coat clad scientists in labs and universities will never impact upon them. However, scientific developments have a great impact on every aspect of our lives; medical developments have allowed us to lead longer, healthier lives and rapid advances in computer technology has fundamentally altered our communication methods and interaction with others.

### What is nanotechnology?

A nanometre (nm) is one-billionth of a metre. It is difficult to imagine just how small this is so think of a human hair....it has a diameter of 10 000 nanometres! At the nanoscale (around 100 nanometres or less) materials can show marked changes in optical, magnetic, electrical, chemical and physical properties; facts that have been known for some time but are only



recently being exploited. Such properties mean that nanotechnology is a very exciting area and may help to find solutions to medical, social and environmental problems which adversely impact upon the quality of life of the people of Europe. Additionally successful exploitation of nanotechnologies will increase industrial competitiveness and boost the European economy.

### What does the ObservatoryNANO do?

The ObservatoryNANO is a four year project funded by the European Commission (EC) to provide information and analysis of new nanotechnology developments to European policy and decision makers. It is not just the scientific and economic information we provide but the project partners also look at areas such as health & safety concerns, ethical issues, and regulations which will allow for the responsible and successful development of nanotechnologies.

More information on the project can be found at our website; [www.observatory-nano.eu](http://www.observatory-nano.eu)

### What can I find in this report?

The aim of this report is to showcase some exciting highlights from the wide ranging analysis conducted by the ObservatoryNANO over the last year.

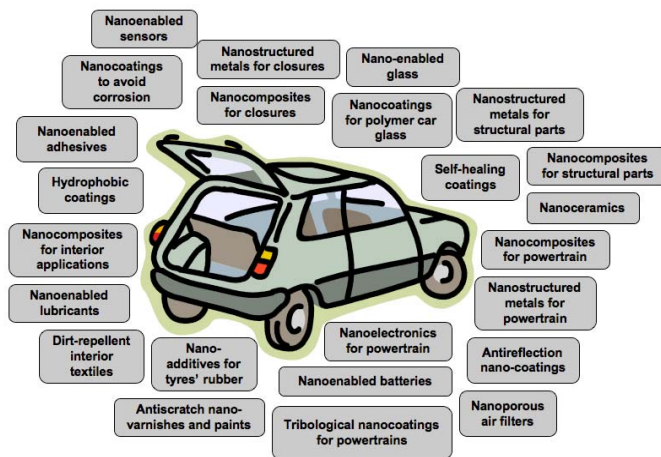
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The ObservatoryNANO project looks at nanotechnology developments in ten application areas: Aerospace, Automotive & Transport; Agrifood; Chemistry & Materials; Construction; Energy; Environment; Health, Medicine & Nanobio; ICT; Security; and Textiles. During the 2nd year of our project we have looked in more detail at a number of 'hot topics' which were seen as having a considerable impact on either European industry/economy or the quality of life of European citizens. These reports are available at [www.observatory-nano.eu](http://www.observatory-nano.eu) but we have selected the most exciting 'highlights' from each sector and these are displayed below.

## Aerospace, Automotive & Transport

Nanotechnologies can be applied to almost every part of a vehicle, as we can see from the cartoon (see right).

Reducing the environmental footprint and improving fuel efficiency will mean cheaper running costs for the consumer and reaching ever stricter guidelines on carbon emissions. Here technologies which reduce the vehicles' overall weight or improve the mechanical properties of materials in the vehicles' powertrains, thus avoiding energy losses, are most important and may be addressed with **nano-coatings** and other **nano-enabled surface treatments**. Increasing passenger safety and comfort is also very important; nanotechnology-enabled surface treatments can also contribute here, increasing visibility and providing dirt-repellent interior textiles, for example.



## Agrifood



Wouldn't it be great if instead of throwing away our food packaging we could eat it?

Food packaging represents a considerable proportion of everyday household waste and 1/6 of the cost of the average household food budget. Not only does it cost the consumer, the ever increasing burden on waste management is putting pressure on our ecosystems. How do we reduce this waste?

Using less packaging is one way of reducing waste; however, there is a global trend towards convenience food and individually packaged items such as sandwiches, fruit etc. Another solution could be to recycle the packaging, but this would require additional costs through energy used.

Nanotechnology is providing critical knowledge on creating biodegradable and edible materials that have the potential to be environmentally friendly whilst being water-tight and strong. The process involves natural polymers, such as sugars and proteins, that are combined with nanoclay and bio-based nanomaterials, such as cellulose nanofibres, to produce **biodegradable** and potentially **edible packaging**.



A recent example of such a development is the production of a material made from pea starch with a cellulose nanofibre filler (made from the pea shell fibres) by Canadian researchers. This nanocomposite material has not only improved the physical properties, but was also found to be highly transparent (most people want to see the food they are buying!). Such bionanocomposites could provide an alternative to usual fossil fuel derived packaging, providing a more sustainable option, help to reduce waste and provide innovative packaging solutions.

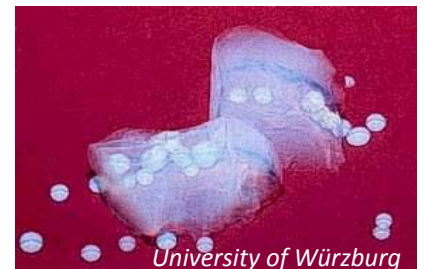
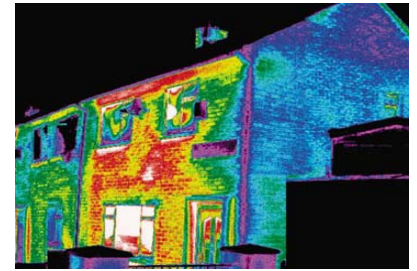
## Chemistry & Materials

Energy efficiency measures such as insulation of existing homes will not only reduce energy consumption, thereby lowering carbon emissions, but will mean warmer homes for European citizens.

Nanomaterials called aerogels offer significantly better insulation than conventional materials such as expanded polystyrene. Aerogels are defined as materials with the lowest density of any known matter; for example silica aerogels are only three times heavier than air!

Besides being a very effective building insulation material, aerogel materials are also suitable for application in windows due to their high transparency (more than 90% of light is transmitted). These windows are not only more energy efficient but are thinner than conventional insulating windows.

There is a very promising market for aerogel materials for insulation applications; in Western Europe the market is estimated in the multi-billion € range. High production costs and the fragility of aerogel materials remain as barriers to their widespread commercialisation; however, increasingly stringent energy efficient legislation for European homes may allow these materials to become more cost effective.



## Construction



The gecko is an amazing creature. Their feet can adhere to almost any surface leaving them free to climb up walls and across ceilings!

In the Construction sector adhesives have a variety of applications such as carpet laying, floor tiling, worktop lamination, and wall coverings amongst others. Indeed in Europe the sector represents the second largest market for adhesives.

Mimicking the 'disbond-on-command' effect seen on gecko feet (where the adhesion effect can be turned on and off) is an area where nanotechnology developments are being investigated; for example, magnetite nanoparticles mixed within the adhesive could enable disbanding at the push of a button. This property would have positive implications for improved recycling of materials allowing for increasing sustainability.

Despite the clear benefits; improved performance, additional functionality, and improved environmental sustainability; of nano-enabled adhesive products factors such as cost-competitiveness, lack of awareness in the construction industry, and risk avoidance concerning health and safety, are hampering uptake. The balance of these drivers and barriers will ultimately dictate the growth of nano-enabled adhesives.

## Energy

Solar power has the potential to provide the world's total energy requirements many times over without contributing to global warming. Solar photovoltaic (PV) technology may be used for multi-gigawatt (GW) solar power farms in sunny climates, at a household level to provide for a single family, or to power consumer electronics.

In addition to these applications there is growing interest in PV being integrated into buildings. For these applications the solar cells should ideally be efficient, durable, lightweight, disposable, and easy to install; it is here that nanotechnology may provide the key.

Silicon is currently the most popular material for solar cells, mainly due to its great abundance. Nano-enabled thin film cells (polycrystalline, polymer, and dye-sensitised) allow for much thinner solar cells with reduced processing costs. However, the reduction in thickness is associated with a decrease in the energy conversion efficiency (ratio of useful power output to power input).

Nano-enabled PV remains an early stage technology but continued innovation together with support from national governments and the EU will allow for a rapid growth in this sector.



## Environment



Maintaining and restoring the quality of air, water and soil is one of the great challenges of our time. Many countries face serious environmental problems such as availability of drinking water, treatment of waste and wastewater, air pollution, and contamination of soil and groundwater.

Conventional remediation technologies have shown only limited effectiveness in reducing levels of pollutants, especially in soil and water. Nanomaterials will be able to perform much more effectively than larger particles because of their much larger surface area; an example is Nano Zero Valent Iron (nZVI). In Europe three full scale remediations and several pilot projects have been carried out successfully using this nanoscale particle. However, the economic and legal constraints in Europe have so far prevented the new technology from wider applications.

Major barriers to the commercialisation of NZVI include the fear of a public backlash, technical challenges such as the material handling and the limited mobility and lifetime of NZVI, as well as the technology is unknown to consultants, governments and site owners. However, the results of the field applications with respect to contaminant reduction are promising and so far no major adverse impacts on the environment have been reported. Therefore NZVI could prove to be a fast and environmentally friendly alternative to other technologies.

## Health, Medicine & Nanobio

The population of Europe is growing older due to improved health-care and longer life expectancies resulting in larger numbers of people being afflicted by age-related conditions such as cardio-vascular disease, musculoskeletal disorders and ulcers.

While there have been great advances in material science and in medical device design related to medical prostheses such as hip, knee and cardiovascular implants, which today often constitute part of the normal treatments for such conditions, such devices often have a finite life within the challenging environment of the body and can give rise to complications during revision surgery to replace them at the end of their working life. In this area **nano-coatings** can improve how well implants, such as the **hip implant** shown in the picture, are accepted by the body thus reducing problems of rejection; these products are expected to be on the market soon.

**Wound healing products** are amongst the most advanced nanotechnological materials in the sector. The rise in cases of diabetes, due to both an ageing and increasingly obese population, is resulting in higher levels of diabetic ulcers; nano-enabled wound healing products will offer decreased healing times and higher healing success rates reducing patient discomfort and reducing healthcare costs.



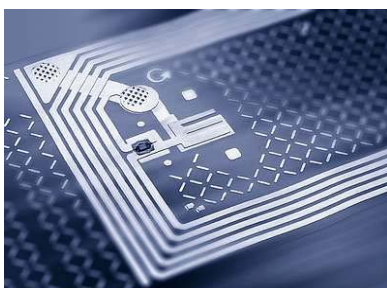
## Information & Communication Technology



Can you imagine a flexible TV display or a computer keyboard that is only a few millimetres thick? Such products will soon be available due to advances in printed electronics.



Printed electronics is the printing of electrically functional inks (not just the normal ink you would use in your printer at home) onto a substrate material such as paper, plastic or silicon thus creating an electrically functional device like a flexible display screen. This allows for simpler, lower cost, and more environmentally friendly fabrication. Other applications include smart labels and RFID tags (used for identification and tracking).



Nanotechnologies can provide advances and improvements in the form of so-called nano inks such as metal or carbon nanotubes inks or by printing at the nanoscale. The use of nanomaterials has allowed for a broader range of applications that printed electronics enables

In the longer term printed electronics is likely to complement conventional silicon electronics technology rather than compete effectively. This is largely due to poorer levels of function and performance. However, application to non-electronic products such as smart labels, decorative and animated posters, and active clothing offers new markets.

## Security

Emergency responders must be protected against threats such as ballistics, knives, fire, and chemical agents. Existing technologies provide such protection but are often cumbersome and uncomfortable. Nano-enabled materials can potentially offer superior qualities over existing technologies. Examples include:

- Prototype protective vests made using nanomaterials (such as carbon nanotubes) with superior ballistic protection but at a fraction of the thickness, and weight, of current materials;
- Quantum Tunnelling Composites offering “smart” functionalities allowing for the illumination of sections of clothing for high visibility purposes;
- Magnesium oxide nanoparticles loaded into nanofibres providing effective detoxification and decontamination of chemical agents;
- Use of nanoparticles in shear thickening and electro-rheological fluids providing advanced ‘liquid’ armours, which can change their rigidity on impact.

Despite considerable progress in utilising nanomaterials and nanotechnologies for security applications there is still some way before their use becomes widespread. However, dual use applications, such as the extreme sports market, is likely to accelerate development in this sector.



www.d3olab.com



www.inteltex.eu

## Textiles



What we wear when taking part in outdoor or sports activities can often impact upon our performance, and for professional athletes can make the difference between winning and losing.

Nano-enabled textiles offer many desirable properties such as; antibacterial function, water repellence, tear resistance, sweat wicking, deodorisation, and UV blocking action amongst others. The largest application of nanotechnologies in textiles is for **water and stain repellent** clothing using coatings of **silica nanoparticles**, **carbon nanotubes**, or **photocatalysts** such as **titanium dioxide** which break down dirt when exposed to light.



The European textile industry is increasingly looking to such ‘added-value’ products in order to compete effectively with low-cost imports from the Far East. The large multinational companies such as Nike and Adidas are very interested but tend to look to smaller, more specialised companies to provide the technological innovations. Therefore small companies can access the global market as long as they are willing to partner one or more of the global players.



There is still some way, however, before nano-enabled products become commonplace as concerns over issues such as durability of functionality under repeated wash and wear, cost effectiveness, and possible negative health effects remain to be addressed.



## Safe and Responsible Development of Nanotechnologies

The drive towards *Responsible Development of Nanotechnology*, emphasized in the EU Nanocode and in the Nano Action Plan, requires investigation into how nanotechnologies are embedded in society, and safe and ethical research and development in nanosciences and nanotechnologies.



A particularly exciting area, emerging from debates across Europe, relates to nanobiotechnology. In the second year of the ObservatoryNANO, a number of application areas have been found to raise specific ethical, legal and societal issues and are the focus of this years' report: namely nanotechnology for health, medicine, biotechnology and agrifood applications.

Human enhancement has been the topic of many nanobioethics debates across the EU on areas as diverse as human enhancement in sports, in healthcare, and in the cosmetic sector with questions being raised on how far they should be regulated and how such technologies will affect the functioning and foundational values in our cultures.

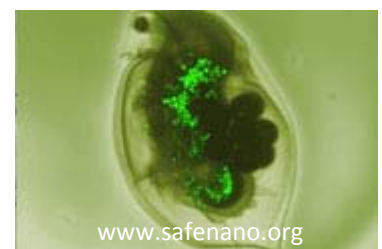
In response, Parliamentary bodies are recognising (and raising) concerns on this issue. For example, what are the implications for the definition and boundaries of notions such as health and disability when human enhancement is a possibility? What sort of social injustices could be involved (those who do/not have access to the technology)? How far in the future is human enhancement? Not at all if we look at cochlear implants or the current advanced in regenerative medicine. Therefore perhaps it would be prudent to consider the potential changes in our healthcare systems, insurance and fundamental values that make up our culture.



### Is Nano Safe?

Over the last year the ObservatoryNANO health & safety expert partners have been looking at each of the ten key technology sectors to determine if any of the developments in these areas are potentially harmful to human health or the environment.

Responsible development of any new materials requires that risks to health and the general environment associated with the development, production, use and disposal of these materials are addressed. This is necessary to protect workers involved in production and use of these materials, the public and the ecosystem. However, it also helps inform the public debate about the development of these new, potentially beneficial, materials.



The ObservatoryNANO looks at the environment, health & safety risk of nanoparticles and nanomaterials at a number of stages through what is called a life-cycle analysis:

1. Risk during the manufacturing or production of the nanomaterials, particularly in terms of occupational exposure;
2. Risk to humans using the resulting product, considering effects of wear and tear;
3. Risk to environment during product use;
4. How the product can be disposed of or recycling and any potential risks to humans or the environment.

## The ObservatoryNANO in the next year....

Starting from June 2010 the ObservatoryNANO will be producing regular 'Briefings' on nanotechnology developments targeted at policy and decision makers within the European Commission and national governments. These are the people who will make the decisions on how much funding is directed towards research and development into nanotechnologies and decide on policies to support companies or industries working in the field.

The Briefings will be very concise, at just 4 pages long, and accessible documents to allow those who are not experts, or even scientists, to clearly understand:

- The scientific importance of the nanotechnology development;
- The economic and societal impacts;
- The technological and economic drivers and barriers;
- Any ethical, legal, societal, or health & safety impacts;
- How the EU performs compared to other world regions such as the US; and
- An insight into future development.

In contrast to previous years of the project the Briefings will be released regularly throughout the year and will respond to relevant developments in technology, policy, and society.

## Where to find more information on Nanotechnology.....

General information on nanotechnology

[www.observatory-nano.eu](http://www.observatory-nano.eu)  
[www.nano.org.uk](http://www.nano.org.uk)  
[www.nanoforum.org](http://www.nanoforum.org)  
[cordis.europa.eu/nanotechnology/](http://cordis.europa.eu/nanotechnology/)

Ethical, Legal & Societal Aspects

[www.nanoyou.eu](http://www.nanoyou.eu)  
[www.timefornano.eu](http://www.timefornano.eu)  
[www.ecsite.eu/?cat=12255](http://www.ecsite.eu/?cat=12255)

Health & Safety of Nanotechnologies

[www.safenano.org](http://www.safenano.org)  
[www.omnt.fr](http://www.omnt.fr)  
[icon.rice.edu/research.cfm](http://icon.rice.edu/research.cfm)