Nanotechnology and Green Buildings

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Tempus

an EU higher education project

Environmental impact of buildings (Percentage of annual impact on US and EU countries evaluation**)**

- energy use - 42%
- atmospheric emissions - 40%
- raw materials use - 30%
- solid waste 25%
- water use 25%
- water effluents 20%

CO_2 reduction

Nanotechnologies are expected to reduce carbon emissions in three main areas:

1) transportation,

2) improved insulation in residential and commercial buildings,

3) generation of renewable photovoltaic energy.

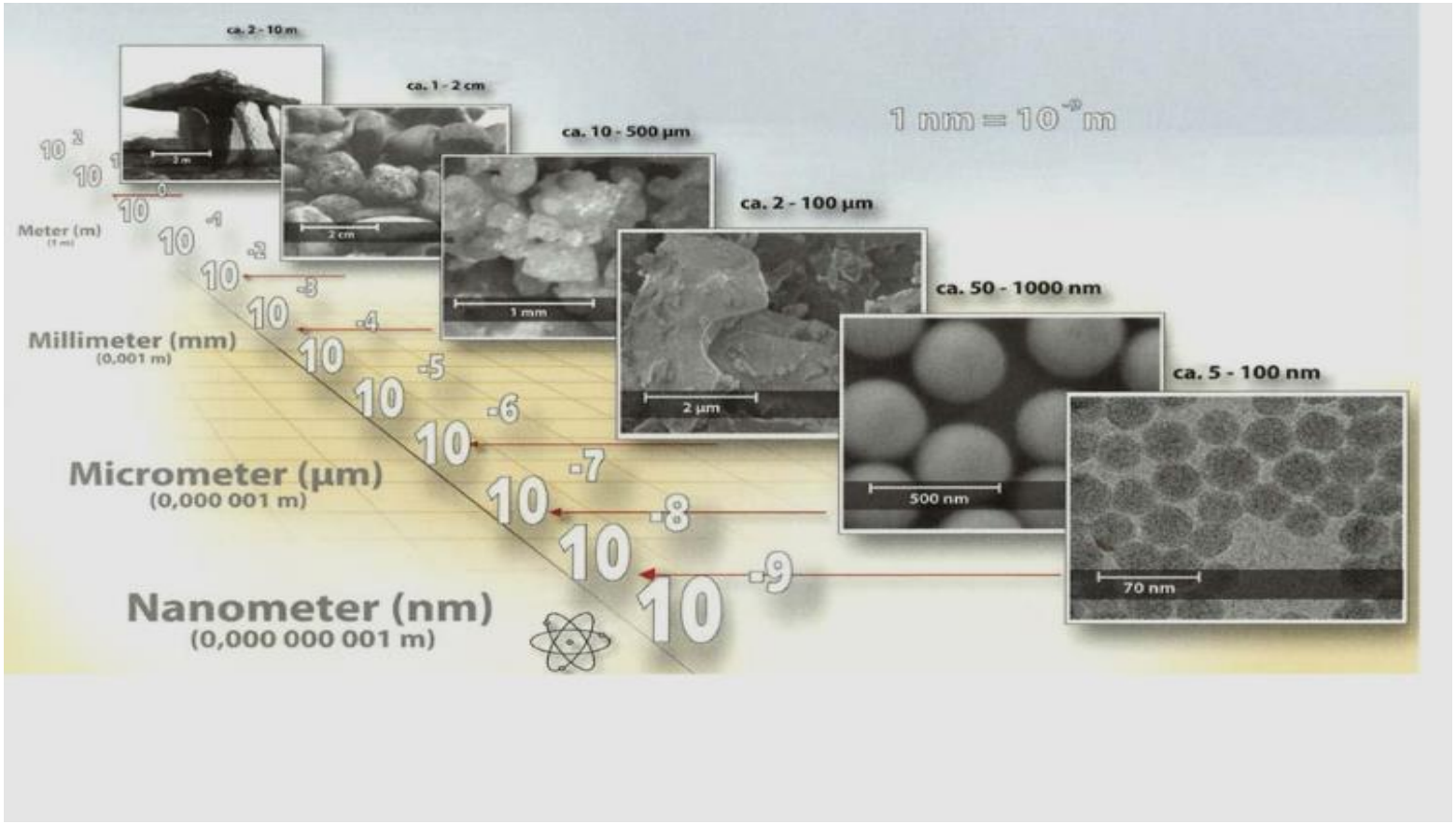
The last two areas are centered in the building industry, suggesting that building could in fact lead the green nano-revolution.

The use of nanotechnologies in construction of buildings according to ecological norms

- Materials
- Energy saving
- Air purification
- Water purification
- Additional advantages
- Future requirements

Materials

- Insulation
- Coatings
- Adhesives
- Lighting
- Solar Energy
- Structural Materials
- Non-structural Materials


ca. 2 - 10 m
ca. 1 - 2 cm
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ca. 2 - 100 µm
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ca. 5 - 100 nm
1 nm = 10⁻⁹ m
Meter (m)
Millimeter (mm)
(0,001 m)
Micrometer (µm)
(0,000 001 m)
Nanometer (nm)
(0,000 000 001 m)
2 cm
1 mm
2 µm
500 nm
70 nm

Aerogels

Aerogel: the world's lightest solid, in which the liquid component has been replaced with gas;

Content: 5 percent solid and 95 percent air;

Architectural applications:

- windows,
- skylights,
- translucent wall panels.

Aerogel in combination with glass

Nanogel panels have highest insulation capability and transparency

Thin-film insulation coatings

Insulation decorative coating

Thin-film insulation

Insulating nanocoatings applied as thin films to glass and fabrics. Thanks to its ability to absorb infrared ray a fiber sheets coated with a nanoscale stainless steel film are able:

- to block out sunlight,
- to lower room temperatures in summer by 2-3º C more than conventional products,
- to reduce electrical expenses for air conditioning.

Self cleaning nanocoatings

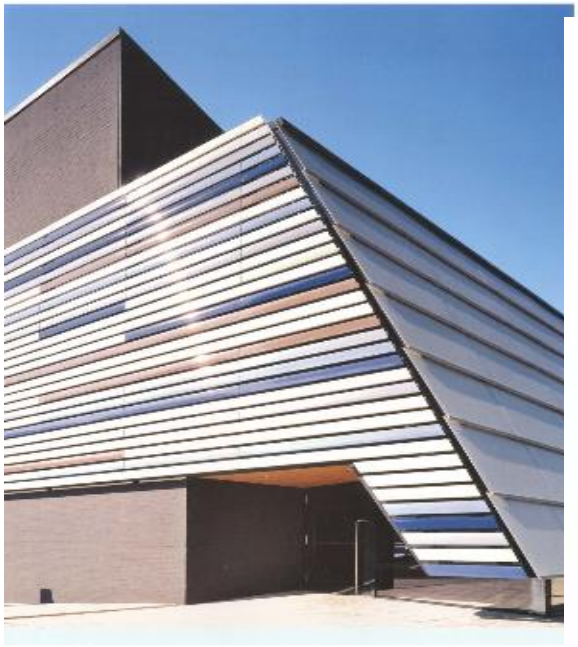
Self cleaning and depolluting nanocoatings offer:

- energy savings by reducing the energy consumed in cleaning building facade;
- reducing the runoff of environmentally hazardous cleansers;
- removing organic and inorganic air pollutants like nitrogen oxide from the air;
- breaking them down into relatively harmless elements
- cleansing indoor air and reducing instances of sick building syndrome (SBS). The World Health Organization estimates that up to 30 percent of new or renovated energy-efficient buildings may suffer from SBS.

In the past, a combination of insulation and fungicidal silicon resin-based paint was used to protect mould formation, however it lasted only two years.

Antibacterial façade paints manufactured on the basis of nanotechnology are used in new buildings in Germany

The use of photo-catalytic self cleaning glass in modern buildings



Muhammad Ali Center (MAC)
in Louisville, Kentucky, USA

Photo-catalytic self-cleaning outdoor coatings have been used in building of a private residence in Osaka, Japan

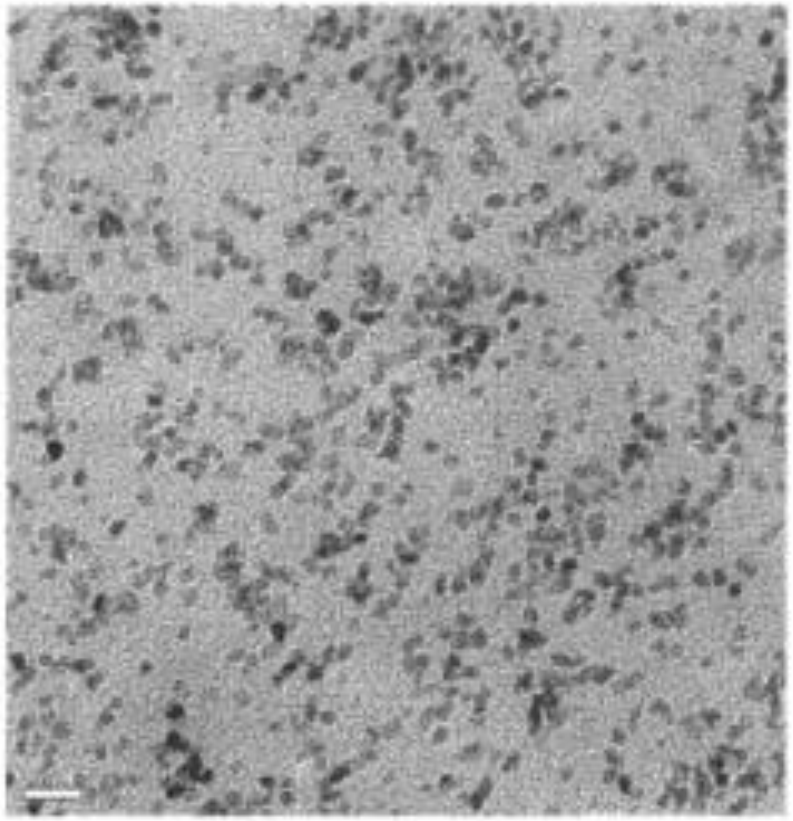
Energy efficient nano materials

The use temperature regulating decorative materials in inside walls reduces energy consumption

Modern and classicism

UV light resistant materials

Electron microscope image of UV-absorbent zinc oxide particles



The use of UV resistant nano materials in play ground of the Japanese National Park

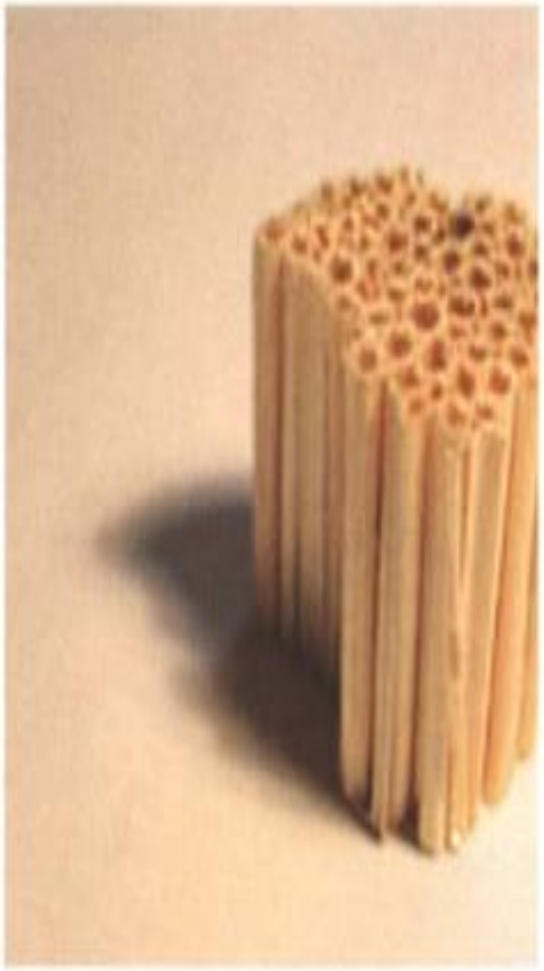
Antimicrobial coatings

- Some ingredients in antimicrobial products pose both environmental hazards and indoor air quality concerns.
- Antimicrobial nanocoatings offer the benefits of conventional antimicrobial products without these environmental and health concerns.
- Nanocoatings with a combination of antimicrobial and heat deflective properties has low thermal conductivity and the ability to reflect up to 90 percent of the sun’s rays reduce heat absorption in coated walls, thereby reducing air conditioning and energy consumption.
- Carbon nanotubes can kill E. coli bacteria (about 80 percent of these bacteria were killed after one hour of exposure).

The use of antimicrobial nano coatings in patient's hospital room

Nano coated materials are used in operation rooms of modern hospitals

Fire-proof materials



Fire safety glass has been used in the landmark 160 m high office tower in Bonn, the former capital city of Germany on the River Rhine

Photo-catalysis based on nano-catalysts is a very promising method for the treatment of contaminated air and water.

The principle of photo-catalysis: a catalyst harnesses the (UV-) radiation from sunlight and uses the energy to break down different substances.

Due to this universal applicability, photo-catalysis with nano-particles as catalysts is used to reduce air pollution, in building materials for self-cleaning surfaces.

Application of photo-caalysis for removing air pollutants including:

- organic materials,
- organic acids,
- pesticides,
- VOCs,
- microbes (including viruses and chlorine resistant organisms),
- inorganic molecules such as nitrous oxides (NOx) and other gases,
- heavy metals such as mercury (Hg)

Air-purifying materials

Some nano materials used for purification of air has anti-bacterial properties

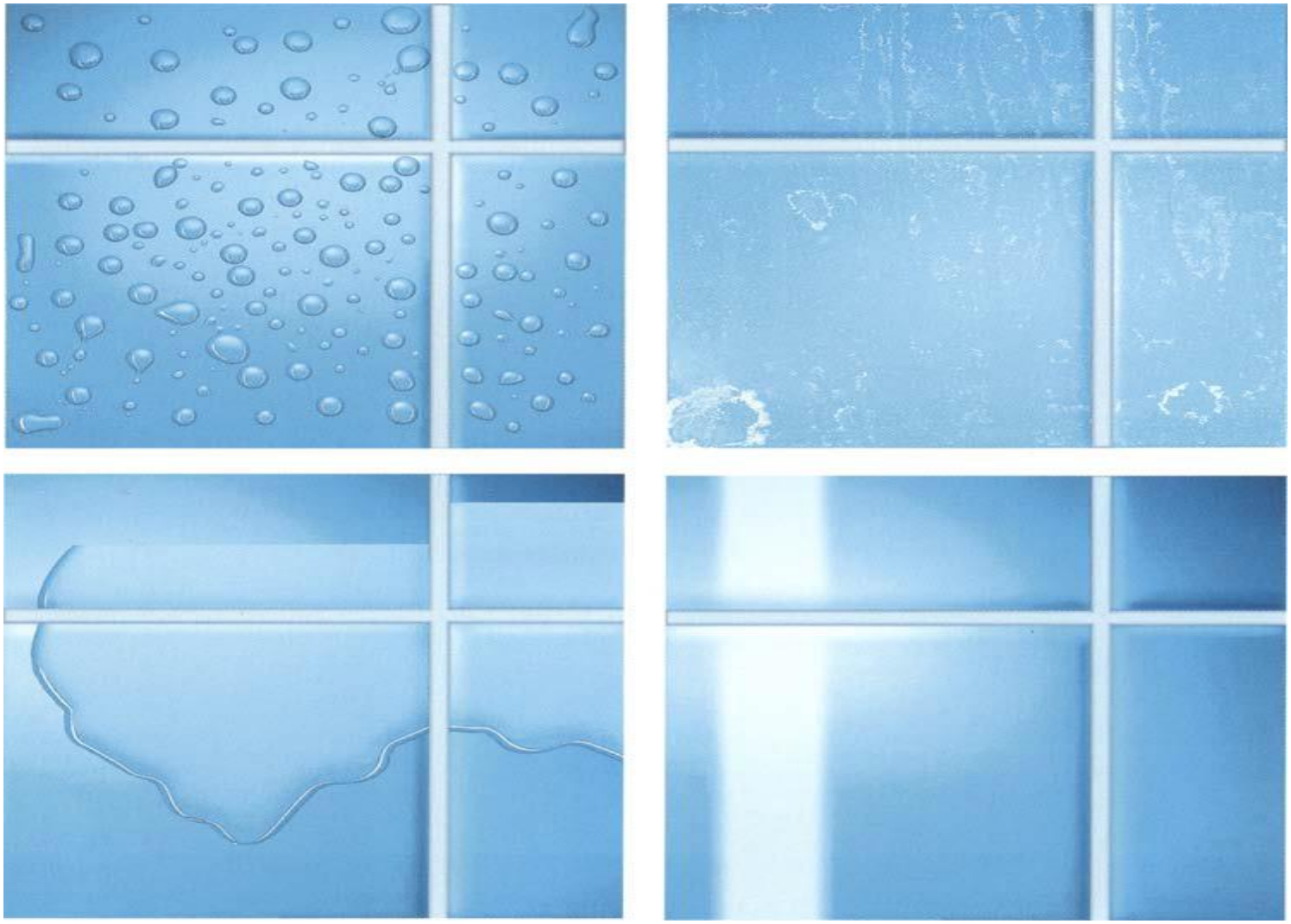
Air-purifying nano material is used in a villa-studio with 62 sq. meter area in Japan

There are several potential photo-catalysts, but the most promising and widespread substance is nano titanium dioxide (nano-TiO_2).

Its preferred features are:

- chemical stability,
- high ability to break molecular bonds leading to degradation,
- abundance,
- inexpensiveness.

UV irradiation from sunlight or artificial light is needed to activate TiO2.



Nano-sized TiO_2 is an active catalyst that promote decomposition of organic compounds from construction materials

Water purification

Nanotechnology is opening new doors to water decontamination, purification and desalinization.

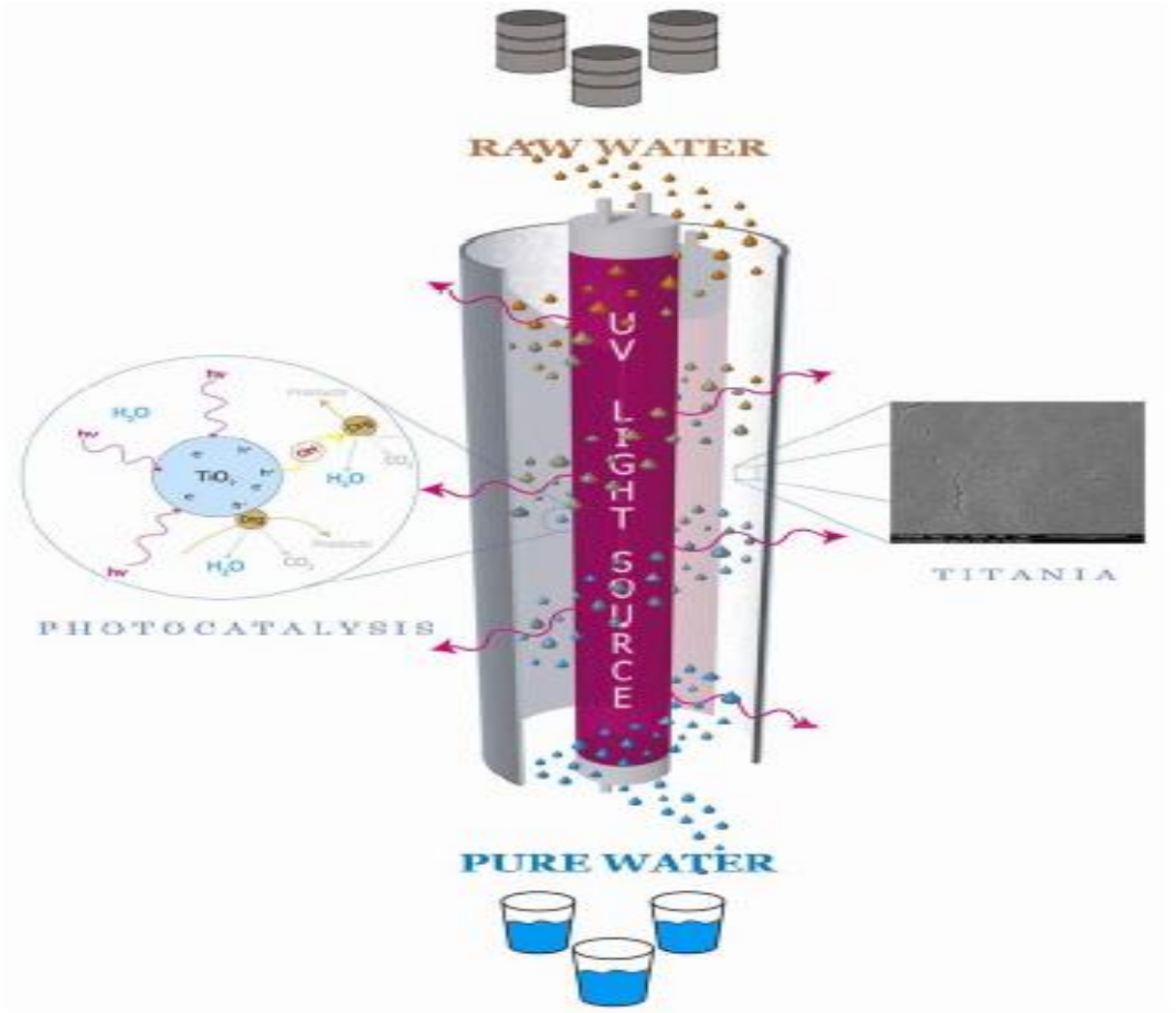
There are two different types of photocatalytic applications in water treatment:

- solar photocatalysis,
- photocatalytic systems equipped with artificial ultraviolet (UV)-light.

Solar photocatalysis technology is inexpensive, environmentally friendly and universally applicable.

Photocatalytic systems with artificial UV-sources can be used:

- New water treatment plants or plants where conventional methods need to be replaced,
- For the treatment of water contaminated with trace contaminants (e.g. estrogens),
- For the treatment of wastewater contaminated with high loads of organic compounds or metals,
- Small scale systems (e.g. for swimming pool disinfection).



A scheme of waste water purification through photocatalysis

Anti-corrosion coatings

For protecting metal surfaces from corrosion, chrome plating is becoming an increasing concern because of the negative health and environmental effects of chromium. Corrosion can be reduced by coating materials with chemically resistant nanofilms such as :

- homogeneous thin films using alkoxides with chemically attached ceramic nanoparticles;
- organic metals that are free from heavy metals to replace lead compounds, chromate treatments and chromate, and the zinc-rich coatings;
- organic metal nanofinishes, technology that can be applied to architectural metals, consumes less than 10 percent of the energy compared to other metallic finishes, and promises to save more than 90 percent of raw materials.

Renovations have been made in Japanese Narita airport (Tokyo) by using nano materials

Structural materials

- Concrete
- Steel
- Wood
- New structural materials

Concrete

Nanotechnology is leading to new:

- cements;
- concretes;
- admixtures (concrete performance-enhancing additives);
- low energy cements;
- nanocomposites, and improved particle packing.

Nanoparticles, can improve concrete’s durability through physical and chemical interactions such as pore filling.

TiO_2 and photocatalytic self-cleaning additive that used in construction of a modern church in Italy (Roma) enabled the architect to achieve his trademark white colouring in an urban environment polluted by car exhaust gases and volatile organic compounds.

Thank you for your attention