

Modern construction materials & environment quality of buildings

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ABSTRACT

Water, wind, light and mechanical effects do not only play a role in complex engineered construction systems, but can also be basis for the development of construction products itself. Two examples will show how phenomenums found in nature have been translated into technical applications for coatings.

Recent decades have been a very interesting and challenging period for the construction market. The use of High-Tech production facilities and powerful computer systems, significant developments in the chemical industry including production of new materials with amazing abilities, and the speed with which information can be distributed throughout the globe, have changed the pace in the development and implementation of new systems, methods and materials. The most important issues discussed concerning a better behavior of buildings, have to be the improvement of energy performance and the assurance of indoor air quality using emissions free or even active- functional materials. Important recent developments in this area can be summarized in the use of improved thermal insulation systems and materials, the use of active transparent insulation materials which can contribute energy gains during the cold period of the year, new totally emissions free coatings and active coatings that will contribute to the overall improvement of the air quality in buildings. The scientific and construction community nowadays have a new task, to implement recent environmental and user friendly solutions in the building sector, undo the consequences of the mistakes of the past and contribute to a safer future for the planet and its inhabitants (Elfors, 2006).

1. INTRODUCTION

Products used in construction contain many organic and inorganic substances which may be released into the air inside buildings, or into the soil and groundwater, through abrasion, degassing, leaching or corrosion, and so pose a danger to the environment and human health. Adequate toxicological assessments are often lacking for components such as solvents in paints and adhesives; biocides, plasticisers, binding agents and flame retardants in floorings, plastics and wood-based panels; additives in mineral construction materials; heavy metals in water piping and roofing materials; or undesirable admixtures used in recycling processes. Therefore, properties such as bioaccumulation or persistency cannot be ruled out; nor can the possibility of carcinogenic, mutagenic, or teratogenic effects, or toxic, sensitizing, irritating or ecotoxic effects.

So far, there is no data available to allow an overview of the quality and quantity of releases of dangerous substances from building materials into the environment. Here are two examples for products which are used frequently and on a large scale, and which may therefore represent significant emissions sources, to illustrate the extent of the flow of critical substances. According to figures quoted by industry, around 2,000 million m² of flooring is produced in Europe each year. In Germany alone the yearly production of particle boards reaches about 500 million m². Both flooring and particle boards are installed mainly indoors; the various volatile auxiliary products used in their production are therefore in the first instance emitted into the indoor air. In the production of traditionally pure mineral construction materials such as tile

adhesives, plasters, mortars and screeds, the use of admixtures of organic additives to improve their workability is also on the rise. So, there is a great need for products that are environment friendly and improve indoor air.

Sustainable building

The concept of sustainable building incorporates and integrates a variety of strategies during the design, construction and operation of building projects. The use of green building materials and products represents one important strategy in the design of a building.

Green building materials offer specific benefits to the building owner and building occupants:

- Reduced maintenance/replacement costs over the life of the building.
- Energy conservation.
- Improved occupant health and productivity.
- Lower costs associated with changing space configurations.
- Greater, long lasting design flexibility.

Building and construction activities worldwide consume 3 billion tons of raw materials each year or 40 percent of total global use (Roodman and Lensen, 1995). Using green building materials and products promotes conservation of dwindling nonrenewable resources internationally. In addition, integrating green building materials into building projects can help reduce the environmental impacts associated with the extraction, transport, processing, fabrication, installation, reuse, recycling, and disposal of these building industry source materials (Built Environment Analysis, 2006).

On the other hand, Indoor Air Quality (IAQ) is enhanced by utilizing materials that meet the following criteria:

- Low or non-toxic: Materials that emit few or no carcinogens, reproductive toxicants, or irritants as demonstrated by the manufacturer through appropriate testing.
- Minimal chemical emissions: Products that have minimal emissions of Volatile Organic Compounds (VOCs). Products that also maximize resource and energy efficiency while reducing chemical emissions.
- Low-VOC assembly: Materials installed with minimal VOC-producing compounds, or no-

VOC mechanical attachment methods and minimal hazards.

- Moisture resistant: Products and systems that resist moisture or inhibit the growth of biological contaminants in buildings.
- Healthfully maintained: Materials, components, and systems that require only simple, non-toxic, or low-VOC methods of cleaning.
- Systems or equipment: Products that promote healthy IAQ by identifying indoor air pollutants or enhancing the air quality.

Energy Efficiency can be maximized by utilizing materials and systems that meet the following criteria:

- Materials, components, and systems that help reduce energy consumption in buildings and facilities.

Water Conservation can be obtained by utilizing materials and systems that meet the following criteria:

- Products and systems that help reduce water consumption in buildings and conserve water in landscaped areas.

Affordability can be considered when building product life-cycle costs are comparable to conventional materials or as a whole, are within a project-defined percentage of the overall budget.

2. FAÇADE PAINTS WITH LOTUS EFFECT

2.1 Introduction

The microrelief of plant surfaces, mainly caused by epicuticular wax crystalloids, serves different purposes and often causes effective water repellency. Furthermore, the adhesion of contaminating particles is reduced. Based on experimental data carried out on microscopically smooth (*Fagus sylvatica* L., *Gnetum gnemon* L., *Heliconia densiflora* Verlot, *Magnolia grandiflora* L.) and rough water repellent plants (*Brassica oleracea* L., *Colocasia esculenta* (L.) Schott., *Mutisia decurrens* Cav., *Nelumbo nucifera* Gaertn.), it is shown here for the first time that the interdependence between surface roughness, reduced particle adhesion and water repellency is the keystone in the self-cleaning mechanism of many biological surfaces. The plants were artificially contaminated with various particles

and subsequently subjected to artificial rinsing by sprinkler or fog generator. In the case of water repellent leaves, the particles were removed completely by water droplets that rolled off the surfaces independent of their chemical nature or size. The leaves of *N. nucifera* afford an impressive demonstration of this effect, which is, therefore, called the "Lotus-Effect" and which may be of great biological and technological importance. More research on the Lotus flower which is revered as a symbol of purity in Asian religions have shown that when emerging from muddy waters it unfolds its leaves unblemished and untouched by pollution. This phenomenon of self-cleaning has been thoroughly researched and gives us a fascinating glimpse of what nature can do to protect itself from omnipresent dirt and pathogenic organisms. By applying this property to technical surfaces almost every material in the open air can be cleansed by rain (Barthlott and Neinhuis).

2.2. Technically manufactured Lotus Effect

Since the Lotus-effect® is solely based physico-chemically and is not bound to a living system, a self-cleaning surface can be technically manufactured. The materials for such new coatings are available. Until today, however, the contradictory demand for rough surfaces as a basis for clean surfaces was ignored. Still scientific investigation and industry have made intensive efforts to develop dirt-repellent or self cleaning surfaces. Some materials allow the production of coatings with hydrophobic and oleophobic properties. They are thus neither wettable nor can they get oil-slicked, and can be called ultra-phobic. Possible fields for application are facade paints, roof tiles, textiles and the rich field of coatings. If application is successfully managed, the Lotus-effect surely is one of the most impressive examples of biomimicry of the last years (Fresnais et al., 1918; Wood, 2005).

2.3 Lotus effect applied on Paints and renders

The problem with conventional facade paints is that over time, dirt accumulates and becomes visible on the outside of buildings. Facades particularly exposed to the prevailing weather also collect a build-up of micro-organisms (algae, bacteria, fungus) which flourish in damp and dirty conditions (Barthlott and Neinhuis).

After well targeted research and applied bi-

onics, Lotus effect has been applied on façade paint and render, named Lotusan. StoLotusan Color offers a superior technology. When it rains, water droplets cannot maintain surface contact and pearl off, keeping the façade clean and dry – even on buildings exposed to the harshest weather. Having a closer look to the microstructure of Lotus leaves with the help of SEM (Figs. 1, 2), it reveals the form and the shape of the leaf that explains the incredible water repellency and the reduced particle adhesion of Lotus leaves (Fig. 3). Applied bionics have created a silicate paint and render, which after being applied on the façade and hardened will have quit the same microstructure, as seen in Figure 4, where one can see rough particles as substrate for micro particles < 1 µm, which sit on top and in between the structures

Figure 5 has been taken with a nanoscope showing the fine structure that reduces the contact surface area water and dirt can cling to. Raindrops simply run off as a result of the extremely super-hydrophobic surface, taking dirt particles with them. At Figure 6 on the magnifi-

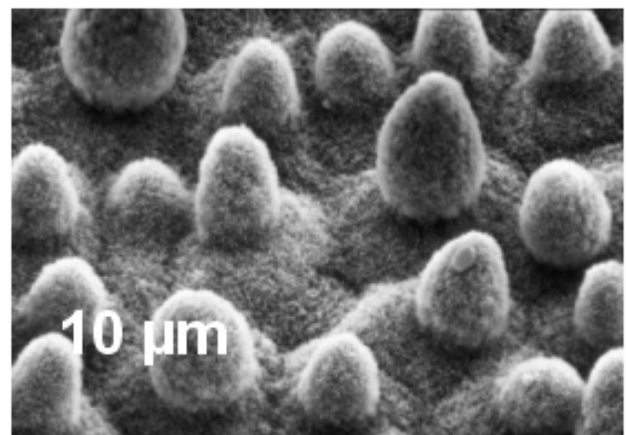


Figure 1: Lotus leaf microstructure, 10µm.

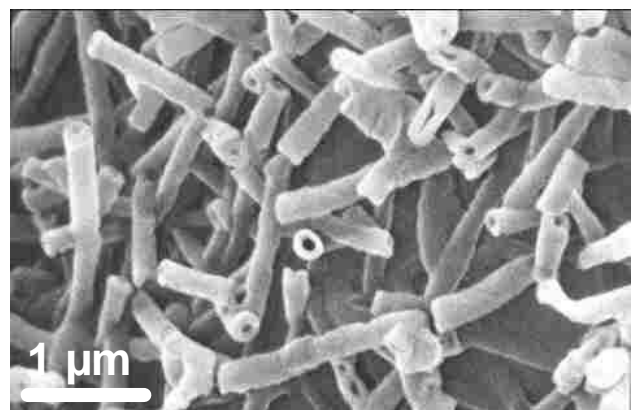


Figure 2: Lotus leaf microstructure (1µm).

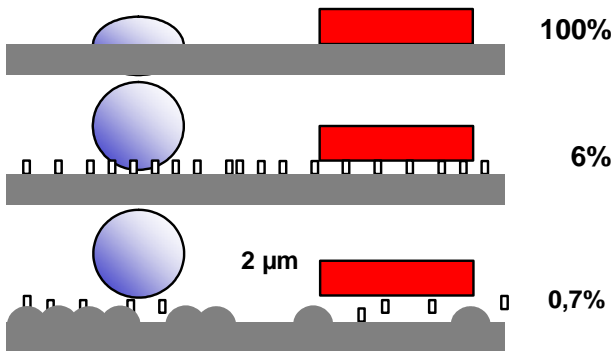


Figure 3: Dirt Particle and Surface: Minimized Contact Area.

ation you can see a similar microstructure in StoLotusan Color. The surface is super-hydrophobic, so rain will immediately run off walls coated with it, carrying dirt particles with it. The effectiveness of the lotus effect ® has been tested and confirmed by:

- Test report P 1977-1 written by the Polymer Institute in Flörsheim.
- Report REB-5/1999 from the Fraunhofer-Institut für Bauphysik, Holzkirchen.
- Test report P2371-1 of the Polymer Institute in Flörsheim.
- Research report Nr. AT 008/00 of the Research institute for pigments and paints e.V. Stuttgart.
- Approval SERVIC BACT, Rodgau, 03/2002.

3. PHOTOCATALYTICAL INTERIOR PAINT

Another excellent example for indoor paint this time, has been StoColor Climasan: a photocatalytic interior paint, to help improve indoor air quality and help to reduce the sick building syndrome. StoClimasan Color incorporates special pigments (VLC - Visible Light Catalysts) which become active under the influence of visible light and set to work breaking down harmful organic substances and odour substances into small, harmless constituents. This process continues as long as sufficient light is available (Kisch).

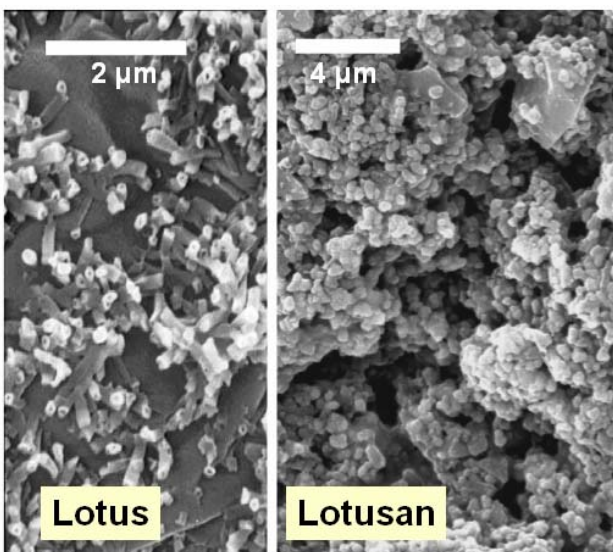


Figure 4: Applied Bionics: Comparable but Not Identical Microstructures.

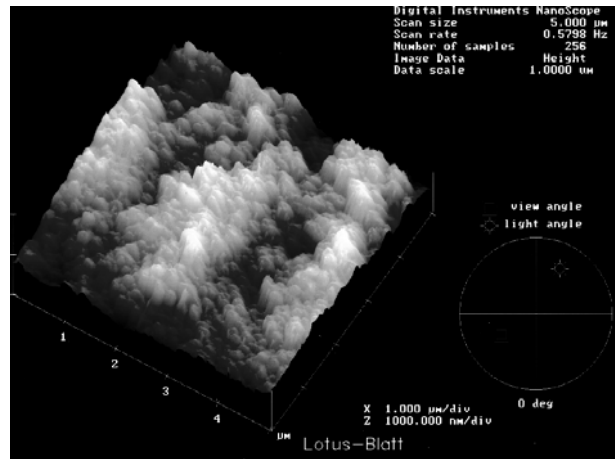


Figure 5: The microstructure of a lotus leaf 7000x magnification.

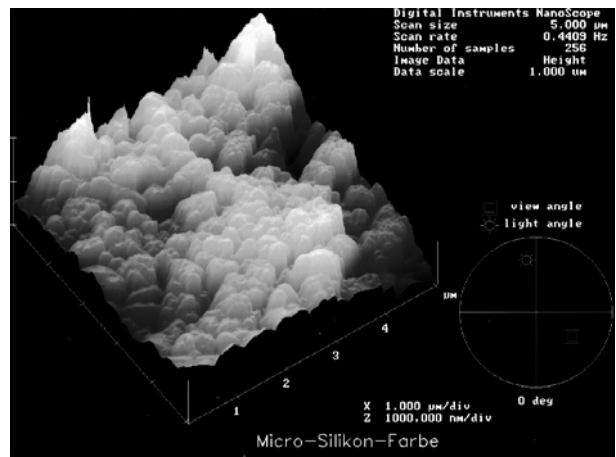


Figure 6: Successful transfer of lotus effect into Lotusan paint.

As it is well known photocatalysis is a catalytic process which is triggered by light. The term catalysis refers to the acceleration of a chemical conversion process by a substance (catalyst) which is not consumed itself. In photocatalysis, the desired effect only ensues after the actual catalyst has been excited by light (sun, lamps). A photocatalyst is thus inactive in the dark.

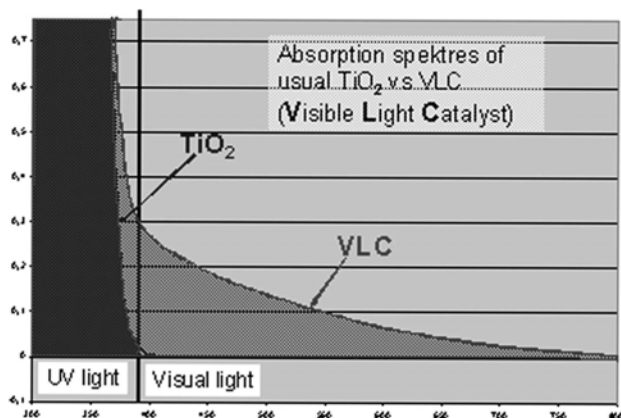


Figure 7: Activity range of VLC.

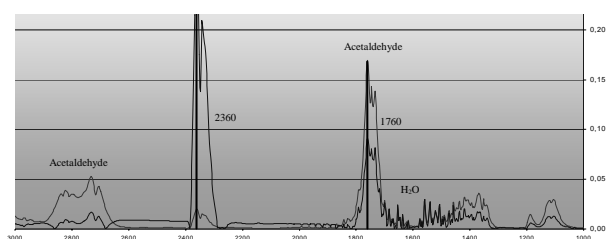


Figure 8: Activity range of VLC.

The performance profile of StoClimasan Color:

It is tested to be free of solvents and plasticizers, it is free of fogging-active substances, it's wet abrasion class is 2 according to DIN EN 13 300. StoClimasan Color is a paint with high covering power and can be used as one-coat paint

The most important thing is that StoClimasan Color is different to all other photocatalytical paints available so far, because it does not need any UV light for decomposition of odours or VOC (Volatile Organic Components).

In the test reports it is mentioned that StoClimasan Color itself does not emit any VOC which are detectable after application and that a mix of defined VOC injected to the testing device shows a reduction in concentration of 80% after already 200 h (Fig. 8). It is also proved that it is efficient against cooking oil odour, significant reduction of smells and has been proved efficient against tobacco smoke odour (Technologie & Innovation).

The effect of StoClimasan Color on indoor environment:

- Capture and degradation of harmful substances.
- No deposit of pollutants.
- Removal of odours.
- Cleaning effect of discoloration.

- Clean paint formulation.

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