Publishable executive summary

SELF-CLEANING GLASS - Contract no NMP3-CT-2003-505952

Nano-structured self-cleaning coated glasses : Modeling and laboratory tests for fundamental knowledge on thin film coatings, EC normalisation and customer benefits

Project context

Superhydrophobic or hydrophobic coatings have been used in the recent years for several applications, such as easy-to-clean surfaces. Since 2001, hydrophilic and photocatalytic self-cleaning glazing have been available in the European market. These latter products are based on the photocatalytic property of a thin layer of TiO_2 deposited at the surface of the glass. When exposed to UVA radiation, TiO_2 reacts with the oxygen and water molecules present in the atmosphere to produce free radicals leading to oxidative species. These species are able to degrade organic material causing stains adsorbed on the surface into volatile molecules. Both technologies cover products designated by the general term of "self-cleaning".

At the moment, the self-cleaning glazing is only tested according to existing appropriate national or international standards to qualify optical and energetic properties. In building applications, for example, these new coated glasses must pass the EN-1096 standard. However, there are no standards to evaluate the self-cleaning performances of these products.

In order to define appropriate tests for the self-cleaning properties of nano-structured surfaces, the project is based on two main objectives. Firstly, it is necessary to acquire a thorough understanding of the real soiling mechanisms of commercial self-cleaning glasses compared to standard float glass. So, the first part will consist of field tests at well-monitored sites. Extensive experimental studies are planned in different polluted atmospheres. Secondly, the definition of standard test methods for the self-cleaning properties, highlighting the benefits for customers will be developed. This second part will consist of the setting-up of the parameters based on:

- Laboratory tests relevant for the characterization of the surface properties of self-cleaning glasses
- Laboratory tests representative of the behavior of self-cleaning glasses compared to standard float glass in a real atmospheric environment and based on the results of the first part

Potential impact

Europe is a major glass market representing 45% of the worldwide market. The European glass sector employs around 300 000 people. In the year 2001, the European window market reached a volume of 75,997 Million window units, representing a sales volume of 17,698 Million Euros. The building glass market represents 75% of the total glass market.

At the moment, the share of self-cleaning glasses is not significant as it represents around 0.2% of the total glass market in Europe. However, the forecasts show the emergence of this market. Therefore, it remains essential for European companies to be innovative in order to face the US and Japanese competition.

Innovative outputs

Investigation of the TiO_2 photocatalytic activity:

- Quantification of the degradation and removal of real contaminants on self-cleaning coatings by field experiments
- Link between outdoor performance of self-cleaning coatings and results of accelerated laboratory tests: Proposal for standard methods
- Time-dependent measurements of decomposition reactions

The studies will also provide an understanding of the chemical and physical interaction between the glazing sealants and self-cleaning glasses during their lifetime.

Scientific and Technical objectives

- To provide scientific knowledge on behavior of standard and self-cleaning glass in urban polluted atmosphere
- To provide fundamental knowledge on mechanisms and modeling of self-cleaning glass functionality
- To provide soiling methods measurements, elements and data, essential for the setting-up of a new standardisation for self-cleaning glass
- To develop a European standard for self-cleaning glass
- To avoid non-appropriate standardization imposed on glass products coming from other substrate types or applications
- To gain fundamental knowledge for future generation developments of self-cleaning products

Work performed and results achieved, intentions for use and impact

Since the project start, samples of different type of glasses have been exposed in Paris test site for soiling mechanism analysis. Preliminary results of WP1 are indicating some differences between photocatalytic self-cleaning glasses and reference glasses.

Correlation between soiling, atmospheric pollution, and glass surface caracterization are already showing some trends. About the self-cleaning properties of photocatalytic glazing: a self-cleaning action is detected in urban and polluted atmosphere, specifically in the POM degradation in sheltered and unsheltered conditions. Hydrophobic and standard glass behave in the similar way.

Samples of glasses have also been exposed in the frame of WP2 in 4 different sites to study the impact of glass processing (annealed, tempered, laminated, silicone joints…), and weathering conditions. Their soling study is going on using methods defined in WP4.

Fig. 1: Racks of unsheltered glass samples on the test site in Paris, France.

WP3 is looking at the chemical reactions at the nanoscale level through macroscopic systems synthesized in the laboratory for which factors governing the photocatalytic effect are taken into account. The influence of different

experimental parameters on photocatalytic efficiency of the self-cleaning glass has been investigated and identified (ie temperature, humidity…) on self-cleaning properties.

WP4 has developped a procedure for a visual quality ranking of product in relation with physical measurements such as haze measurement The test method simulating real conditions has been established : it is showing promising results allowing to descriminate self cleaning glass from standard glass and it is further optimised. In parallel, a flow chart describing a strategy to standardisation has been submitted in the frame of WP6.

Fig. 2: Unsheltered exposition racks in the UK test site.

Fig. 3: Panel evaluation in transmission.

The work done by all the partners of the workpackages has either confirmed or taken shape from the 30-month experiments and observations. At this stage, the consortium is up to propose a project of standardization for self-cleaning glasses. Both the understanding at a fundamental level and real conditions of the pollution of glass, and the mechanism of photodegradation of these pollutants or model pollutants have allowed the development of a laboratory test that is to be proposed to certifications (ISO and CEN).

Principle of the test procedure:
A soiling solution is sprayed on a self-cleaning glass and haze measurement is taken. After UV-A illumination and water sprayed on the surface, another haze measurement is recorded. Then a second soiling cycle is carried out. The criteria for self-cleaning evaluation is given by the % : Hd-Hf/Hd-Ho (i)
(i) Hd = haze after drying of the soiling solution on glass,
Ho = initial haze
Hf = haze that has been measured after the second cycle of soiling.
When the percentage of cleaning is >85%, the sample is said “self-cleaning”.

During the last year of the project, in addition to the proposition of a standardized test to certification committees, the another expected goal is the wide publication of the work done in the project in high-level scientific journals and conferences.

Expected end results, intentions for use and impact

The expected results at the projet end are the knowledge gained on soiling and self cleaning mechanisms, the definition of tests caracterising the soiling phenomena and parameters influencing them. A test proposed for a standard is the end result of this work. The work already performed conducted to some publications. It will be further disseminated by publications and other dissemination means.

Consortium

The Self-Cleaning Glass consortium is multi-national with 11 partners from 5 EU member states. There is a core of three industrial partners, seven research units and a consultancy company.

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