"Novel Self-cleaning, anti-bacterial coatings, preventing disease transmission on everyday touched surfaces"

Project summary

SELFCLEAN is a successful 2 years project within the EU Seventh Research Frame Programme (FP7) in the area of Research for the benefit of SMEs. 9 partners from 5 different countries engaged in the development of new self-cleaning-antibacterial coatings of high aesthetics and durability by applying electroplating technology, targeting to meet the important need of public hygiene in common touched surfaces as knobs and handles.

Currently, hygiene/antimicrobial issues in public places (hospitals, schools, restaurants, public transportation etc) are of crucial importance as inattention could lead to spread of viral diseases or epidemics and consequently to deaths. A typical example is that of hospital acquired infections (HAI). According to The European Centre for Disease Prevention and Control (ECDC) in the EU, about 3,000,000 are infected annually with HAI and about 25,000 patients die from this. The SMEs of the consortium having identified this Need and a NEW Market for their products proposed the solution of self-cleaning, antibacterial electrolytic (metallic) coatings of Sn-Ni matrix with doped TiO_2 nanoparticles as a reinforcing mean.

The SelfClean project in just 24 months produced successfully novel self cleaning – antibacterial coatings of high aesthetics and durability based on the photocatalytic properties of "SelfClean doped" TiO_2 nano-particles, immobilized in Sn-Ni matrix that are able to operate under indoor light in addition to UV-light. The immobilazation (incorporation) of these doped-TiO_2 nanoparticles in the Sn-Ni matrix -typically exhibiting high esthetics coatings- results to **Unique** self-cleaning and antibacterial properties of the alloy coatings.These type of composite coatings have been applied to common touched objects and handles in Metropolitan Hospital, via the process of electroplating and reduced the risk of getting infected by communicable diseases.

The SelfClean composite coatings present the following truly advanced elements for the SME partners:

- World's first metal matrix composite coating reinforced by TiO_2 nanoparticles operating as a self cleaning – antibacterial coating under indoor light irradiation with enhanced mechanical and anti-corrosion properties applied in common touched objects.
- Doped TiO2 nanoparticles with band gap less than 2.3 eV, able to be activated by indoor light irradiation, via a process easily up scalable by NADICO.

- Optimized Pulse current electroplating process enabling high codeposition rate of doped TiO_2 nanoparticles and rather uniform distribution in the tin-nickel matrix, easily adaptable by ELPLATEK succeeding to reduce consumption of raw materials, energy and time.

SelfClean Project Gave the participating EU SMEs long term competitive advantage in novel "self cleaning – antibacterial coatings" manufacture enabling a technological leap towards indoor usages.

Description of the work performed and Final Results

The main scope of SelfClean project was to overturn the current downward trend in European electroplating and nanotechnology industry by offering in the market innovative "self cleaning – antibacterial coatings" that will meet the important social need of public hygiene and will allow sales growth rate for the participating SMEs.

In order to successively produce the metal articles which combine the self-cleaning and the antibacterial actions, knowledge from different scientific and technological fields was combined during the last 24 months: chemical companies, metal articles manufacturers, plating industry as well as a Hospital, where the optimized project's products were applied and tested under real environment conditions . Figure 1 depicts the concept of SelfClean project.

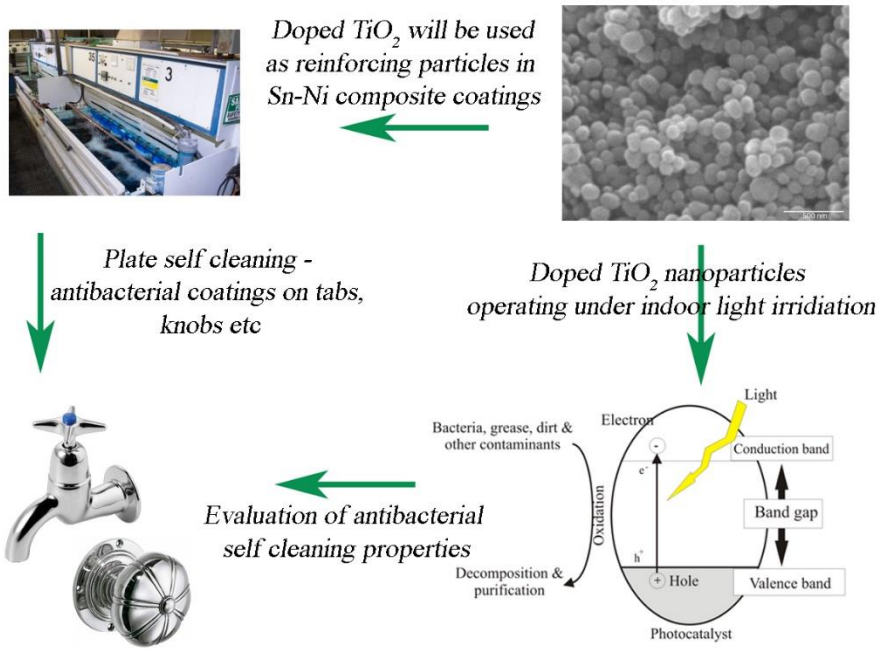

Figure 1. Overall concept of SelfClean.

Technical problems that required the RTD's input are listed below:

- The chemical modification (**doping**) of TiO_2 nanoparticles in order to achieve lower band gap and thus become capable of operating in indoor light. This type of product would be of an added value for NADICO.
- Development of **sol-gel mass production method** of doped-TiO_2 nanoparticles.
- Development of **pulse plating process** in order to achieve **high** incorporation rate and **uniform** distribution of reinforcing nanoparticles on the surface of metal/alloy matrix leading to an **effective immobilization** of photocatalytic particles on the surface. This type of process would be of an added value for ELPLATEK.
- Optimization of the pulse plating process in order to be sustainable in terms of **saving energy**, **time** and **raw materials.**

- Realization of **robust process parameters**.
- Enhancement of functional properties of produced coating exhibiting high adhesion with the substrate.
- Testing the **self – cleanin**g and **antibacterial character** of the coating under different relevant light conditions (Proof of concept).

The SelfClean project within 24 months achieved all specific objectives from the individual research work packages 1 to 7. The outcomes of these individual research work packages culminate in the development, demonstration and dissemination of produced **novel self cleaning – antibacterial coatings** of high aesthetics and durability based on the photocatalytic and antimicrobial properties of the doped TiO_2 nano-particles immobilized in Sn-Ni matrix, when exposed to indoor light. These coatings were applied to common touched objects via the process of electroplating proved to reduce the risk of getting infected by communicable diseases by a factor of 60 % (in some cases above 80%)..

The Technical & Scientific Objectives of the SelfClean project in combination with the means of verification as well as the related deliverables and milestones were:
Technical Objectives:

- Delivery of doped-TiO_2 nanoparticles exhibiting photocatalytic activity under visible light irradiation. Means of verification: by a) measuring energy bang gap and b) testing the powder's photocatalytic action under visible light irradiation. (D.2.1, D2.2, MS2, MS4).
- Delivery of production line of doped TiO_2 nanoparticles. By producing batches of 100 g of doped-TiO_2. (D3.1, D3.2, MS3, MS4).
- Delivery of a direct - pulse electroplating process for composite tin-nickel matrix self cleaning – antibacterial coatings, exhibiting enhanced mechanical & anticorrosion properties, with current efficiency > 95%. By coating samples in the electroplating line and testing the deposits in a series of analyses. Current efficiencies were calculated via the monitoring of electrical signals. (D4.1, D4.2, D4.3, MS5, MS6).
- Achievement of TiO_2 codeposition rate up to 20 wt. % (~30 vol. %) in the composite coating by applying optimised pulse plating conditions specifically for the Sn-Ni/TiO2 electroplating.. Determination of TiO_2 codeposition rate of coatings by applying EDS technique. (D5.1, D5.2, MS7).
- Plating of metal articles surface with the self cleaning – antibacterial composite coating by applying the optimised pulse plating conditions. Proof of concept following International Standards in Lab and Real environment (Metropolitan Hospital: Intensive Care Unit (ICU), WC-tiles and Office desks) (D6.1, D6.2, D6.3, MS8).

Scientific Objectives:

- To reduce energy band gap value of TiO_2 nanoparticles by doping to less than 2.3eV. Means of verification: By measuring energy band gap by UV-Vis spectroscopy (D2.1, D2.2 MS2, MS9).
- Advances in 2 years in producing doped-TiO_2 nanoparticles operating as photocatalyst for indoor applications. Means of verification: By: a) investigating the possibility of a patent application for the benefit of SME partners and b) by a successful build of a prototype production line of doped-TiO_2 nanoparticles (D3.1, D3.2, MS3, MS4).
- Advances in 2 years in pulse current plating technique for coating Sn-Ni/doped-TiO_2 composite coatings with high codeposition percentage (~20 wt. %, the highest ever recorded for TiO_2 nano particulates included in a metal matrix). Means of verification: By: a) investigating the possibility of a patent application for the benefit of SME partners and b) prove by surface quantitative analysis (EDS) of the TiO_2 percentage (D4.1, D5.1, D5.2 MS5, MS7).
- To produce Sn-Ni/doped-TiO_2 coatings with identical mechanical and anti-corrosion properties to the existing products and high adhesion, evaluated by measuring hardness, adhesion, wear, corrosion and tribocorrosion resistance -under conditions simulating the real environment i.e. finger abrasion test in artificial sweat-, following International Standards (D5.2, D6.1, MS8).

In brackets, the related deliverables and milestones are denoted.

Potential impact and use

SelfClean aimed to overturn the current downward trend in European electroplating industry by offering in the market innovative "self cleaning – antibacterial coatings" that will meet the important social need of public hygiene and will allow sales growth rate for the participating SMEs.

The successful conclusion of this project has a greatly positive impact on the business growth prospects of the SMEs partners plus its associated positive impacts on their European supplier network and employment level such as the metalworking and metal articles sector (MMA or Metalworking) which is a very large sector that provides technologies, services and equipment's to all other industrial sectors. A further added benefit resulted by optimizing the pulse current codeposition process and thus achieving reduction in energy and time. Moreover, a huge societal profit is gained due to the alleviation of the health system resulting from the reduction of disease transmission.

Consortium members

Partner	Short name	Country
NATIONAL TECHNICAL UNIVERSITY OF ATHENS	NTUA	Greece
ELPLATEK AS AF 1995	ELPLATEK	Denmark
KAMPAKAS METALLOURGIKI TECHNIKI EMPORIKI & VIOMICHANIKI AE	KAMPAKAS	Greece
SP SVERIGES TEKNISKA FORSKNINGSINSTITUT AB	SP	Sweden
TEKNISKA HÖGSKOLAN JÖNKÖPING AB	JTH	Sweden
INSTITUTTET FOR PRODUKTUDVIKLING - IPU	IPU	Denmark
CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS	CERTH	Greece
METROPOLITIKO THERAPEFTIRIO PERSEYS YGEIONOMIKIS MERIMNAS	METROPOLITAN	Greece
NADICO TECHNOLOGIE GMBH	NADICO	Germany

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