 

Green Design, Materials and Manufacturing Processes

Editors:
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Green Design, Materials and Manufacturing Processes

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Preface

Green Design, Materials and Manufacturing Processes contains papers presented at the 2nd International Conference on Sustainable Intelligent Manufacturing (SIM 2013), conjointly organized by two Portuguese institutions, the Polytechnic Institute of Leiria through its research unit of excellence, the Centre for Rapid and Sustainable Product Development, and the Faculty of Architecture of the Technical University of Lisbon. This event was held at the facilities of the Faculty of Architecture at Lisbon, Portugal, from June 26 to June 29, 2013.

The Centre for Rapid and Sustainable Product Development of the Polytechnic Institute of Leiria (CDRSP-IPL) is a FCT Research Unit of Excellence aiming at contributing to the advancement of science and technology, leading to more suitable, efficient and sustainable products, materials and processes, helping to generate added value to the industry, and promoting the awareness of the role and importance of rapid and sustainable product development in society.

The main mission of the Faculty of Architecture of the Technical University of Lisbon (FA-UTL) is to ensure the creation, development, and transmission of scientific, artistic, and technical knowledge in a socio-culturally responsible and operative manner. The research work developed at FA-UTL promotes the production of knowledge and innovation in architecture, urbanism and design. Its Research Centre for Architecture, Urbanism and Design, called CIAUD, is a FCT research unit of Excellence.

The rise of manufacturing intelligence is fuelling innovation in processes and products considering a low environmental impact over the product's lifecycle. Sustainable intelligent manufacturing is regarded as a manufacturing paradigm for the 21st century, in the move towards the next generation of manufacturing and processing technologies. On the one hand, the manufacturing industry is at a turning point in its evolution and new business opportunities are emerging. On the other hand, sustainability has become a key concern for government policies, businesses and general public. Model cities are moving forward towards novel ecosystems, combining environmental, social and economic issues in more inclusive and integrated frameworks.

This International Conference on Sustainable Intelligent Manufacturing was designed to be a major international forum for academics, researchers and industrial partners to exchange ideas in the field of sustainable intelligent manufacturing and related topics, making a significant contribution to further development of these fields. Participants came from more than 35 countries and very distinct backgrounds, such as architecture, engineering, design and economics. Such diversity was parallel to the various multidisciplinary contributions to the conference, whose subjects cover a wide range of topics like Eco Design and Innovation, Energy Efficiency, Green and Smart Manufacturing, Green Transportation, Life-Cycle Engineering, Renewable Energy Technologies, Reuse and Recycling Techniques, Smart Design, Smart Materials, Sustainable Business Models and Sustainable Construction. All participants were strongly engaged in the development of innovative solutions to solve industry problems, contributing to a more healthy and sustainable way of life.

We are deeply grateful to authors, participants, reviewers, the International Scientific Committee, Session Chairs, student helpers and administrative assistants, for contributing to the success of this conference. The conference was endorsed by:

- The Centre for Rapid and Sustainable Product Development, Polytechnic Institute of Leiria
- The CIAUD Research Centre for Architecture, Urban Planning and Design, Faculty of Architecture, Technical University of Lisbon
- The Portuguese Foundation for Science and Technology

IPL cdrsp - centre for rapid and sustainable product development instituto politécnico de leiria

Centro de Investigação em Arquitectura Urbanismo e Design CIAUD FACULDADE DE ARQUITECTURA

FCT Fundação para a Ciência e a Tecnologia MINISTÉRIO DA EDUCAÇÃO E CIÊNCIA

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New patent on nanomaterials for preserving stone and wood structures

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ABSTRACT: Nowadays, we recognize the need for a renewed commitment to the questions posed by the contemporary city to imagine new constructability scenarios paying attention to energy efficiency and cost saving, in order to obtain the recovery of identity of a city, achieving efficiency and effectiveness of the results. This paper focuses on developing effective strategies, based on sustainability and policies applicable to the built environment. Scientific experiences of the Author, demonstrated by scientific and technological patents, regarding the implementation projects on Nanomaterials, nanostructured inorganic oxides, and more particularly titanium sesquioxide and silicon, show that it is possible to obtain materials with high level of biocompatibility that can be used for the consolidation of ancient wood and stones.

1 INTRODUCTION

1.1 *Premise*

The search for coherence between the need for the recovery of identity and sustainability of interventions in the built heritage, highlights the issue on methods for selecting most appropriate strategies and tools to achieve the purpose, both at national and European level (Brandon & Lombardi 2011). In Italy, the current activities on the preservation and appreciation of the built environment and predictions about its future lead to considerations on the European scenery that can help to better understand the future behaviour in our national context. The theme of recovery of old buildings, applying non-traditional technologies, requires, in particular, a comprehensive overview of strategies for reliable interventions and a methodology to achieve goals that are consistent with the concept of sustainability.

1.2 *The sustainable approach*

In this perspective, the preservation and appreciation of the built heritage is of particular interest, through experimentation and innovative technologies. As evidenced by the good results obtained in some interventions both at national and European level, activities for the conservation of built heritage must be the result of synergies and collaboration of multiple groups, science and knowledge: architecture, engineering, technology, sociology, economics, urban planning, legislation must be managed and planned to work together. In fact, if sustainability ultimately means learning to think and act in terms of guaranteeing the prosperity of interdependent natural, social, and economic systems, then the built heritage, with its unique values and experiences must be contextualized and integrated with this view (Ayong Le Kama 2001).

Since the 1970s sustainability has evolved as a significant mode of thought in nearly every field of intellectual activity. As we know, decisions concerning conservation of the built environment have in the past been the domain largely of architectural historians, urban planners, conservation specialists, and related professionals. But conservation cannot remain a closed and solely self-referential profession, and indeed it has not (Macinnes 2004). With particular regard to the conservation of historic neighbourhoods and city centres, as well as individual monuments and sites of unique beauty, the challenge facing the conservation community is to develop a set of strategies and priorities that will permit it to focus its efforts on the conservation of those resources where the benefit-cost ratio is most favorable (Matero & Teutonico 2001). In this case sustainability means controlling change and choosing directions that capitalize most effectively on the inheritance from the past. In any decision about change and about the impact of the future on the remains of the past, therefore we should be conscious of two separate questions: the first is how to reconcile minimizing loss with the needs of the present; the second is how to ensure that the balance we strike does not reduce too greatly the options for future generations when they come to understand and enjoy their inheritance. Actually, built environment and heritage conservation should provide a dynamic vehicle by which individuals and communities can explore, reinforce, interpret and share their historical and traditional past and present, through community membership as well as through input as a professional or non-professional affiliate.

As claimed by Marion King Hubbert, *during the last two centuries we have known nothing but exponential growth, and in parallel we have evolved what amounts to an exponential-growth culture, a culture so heavily dependent on the continuance of exponential growth for its stability that it is incapable of reckoning with the problems of non-growth. Since the problems confronting us are not intrinsically insoluble, it behoves us, while there is yet time, to begin a serious examination of the nature of our cultural constraints, and of the cultural adjustments necessary to permit us to deal effectively with the problems rapidly arising* (Hubbert et al. 1949). The reflection of Hubert, highly topical, highlights how little has been recorded on our growth model in the last thirty years, and the need to start, with ambition and care, structural changes in our economies and in urban cultures to face the current crisis. The city we live in, today is incapable of performing its functions of "structure", it is not able to be a "cultural guide" anymore. The use of innovative technologies can be a test and a challenge for the re-construction of the rules to redevelop the built and "buildable" environment, by inserting the ecological variable and the resulting technologies and manufacturing solutions (Fairclough 1999).

2 INNOVATIVE TECHNOLOGY

2.1 *Inventions in progress*

In the building industry, sustainability has become synonymous with "green architecture", or building designed with healthy work environments, energy conserving systems, and environmentally sensitive materials. For historic tangible resources—whether cultural landscape, town, building, or work of art—the aim is notably different, as the physical resource is finite and cannot be easily regenerated (Stubbs & Makaš 2011). Instead, sustainability in the preservation of built environment means ensuring the continuing contribution of heritage to present through the thoughtful management of change responsive to the historic environment and to the social and cultural processes that created it. By shifting the focus to perception and valuation, conservation becomes a dynamic process involving public participation, dialogue and consensus, and understanding of the associated traditions and meanings in the creation, use, and re-creation of heritage. Sustainability emphasizes the need for a long-term view. But in the transformation of our physical environment, what relationships should exist between change and continuity, between the old and the new? Only when history is rightly viewed as continuous change can conservation affect an integrated and sustainable environment. Conservation, based on the concept of sustainability, helps to extend places and things of the past into the present and establishes a form of mediation critical to the interpretive process that reinforces these important aspects of human existence. The fundamental objectives of conservation concern ways of evaluating and interpreting cultural heritage for its preservation and safeguarding now and for the future (Bennet 1996).

2.2 *The research: A new patent on nanomaterials for preserving stone and wood structures*

Thorough investigations give rise to new studies on the evaluation of characteristics, opportunities and effects of re-involvement of technology in knowledge, enhancement and communication of the built heritage, both ancient and modern. Research papers relating to technological innovation for the preservation and appreciation of the built heritage are many. Scientific experiences of the Author of the present contribution, shown by scientific and technological patents, regarding the implementation projects on nanomaterials, nanostructured inorganic oxides, and more particularly titanium sesquioxide (Ti_2O_3) and silicon (Si_2O_3), have demonstrated that it is possible to obtain materials with a high level of biocompatibility that can be used for the consolidation of archaeological wood and stones.

For example, the invention, entitled *Innovative sonochemical process that employs ultrasonic cavitation for the synthesis of monodispersed amorphous silicon dioxide nanoparticles, and a method for producing high-performance water-soluble lithium silicate compounds, for the application in the consolidation in situ of ancient stone and wood structures* (Di Salvo S., Patent Pending PA2011A000012), represents a powerful breakthrough in the synthesis of new materials for the protection of buildings, therefore for the improvement of the built environment. This patent has been stimulated by the need to obtain nanomaterials to be used for the consolidation and more particularly for the conservation and protection of natural stone and wood of ancient structures. As we know, the deterioration of stone and wood with which the ancient structures and monuments are built is a complex physical-chemical process caused by the interaction of several factors: climate of the locations, urban pollution, and the same material properties. Every direct method to consolidate and, more particularly, to protect and conserve the ancient structures must have the following characteristics: a) to be respectful of the environment; b) to be careful not to damage the wood surfaces or stone material of the ancient structures; c) not to affect the structural characteristics of the material that forms the structure to be preserved; d) to be well absorbed by capillarity; e) not to produce any change of colour of the treated material; f) to have a good penetration and ensure a high degree of consolidation. One of the most promising inorganic compounds for the consolidation of stone materials is lithium silicate. At the state of the art, two patented inventions in the United States, respectively US n. 4.443.496 (Obitsu et al., Application No. 400,820) and US n. 4.521.249 (Obitsu et al., Application No. 567,028), claim the use of lithium silicate to impregnate concrete surfaces. The first invention (1984) is titled *Agent and method for modifying surface layer of cement structures* and the second invention (1985) is titled *Silicate containing agent cement surface modified with this agent*. The descriptions of said patents highlight a method for the formation of a silicate coating on the surface of concrete. However, the inventions claimed by the above-mentioned U.S. patents do not address the problem of consolidation and conservation of stone, of which the pH is much lower than the matrix of cement. The patents provide for the use of a plasticizer which is sodium salt of naphthalene-sulfonate condensed with formaldehyde. This polymer has a typical dark brown colour and its application produces an undesirable colour formation of substrate (brown staining). Furthermore, the introduction of said organic material produces a microbial infestation of the stone.

Currently, the research aims to constantly create new materials capable of consolidating structures of stone and wood of ancient buildings, without generating any of the aforementioned problems. The function of the present invention is to create economically and conveniently nanoparticles of silicon dioxide, through a new process of synthesis which employs ultrasonic cavitation, totally unknown in the state of the art of science and technology. Ultrasonic cavitation is the energetic effect which is basically used by ultrasound. To be more precise, the ultrasonic cavitation is a physical phenomenon consisting in the creation of vacuum "tears" commonly referred to as "bubbles" in a fluid which immediately and violently implode. This compound of silicon dioxide in nanoscale structure can subsequently react with lithium hydroxide and/or carbonate, in water, to form a specific inorganic material of high performance, with new characteristics. The nanoparticles of silicon dioxide have a crucial role in the creation of a new form of water-soluble lithium silicate, to be applied *in situ* to improve the performance of stone and wood materials of ancient structures, essential for many applications in various fields of technology. This water-soluble compound can be used as a hardener, characterized by the unique ability to penetrate by capillary action in the pores, cracks and lesions of structures of stone and wood. This new material of lithium silicate performs the task perfectly respecting the environment, without changing the physico-chemical and mechanical structures of the treated materials, and all with no lasting effects. These nanoparticles, characterized by an average diameter of ~20 nm (Fig. 1),

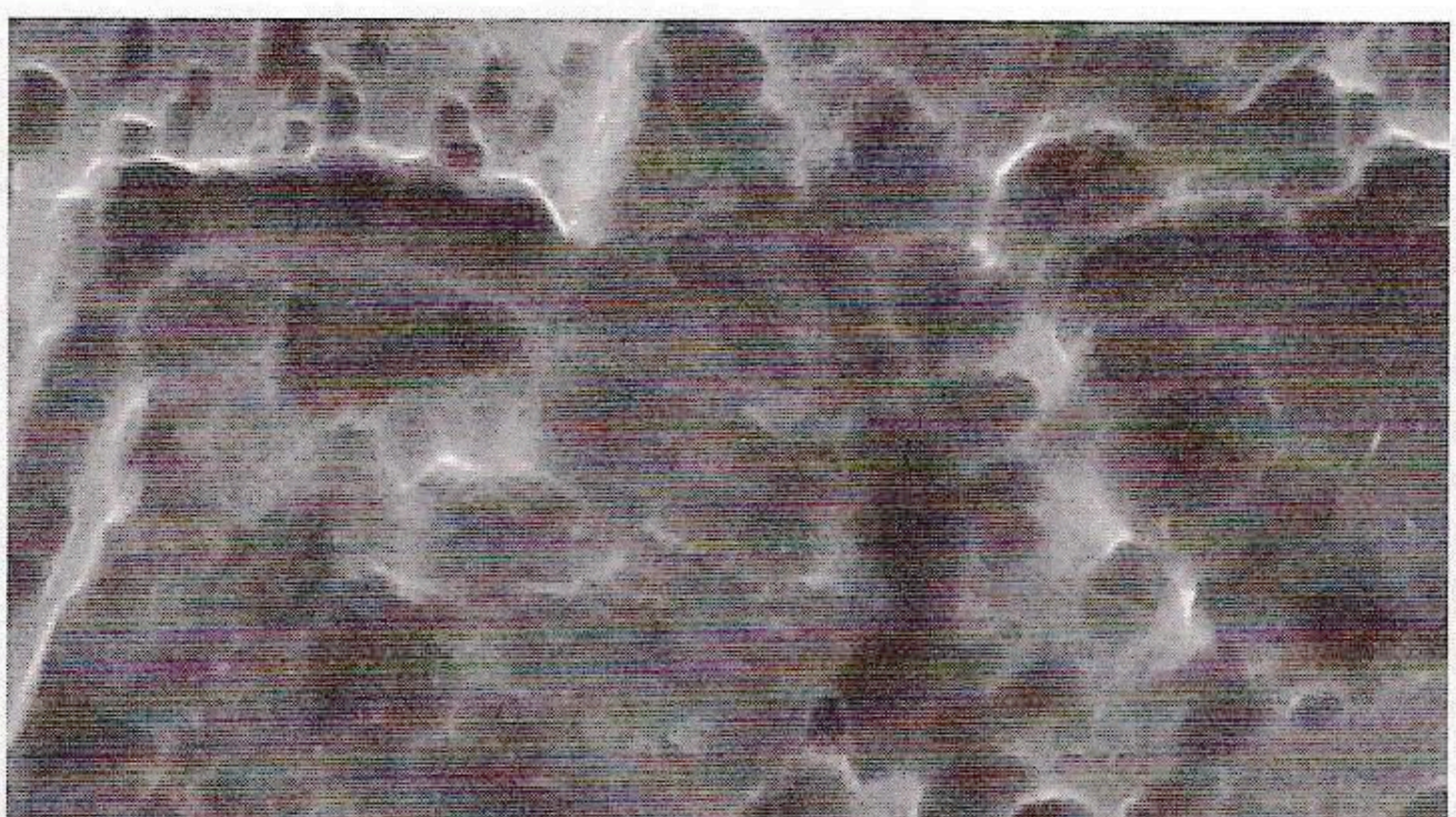

Figure 1. Image SEM (Scanning Electron Microscopy). Morphology of the surface of a porous stone sprayed with a 10% solution of lithium silicate which contains nanoparticles of silicon dioxide (~20 nm).

are synthesized through the use of the ultrasonic cavitation that determines the optimal conditions for the formation of molecules with a well-defined, regular spherical structure. More particularly, the Author of the present invention has found that an adequate ultrasonic frequency is indispensable, in order to avoid the agglomeration of the nanoparticles silicate dioxide. To have an optimum cavitation, capable of generating spherical nanoparticles well-defined of silicate dioxide, this ultrasonic frequency must be between 20 KHz and 60 KHz.

In fact, various experiments conducted by the author of this patent have shown that an ultrasonic frequency too high may generate the formation of nanoparticles of silicate dioxide characterized by irregular shapes, while an ultrasonic frequency too low may delay the formation of nanoparticles. The consolidating power of lithium silicate water-soluble is highly dependent on the size of the amorphous and mono-dispersed nanoparticles of silicon dioxide. The sonochemical technique, which uses ultrasonic cavitation, has the following advantages in the synthesis of nanoparticles of silicon dioxide: versatility and ease of execution, purity, consistency and high performance of the material obtained. In fact, the self-cleaning ability of this new type of silicon dioxide, having a nanoscale structure, applied directly to the stone surfaces, allows us to preserve their condition unchanged, without any alterations to their appearance of technical features, preventing biological pollutants and corrosion impurities, effectively counteracting the deterioration of the surfaces of stone materials and significantly reduces maintenance costs (Di Salvo 2012).

3 CONCLUSIONS

As we imagine, the city of the future will no longer be comparable to today's cities, largely because the technological challenges we face are so immense. Several sentiments reflect respect for antiquity and a distaste for modernity, a common conservative instinct, rather than an active concern for conservation. It is a persistent element in the culture of all modern societies, which eventually leads to a demand for government action to preserve the relics of the past. Cultural heritage is the mirror of society. It constitutes the legacy of tangible artefacts, such as historical buildings and monuments, as well as intangible features, such as traditions, customs and practices. Built environment and cultural heritage operate through a symbiotic relationship, whereby the physical symbols serve as evidence of underlying norms and values of a culture. Taking this into consideration, the importance of protecting tangible cultural heritage is significant not only in order to reflect on and to better understand the past but also to maintain identification in the future. The cultural heritage of the European Union is crucial for establishing a shared European identification through progressive integration. All the projects, the interventions and recent new patents show the commitment and interest in the experimental research in innovative materials and reliable systems to ensure the preservation, enhancement, appreciation and enjoyment of the built environment. In recent years several lines of research have developed innovative methods and new production processes that allow nanostructured particles to become an advantageous and indispensable component for the preservation, enhancement and appreciation of the built environment. These new nanomaterials can be successfully tested and verified to help bringing history to life, to protect our built environment, setting the stage for a really accessible and safeguarded city in the future.

Finally, the combined approach of multiple disciplines is a methodological strength of all inventions and projects (Pearce et al. 2012). In shared projects, a large number of transverse phases may well allow research teams to join in the development of common activities, useful to compare experiences and adopt the successful patterns of scientific knowledge. Experience has shown that innovation occurs when a process of change reaches a critical mass able to overcome the inertia of the "traditional system", and that it is only by focusing on new and innovative processes it is possible: 1) to establish groups of interdisciplinary research designed to implement plans and practices much more ambitious than the current ones; 2) to develop a set of reliable strategies which can be relevant both locally and internationally; 3) to improve the responsibility of groups involved; 4) to reinforce the concept of participation on clear objectives. In this scenario, it will be possible to read the signs of a possible different future, the feasibility of a new relationship between technology and the built environment.

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Green Design, Materials and Manufacturing Processes includes essential research in the field of sustainable intelligent manufacturing and related topics, making a significant contribution to further development of these fields. The volume contains reviewed papers presented at the 2nd International Conference on Sustainable Intelligent Manufacturing, conjointly organized by the Centre for Rapid and Sustainable Product Development, Polytechnic Institute of Leiria, and the Faculty of Architecture, Technical University of Lisbon, both in Portugal. This event was held at the facilities of the Faculty of Architecture, Lisbon, from June 26 to June 29, 2013. A wide range of topics is covered, such as Eco Design and Innovation, Energy Efficiency, Green and Smart Manufacturing, Green Transportation, Life-Cycle Engineering, Renewable Energy Technologies, Reuse and Recycling Techniques, Smart Design, Smart Materials, Sustainable Business Models and Sustainable Construction.

Green Design, Materials and Manufacturing Processes is intended for engineers, architects, designers, economists and manufacturers who are actively engaged in the advancement of science and technology regarding key sustainability issues, leading to more suitable, efficient and sustainable products, materials and processes.

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