

Bioinspired materials for sustainable architecture and construction learning from Echinoids (Sea Urchins): new research avenue

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Abstract:

Creating and manufacturing materials that respond to both socio-economic and environmental issues are major challenges for architecture and industry [1]. The issue of lightening structures to save material and consumed energy is a today challenge. This requires research on new lightweight and multifunctional materials and / or new combinations and architecture of materials in order to improve their performance. The architecture must be designed at a relevant scale of matter: at the nanometer scale for polymers, if we are interested in the properties of chemical-physical barriers/interaction or at the centimeter scale for metal alloys if we want flexible materials but able to keep their properties at high temperature (for example at 800 °C in aerospace). In the same way, the replacement of existing materials with rare or polluting primary resources requires the development of new materials or to revise old ones. Bio-based polymers are beginning to replace petroleum-based polymers in some applications. In architecture, vegetal fiber concrete is making its appearance. The stone saves the ground compared to the concrete in the construction of work as well as the wood which it is possible to make translucent.

Biomimicry is a promising path on which interdisciplinary research teams in biology, engineering and architectural design, are starting to work within UMR MAP MAACC CNRS collaborating with external experts: in biomimetics from *Transarch: biomimetics + transdisciplinary design*, Vienna, Austria [2] and in biology and engineering from the University of Campania “Luigi Vanvitelli” and Federico II of Naples, Italy [3,4] to develop new multi-functional materials, optimizing the properties of existent materials and structures to minimize energy consumption during the production and manufacturing [5].

In our initiative research, we have chosen Echinoids, known as sea urchins as a biological role model. The echinoid skeleton (test) presents interesting functional features on their macro and micro architectures, mechanical performances and material properties. This hierarchical design fulfills several functional principles acting as a lightweight and load-bearing system adapted to withstand biotic and abiotic stresses. Due to its functional strategies, the echinoid test has a long history as an inspiring model for engineering structures and materials [6]. We aim to study the sea urchins and use biomimetic methodologies to transfer their interesting aspects to create new bio-inspired material / or develop existing materials which have lightweight, material efficiency, multi-functional qualities and be able to adapt to large scale architectural design. We are also aware of the durability of the new type of materials to the real-world construction requirements.

The research works require a fine understanding of the material at different scales and multidisciplinary skills in materials sciences, instrumentation including in data analysis. This initial research on bio-inspired materials for sustainable architecture and construction is part of the research theme on biomimetic strategies for architectural design at the laboratory MAACC within the framework of GDR 2088 « BIOMIM » – Biomimicry and Bioinspiration.

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