The Enigmatic Biomaterial Spongin: Creating a New Generation of 3D Composite Materials

The aim is to design a bridge between Extreme Biomimetics and Bioinspired Materials Science where the basic principle is to exploit chemically and thermally stable, renewable biopolymers for development of the next generation of biologically inspired 3D composite materials never reported, or even suggested before with sizes and properties which will allow their application in the extremes of modern industry including large scale level.

The project prosed herewith possesses both a high degree of novelty and challenging tasks. We will discover the key principles of molecular structure of proteinaceous marine biomaterial spongin that will finally let us realize the more than 300 year dream of understanding the chemistry and materials science of these unique biocomposite spanning from atomistic detail to the macrolevel. The presented project stems from our pioneering discovery concerning preservation of molecular detail in centimetre-scale samples of spongin scaffolds even after it carbonization at 1200°C, which mark a ground-breaking step in extreme biomimetics and bioinspired materials science forward. Our concept will adopt a truly multidisciplinary and multi-scale approach to study not only the structural peculiarities of a spongin, but also the mechanisms of it transformation in carbon allotropes during carbonization up to 3000°C. By focusing on two different extreme biomimetic scenarios, melting of steel forms on carbonized spongin templates and high temperature transformation of iron-rich spongin into "*SpongoSteel*" material, the proposal will bring together an array of disciplines ranging from biomaterials science to hydrothermal chemistry, solid state physics, and even electronic structure of materials. If we are to understand the mechanisms of corresponding phase's transformation under such unusual for biocomposites conditions, extreme biomimetics must be fully integrated. A holistic understanding of development of new generation of spongin-based composites and its impact on large-scale biomimetics with future input in modern technologies can only be achieved by such a multi-facetted approach, which has not been attempted before.

Without this knowledge, the idea of fabricating carbon-based composite materials with controlled microstructure and morphology, especially at large scales and from renewable and biodegradable natural sources as spongin, seems to be not realisable.