LIVEMAT: Hybrid Living Materials on Bio-based Composite Scaffold

Human activity, including the production of concrete, metal, plastic, bricks, and asphalt, brought the world to a crossover point where human-made mass, driven mainly through enhanced consumption and urban development, exceeds the overall living biomass on Earth. In parallel, anthropogenic activity introduces different gas pollutants into the environment, the removal of which is technically problematic and costly. This creates motivation to search for alternative mitigation strategies able to provide long-term carbon storage and actively remove air pollutants. The LIVEMAT project will try to understand and promote the interaction and symbiosis of selected microorganisms with precisely designed and manufactured polymer composites. Polylactide (PLA) is one of the versatile aliphatic linear thermoplastic biodegradable polymers obtained from fully renewable sources. It has several desired characteristics like good mechanical strength, possibility of shaping with highly efficient forming methods, biocompatibility, and compostability. On the other hand, it also has some limitations, such as low gas and water barrier properties, high brittleness, low glass transition temperature, and susceptibility to degradation, including hydrolysis or photodegradation. These drawbacks strongly limit PLA use in commercial applications, especially in the building sector.

The goal of the LIVEMAT project is to design and create a sustainable composite material that will provide an optimal scaffold for the growth and reproduction of selected living organisms: algae, cyanobacteria, and fungi. By merging abiotic and cellular components, the developed material will possess unique functionalities not existing for conventional ones, such as carbon sequestration, photosynthesis, and bioremediation. The developed material will effectively protect new and existing buildings, serving as an active and resilient material capable of interacting, adapting, and responding to environmental changes.

The majority of polymer-based materials can be classified as passive materials, unable to react and respond to environmental factors and their changes, inducing their degradation. The development of active materials might provide novel possibilities for their use. However, current active materials are manufactured mainly from non-renewable components, while their substitution with renewable ones is strongly desired. To achieve this goal, an interdisciplinary approach to material design should be implemented. By incorporating living cells with complementary properties into traditional, static materials, a fundamental change in materials production and performance can be achieved. The optimal configuration of both polymeric substrate and microbial culture will be identified to provide a basis for further functionalization of a new generation of hybrid living materials (HLMs). Algae, cyanobacteria, and fungi are proposed as living parts of developed active material, which aims to provide unique characteristics. It is expected that the presence of algae and cyanobacteria in the developed HLMs will allow active carbon sequestration and enable photosynthesis leading to oxygen production. The fungi will permit bioremediation and assure selective antimicrobial protection and scaffold for the photosynthetic microbes. The presence of both living components will provide additional UV protection. The living bio-composite developed by LIVEMAT will effectively and actively protect new and existing surfaces, alternatively may also serve as a fence and barrier material.

The LIVEMAT project proposes a novel concept for material design and manufacturing by merging two generally unrelated disciplines – material science and microbiology. The LIVEMAT project will be implemented over four years by three partners from two different countries.

The LIVEMAT project's ambition is to promote the development of the emerging field of HLMs, which is still considered an avant-garde solution to materials advancement. It will boost fundamental change in materials' production and performance, enabling new, better, or similar functionalities, compared to traditional materials but with decreased costs and environmental impact.

The project has the ambition to contribute to global sustainability by addressing several of the UN SDG. It aligns with the recently published Chemicals Strategy for Sustainability and the European Green Deal priorities. LIVEMAT will contribute to the EU's 2050 long-term strategy for a climate-neutral Europe by replacing fossil-based materials with renewable ones and boosting innovation for safe and sustainable chemicals. The community will profit from the bioremediation capacity of the developed material. Application of developed HLMs in big cities will potentially contribute to lowering air pollution, a major global urban challenge resulting in an estimated extra 800,000 deaths a year in Europe. The presence of algae and cyanobacteria and their active sequestration of CO_2 has the potential to lower the concentration of Green House Gases (GHGs). All embedded living elements have enormous potential to combat climate change.