Abstract for the general public:

The world is moving rapidly toward renewable and sustainable energy, and solar power is at the heart of this transition. For Photovoltaic (PVs) technologies to make a real impact, they must combine high efficiency, long-term durability, environmental safety, and affordability. Over the past decade and a half, a new class of solar devices known as perovskite solar cells (PSCs) has generated enormous excitement. These devices can be made using low-cost, solution-based fabrication techniques and have already achieved record power conversion efficiencies above 27%, comparable to or even exceeding those of traditional silicon solar panels.

However, despite these impressive achievements, large-scale commercialization of PSCs is still hindered by two major problems: instability under real-world conditions (such as moisture, heat, and ultraviolet radiation) and the toxicity of lead (Pb)-based components. To overcome these barriers, researchers have recently turned their attention to perovskitoids, a new family of materials that are structurally related to perovskites but chemically more robust. Perovskitoids can form diverse architectures, ranging from 0D isolated clusters to 1D chains, 2D sheets, and layered structures, which provide tunable optoelectronic properties and improved resistance to environmental stress. Yet, their use in solar cells remains limited due to low charge transport efficiency and high recombination losses.

At the same time, biopolymers, renewable and biodegradable materials obtained from plants, marine organisms, and microorganisms, are emerging as promising candidates for sustainable electronics. Materials such as chitosan, alginates, cellulose derivatives, and furan-based systems contain functional groups (hydroxyl, carboxyl, amine, catechol) that interact strongly with semiconductor surfaces. In solar cells, these interactions can passivate defects, suppress harmful ion migration, improve crystallinity, and enhance environmental stability. In fact, when integrated into conventional perovskite devices, biopolymers have already enabled efficiencies of 21-25%, while maintaining over 90% of performance during extended operation. Despite this success, the potential of biopolymers in perovskitoid-based devices remains virtually unexplored.

The proposed project represents a breakthrough by combining two complementary strategies: the structural stability and reduced toxicity of perovskitoids with the renewable and multifunctional benefits of biopolymers. For the first time, perovskitoid-biopolymer hybrids will be systematically developed and tested as a new materials platform for solar energy. We aim to build devices with around 15% efficiency and long-term stability exceeding 4000 hours, even under stress from moisture, heat, and UV light. Prototypes will start at 0.06 cm^2 and be scaled up to 6.45 cm^2 mini-modules, moving closer to practical application. By combining scientific innovation with sustainable design, this project will provide both fundamental insights and a technological pathway toward affordable, long-lasting, and eco-friendly solar panels. The outcomes will support the global shift to clean energy while reducing reliance on toxic and unsustainable materials.