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Biomaterials for Boosting Food Security

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Introduction

The infrastructure of agro-food systems is responsible for more than 25% of anthropogenic greenhouse gas emissions while facing pressure to support an increasing world population. For the first time in history, the availability of arable land has plateaued, and crop yields are threatened by stressors such as soil salinity and drought that are further exacerbated by climate change. Food security and food waste are twin crises; more than 800 million people are undernourished, and 30% of food is lost or wasted from farm to fork. As new technologies that are economically sustainable, scalable, and rapidly deployable to market are needed to address these challenges, an opportunity lies for biomaterials to lead innovation in the agro-food industry. Our laboratory strives to reinvent silk proteins as advanced materials for boosting food security.

Experimental

We use advanced manufacturing techniques and directed assembly processes (e.g. templated crystallization) to fabricate biopolymers in advanced materials. Obtained structures are characterized across scales using SEM, TEM, AFM, FTIR, Raman, XRD, and mechanical tests. Microbiological characterization and plant work is also performed to study biodegradation, drug release and biomaterials-plant interactions.

Results and Discussion

Through nanomanufacturing we designed silk edible coatings that prolong the shelf-life of perishable food, microenvironments that boost seed germination in marginal land and different solutions to precisely deliver payloads in planta. These examples provide an opportunity to study the interface between biomaterials and plants tissues and to develop basic scientific knowledge on: mechanics of disorder to order transitions in proteinaceous materials nanoscale condensation processes, fluid mechanics and transport phenomena in plants vasculature, and swelling of porous materials exposed to plant fluids.

Conclusions

Biomaterials can be used as disruptive technology to make the agro-food systems more resilient and precise, also minimizing waste.

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Biography

Benedetto Marelli is the Paul M. Cook Career Development Associate Professor in the Department of Civil and Environmental Engineering at the Massachusetts Institute of Technology. He received a B.Sc. and a M.Sc. in Biomedical Engineering from Politecnico di Milano in 2005 and 2008 and a PhD in Materials Science from McGill University in 2012. After a Postdoc in the Silklab at Tufts University, Benedetto joined the MIT Faculty in late 2015. At MIT, the Marelli lab works on structural biopolymers and nanomanufacturing to design biomaterials with applications in precision agriculture, food security and food safety. Benedetto has received several awards, including PECASE, NSF CAREER, ONR Young Investigator Award and ONR DoRECA. Benedetto has also joined the 2021-2023 New Voices Program promoted by the National Academies of Sciences, Engineering and Medicine and recently received the 2022 BII&Science AAAS Prize for Innovation. Benedetto is the co-founder of Mori, a startup that employs >90 people and commercializes silk-based edible food coatings to extend shelf-life and reduce packaging.