Beyond the Circular Economy: A Look at the Cross-Economy and Case Study Example of Pollen-Based Materials Innovation

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The circular economy seeks to create a virtuous cycle of recycling materials and reducing waste to protect the planet with more sustainable practices. While progress has been made, there are calls to think beyond the recycling of existing materials as a means to an end and instead to imagine what is possible by creating new classes of and ways to produce innovative materials based on harmony with the environment. This cross-economy concept is based on a new growth model of "transforming waste to innovation," enabling economic growth with a positive social impact. The key enabling factor is material innovation by utilizing fundamental engineering principles based on material innovation and sustainable processing to construct more harmonious ecosystems and networks. Indeed, new materials have been the foundation of disruptive technologies throughout history. From bronze, paper, and ceramics to steel, polymers, and semiconductors, each new class of material enabled far-reaching advances and defined the era. Seventy years ago, the synthesis of pure semiconductors as single crystals led to a complete transformation of the electronics industry and sweeping changes in communications, computing, and transportation. Today, inspired by the United Nation's Sustainable Development Goals (SDGs) – a blueprint to achieve a better and more sustainable future for all – another new class of materials is emerging—one with both the potential to alleviate the environmental burden, provide radically new functions, and to challenge our notion of what constitutes a "material". These materials, inspired and co-opted from biology, combine (1) hybrid-composite design, combining disparate building blocks; (2) compartmentalized architecture, encapsulating desirable biomolecules while excluding others; and (3) hierarchical organization. Together, they enable unique and remarkable properties, including adaptability, plasticity, multi-functionality, and environmental responsiveness – far beyond those achieved by monolithic materials of the synthetic world.

An extraordinary example is pollen, a discrete mesoscale compartment, which encapsulates, protects, and transports male genetic material in flowering plants enabling the biological imperative of reproduction. In this talk, I will introduce our ongoing efforts to explore the materials science of pollen and to transform pollen into a valuable commodity to produce pollen-based materials innovation as a sustainable solution to numerous outstanding environmental challenges. Key examples that will be covered include digital printing of shape-morphing materials, recyclable and reusable paper, and oil-absorbing sponges, and highlight how the cross-economy concept enables forward-looking solutions that enhance sustainability while also harnessing scientific knowledge and technological innovation to achieve continued industrial progress in more harmonious ways.

Biography

Nam-Joon Cho is the MRS-Chair Professor in the School of Materials Science and Engineering at Nanyang Technological University in Singapore. His research activities focus on biointerfacial science approaches to solve important biomedical problems and translate these capabilities into practical applications for global health. Key research activities include model membrane platforms for biological surface science, acoustic and optical biosensor applications, pollen-based biomaterials, tissue engineering, and the development of membrane-active antimicrobial strategies. His research team has published over 270 scientific papers in top journals such as *Nature Materials, Nature Medicine, Nature Communications, Nature Protocols, Science Translational Medicine, Science Advances, Advanced Materials, ACS Nano,* and the *Journal of the American Chemical Society*. Dr. Cho's scientific work has been highlighted by international media organizations such as *Reuters*, *CNBC*, and *Businessweek*, and has led to licensed technologies in the fields of antiviral medicine, biomaterials, and biotechnology. He is a graduate of Stanford University and the University of California, Berkeley.