Architects of a Sustainable Hemp Industry

For centuries, the hemp plant has been recognized as a robust and renewable source of raw material for a host of purposes. However, for decades United States law conflated hemp with marijuana, and it fell out of use. Now, with such restrictions lifted, hemp has a bright future as a sustainable, high-value raw material for consumer and industrial products.

"Realizing that potential will require a lot of fundamental planning and development work, conceiving and establishing systems and platforms essential for building robust agricultural- and manufacturing-focused hemp industries," says **Ronald Kander, PhD**, associate provost for applied research and dean of Kanbar College of Design, Engineering and Commerce. Success will require the convergence of a broad array of expertise, perspectives and tools—ranging from plant biology, biochemistry and textile engineering, to economics and systems management.

"On the scientific and technical side," Dr. Kander explains, "that work ranges from materials science research on the hemp plant, to the engineering processes that will be used to transform hemp biomass into new materials with unique mechanical, physical or biochemical properties.

"On the business and economic side," he continues, "that work includes characterizing high-value hemp-based products that have well-defined markets; conceptualizing business models and supply chain systems and describing the infrastructure necessary to support a growing industry."

Jefferson is pursuing an array of research and development initiatives that will help make that happen, driven by transdisciplinary teams of faculty and students from engineering, materials science, industrial design, business and other fields. Those teams, in turn, are collaborating with researchers and practitioners from industry and government to conceive an integrated system of new materials, processes, products, business models and regulatory frameworks for a robust and sustainable industry.

"In this context, when we use the word 'sustainable,' we are aiming not just for environmental sustainability," Dr. Kander notes. "We are helping create a hemp industry that is also sustainable economically, technically and in socio-political terms." Toward this definition of a sustainable hemp industry, Kander and his research colleagues are developing a comprehensive Systems Dynamic Model for a complete supply-to-process-to-sale operation. "We intend this model to be an open-source resource that researchers, policymakers, companies and investors can use to simulate results based on their individual data sets and criteria," he explains.

Gurinder Kaur, a PhD candidate in textile science and engineering, is a member of Kander's team. For her doctoral work, she is developing the supply and environmental facets of the comprehensive Systems Dynamic Model. She is using two hemp-derived products now in development as the objects of the model. (See the sidebar, Prototyping Hemp Products.) "As a former manager focusing on sustainable industry supply chains," Kaur explains, "I am enthusiastic because the simulated supply chain model we are developing will create a risk-free method for companies to test the impact of state policy changes—and to do so without fear of losing valuable time and assets."

In addition to guiding the University's overall initiative, Dr. Kander is directly engaged in policy-focused work: he chairs the Pennsylvania Department of Agriculture's Hemp Steering Committee, which is developing a strategic plan for a Pennsylvania-based Industrial Hemp Center of Excellence. And, in parallel with those efforts, Jefferson is helping to develop a vision for the education, training and workforce-development infrastructure necessary to power a growing hemp industry. ■

Prototyping Hemp Products

Over the past few years, a series of industry/University partnerships have led to five "product-by-process" patents for hemp-derived materials—and commercialization is progressing on each of them. Currently, faculty/student teams are working with industrial partners to develop prototypes for two locally sourced and manufactured hemp-based products.

The first uses hemp-reinforced bioplastic for 3D printing. To most effectively capitalize on 3D printing technology for rapid production of customizable and functional products, manufacturers need basic materials with improved physical properties. While reinforced polymer composites could serve that purpose, they are often difficult to recycle and not biodegradable. Jefferson researchers are working with Pennsylvania-based Coexist, Inc. to develop a line of hemp-reinforced polymer 3D printing filaments that are sustainable and biodegradable and have superior physical properties. The project involves processing locally grown hemp and incorporating it into polymers via lab-scale compounding and extrusion processes. By developing this novel material and associated manufacturing process, the R&D team hopes to enable the company to advance new products and processes and be a magnet for new industrial investments.

The second project uses hemp to create injection-molded consumer and industrial parts. Injection molding of polymers and polymer-based composite materials is one of the most common manufacturing processes to make common industrial and consumer products. But these composites can be improved on, both for functionality and environmental sustainability. Therefore, Jefferson researchers are collaborating with Eastern Hemp Company to develop hemp-reinforced polymer-composite injection molding pellets that will allow manufacturers to make sustainable products with superior mechanical and physical properties compared with current polymer-based materials.