The National Institute for Materials Advancement (NIMA) – Sustainable Polyurethanes and Workforce Development

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Abstract:

Polyurethanes face regulatory pressures (in both raw material production and PUR manufacturing) and market pressures to include renewable feedstocks, all while facing a dwindling tech-competent workforce. The Kansas Polymer Research Center (KPRC) at Pittsburg State University (PSU) has been developing bio-based polyurethanes for over twenty-five years. And now, the newly established National Institute for Materials Advancement (NIMA), funded by grants from the National Institute for Standards and Technology (NIST) and the U.S. Economic Development Administration (EDA), is leveraging the KPRC's decades of experience in bio-based, and non-isocyanate polyurethanes, along with one of the nation's oldest plastics engineering technology programs (established in 1969), and polymer chemistry program, to address the environmental and health concerns associated with the use of isocyanates, the demand for greater utilization of renewable resources in PURs, and the desperate need for a workforce knowledgeable in polyurethane chemistry and processing.

Background:

In 1969, Pittsburg State University (PSU) launched one of the first, and most comprehensive, Plastics Engineering Technology programs in the nation. Housed in the 288,000 sqft Kansas Technology Center (KTC), the program continues to graduate students with AA, BS and MS degrees that are highly recruited across the nation.

In 1996, Prof. Zoran Petrovic initiated research into the use of vegetable oils as a feedstock for polymer production in an abandoned dormitory on PSU's campus in Pittsburg, KS. With multiple successes in this area of work, including sharing the 2007 Green Chemistry Award with Cargill, the KPRC continued to expand, and strengthen, its core competencies in polyurethanes and polyisocyanurates. In 2007 construction of a 25,000 sqft state-of-the art polymer research facility was completed on the university grounds.

In September, 2020, PSU was awarded $2.39M to support establishment of the new National Institute for Materials Advancement (NIMA) at PSU. The vision for NIMA is to be a global leader in bio-based materials research, centrally located in mid-America's agroeconomy, acting as a lighthouse for recruiting high potential students and talented researchers, focused on developing a highly sought-after technology-based workforce in the field of plastics and polymers. More specifically, based on decades of research experience in polyol production from biomass for use in a broad range of polyurethane applications, the strategic focus for NIMA's research efforts at the KPRC, and educational efforts in our polymer chemistry program, our plastics engineering technology program, and our materials science program will have a strong propensity towards polyurethane synthesis, processing and recycling.

Polyurethanes focus strategy:

An obvious progression from research on vegetable oils as raw materials was to create a broad range of polyols, and that logically led to developing deep expertise in various polyurethanes and their fitness-for-use criteria. Over the years industry collaborations have been, and continue to be, the primary source of revenue for the KPRC, and these shared interactions have provided insight to the critical need for a skilled workforce knowledgeable of the chemistry and processing of PUs with broad applications and equally broad processing and performance requirements.

As the concept of NIMA was being developed, it was clear that, in order to have the greatest impact, a strategic focus was critical, and leveraging our existing competencies provided the most expeditious route. Resonating strongly in our wheelhouse was research in bio-based materials, polyurethanes, and foams, along with our newly added emphasis on recycling (mechanical and chemical).

Hence, among NIMA's first moves was to join the Polyurethane Manufacturers Association (PMA) in order to gain greater insight into the industry and its broader needs. It is hoped that, with greater networking throughout the industry, NIMA's educational and research strategies can be more closely aligned with the PU industry's R&D, testing/analytical, and workforce development requirements.

Workforce development

Regarding workforce development, funding from EDA is allowing the purchase of $2M dollars in new tools for synthesis, analyses and testing. This includes: Differential Scanning Calorimetry (DSC), Thermal Gravimetric Analysis (TGA); Dynamic Mechanical Analysis (DAM); Thermal Mechanical Analysis (TGA); Field Emission – Scanning Electron Microscope (FE-SEM); X-ray Diffractometer; tensile and flex testing; gel permeation chromatography (GPC); IR/UV/Vis spectroscopy, and more. Suffice it to say that the KPRC will now be equipped broadly for polymers research using the latest technologies available.

In addition, the NIST funding is primarily focused on adding new research and teaching talent in the field of polymers synthesis, processing, analysis testing, and recycling. Bio-based, or sustainable, materials will continue to be a common theme, although not exclusive. These funds will support the hiring of full-time PhD researchers, post-docs, instructors, and technicians as well as provide scholarships to support student recruiting.

Currently, high school students are being introduced to polymer research with summer internships. This allows students first-hand experience in the lab doing actual industry related research – as opposed to typical cookbook laboratory assignments. In addition, high school chemistry and physics instructors are employed as summer interns in the KPRC to support polymer research efforts. These individuals have demonstrated that they are the strongest, and best, recruiters for our material science programs. The ultimate goal is to expand our polymer chemistry, plastics engineering and materials science program by several fold.

It is anticipated that close alignment with the PU industry will lead to a broad range of internships to broaden student insights into career opportunities and provide valuable manufacturing related experience.

Analyses/Testing:

Historically, the KPRC has offered materials analysis and physical testing for several industries within the region, and for legacy clients who were familiar with the facility's capabilities. With the addition of new staff and updating/expansion of analytical/testing equipment as part of NIMA, the KPRC will promote and provide analytical services broadly throughout the polymers/plastics industry; but with special emphasis on expanding capabilities particularly directed towards the broad CASE, foam, and TPU needs of the polyurethane industry.

Prove-out facility:

In addition to workforce development, NIMA is pursuing the construction of a 15,000 sqft prove-out facility that will allow the flexible introduction of pilot-scale equipment operations for process validation and market entry quantities of materials. It is anticipated that this will be used by industry operations that do not want to break into their manufacturing line schedules; for those looking to trial new processes; and for entrepreneurs that wish to test the waters with new product ideas or process models.

Curriculum:

As noted earlier, the current polymer chemistry and plastics engineering curriculum reflects a broad, generalized approach to education/training in this area of materials science. However, while this broad polymers/plastics training will not be abandoned, the new strategic focus on polyurethane chemistry and processing requires a significant revision/expansion of the legacy classroom and laboratory experiences for students. By identifying polyurethanes as our niche for emphasis, NIMA will strive to provide unmatched education/training opportunities for our students and a steady flow of highly skilled graduates for the industry. This, clearly, will require consistent and insightful input, and collaboration from across the expansive PU industry spectrum.

Summary:

PSU's National Institute for Materials Advancement is intent on becoming one of the polyurethane industry's go-to resources for pioneering research, new technology development, analytical and physical testing, and a work-ready talent pool. This will require strong industry guidance and collaboration. The combined resources of PSU's polymer chemistry program, plastics engineering technology program, and materials science program, along with the research and analytical/testing capabilities of the Kansas Polymer Research Center provide confidence that this goal is realizable.