2023
Third Quarter
PTC Newsletter

Polymer Technology Consortia

UPCOMING EVENTS

Mark Your Calendars for the PTC Fall meetings!

Scratch Behavior of Polymers Consortium-SCRATCH

SCRATCH FALL meeting-October 12th, 2023
Texas A&M University-College Station, TX

Polymer Technology Industrial Consortium-PTIC

PTIC FALL meeting—October 12th & 13th, 2023
Texas A&M University-College Station, TX

Inside the Newsletter

Surface and Core Hardness Testing of Additively Manufactured Thermoplastic Engineering Materials for Design Suitability Evaluation

Albert E. Patterson, Manufacturability-Driven Design Laboratory (MDDL), Department of Engineering Technology and Industrial Distribution

When considering thermoplastic engineering materials (both standard materials and polymer matrix composites) for a major design application involving any surface contact or wear, one of the most important properties is the hardness of the final material under different levels of dehydration. This is particularly vital for additively manufactured (3-D printed) materials due to their porosity, naturally anisotropic properties, and tendency to be affected by ambient moisture levels. This was the motivation of a recent project completed by a group of undergraduate student researchers, Pedro Palacios, Anibal Valezquez, and Ricardo Zelaya, led by Dr. Albert E. Patterson in the Department of Engineering Technology and Industrial Distribution and based in the Manufacturability-Driven Design Lab (MDDL). This work was published in *Materials Today Communications* (https://doi.org/10.1016/j.mtcomm.2023.105971).

In this study, 10 different materials processed by fused filament fabrication (FFF) were tested according to ASTM D2240 using Shore A and Shore D scales. Five standard commodity-grade engineering plastics (acrylonitrile butadiene styrene, polylactide, polycarbonate, polyethylene terephthalate glycol, and polyamide) were the basic set of tested materials, along with each of these with imbedded chopped carbon fibers. After testing the basic set of materials (Figure 1), further tests were done on samples dehydrated for different lengths of time in a drying chamber (Figure 2). The dehydration cycle was found to have a statistically significant impact on at least one of the hardness scales (Table 1), indicating that the moisture content of additively manufactured thermoplastic parts is an important consideration. This is normally ignored in practice, but clearly should be part of the decision to use these materials for end-user products.

Continues on Page 2

Continues from page 1- **"Surface and Core Hardness Testing of Additively Manufactured Thermoplastic Engineering Materials for Design Suitability Evaluation"** **Dr. Albert E. Patterson, ETID**

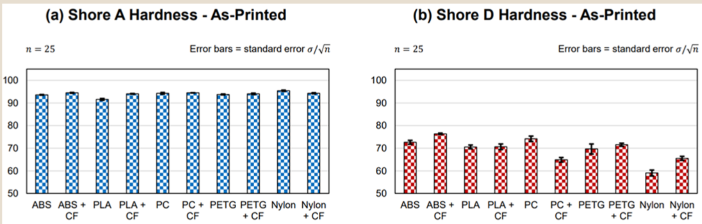


Figure 1. (a) Shore A and (b) Shore D hardness testing results for 10 FFF-processed materials as printed.

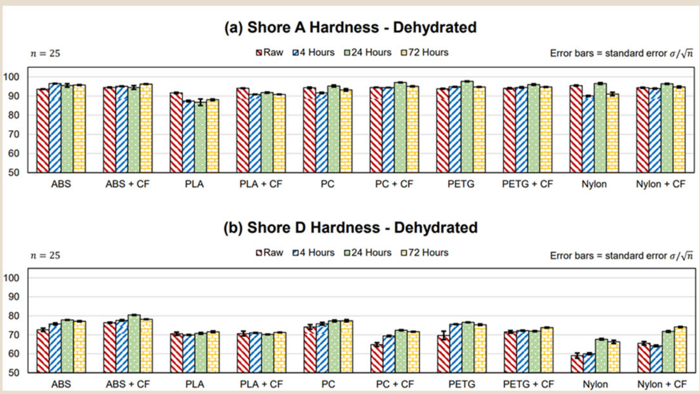


Figure 2. (a) Shore A and (b) Shore D hardness testing results for 10 FFF-processed materials after dehydration, compared with raw sample hardness.

Table 1. P-values for statistical analysis showing the effect of dehydration. Values of $p > 0.05$ indicate that no statistically significant difference between the distributions exists.

Material	Shore A	Shore D
ABS	0.008	< 0.001
ABS + 15%CF	0.056	< 0.001
PLA	0.001	0.197
PLA + 15%CF	< 0.001	0.677
PC	< 0.001	0.015
PC + 15%CF	< 0.001	< 0.001
PETG	< 0.001	< 0.001
PETG + 15%CF	< 0.001	0.001
Nylon	< 0.001	< 0.001
Nylon + 25%CF	< 0.001	< 0.001

The use of both the Shore A and Shore D scales allowed a deeper look at the potential performance of these materials, as Shore A allowed the evaluation of the surface hardness, while Shore D enabled evaluation of the bulk hardness due to actual penetration into the material. In all, over 2200 samples were collected for this work to give a deep and useful dataset to be used to inform mechanical design decisions when using these materials in practice. As can be seen in the figures below, the variance in hardness across the surface was very small; this indicates that the properties are very stable and repeatable.

One of the expected risks associated with FFF-processed materials was the tendency to split or separate along the printed elements during testing, as has been observed for some mechanical tests. To evaluate this risk, microscope evaluations were done of the surface indentations made during the tests. These tests (Figure 3) showed that the indentations did not affect the integrity of the samples and behaved as would be expected for injection molded or machined thermoplastic materials. This is a valuable conclusion, as it shows the feasibility of a non-destructive testing method for these materials which will increase user and designer confidence and enable the expanded use of additive manufacturing for end-user consumer products in the future.

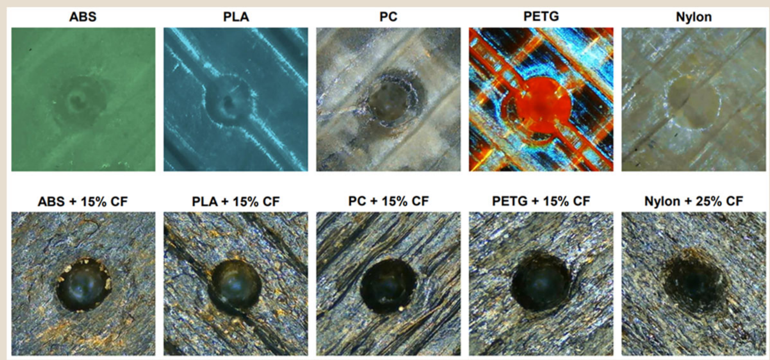


Figure 3. Indentation points for each of the materials, showing clean and well-defined indentations without deep penetration or splitting of displacing the printed elements.

This project provided a much deeper look at the surface properties and potential wear behavior of FFF-processed materials as well as the impact of dehydration on the hardness properties. The results from this work are useful for mechanical designers considering using these materials, particularly for parts that need to interface with or move against others (such as gears and pulleys) in a mechanical system. In addition, this study and evaluation was designed to be easily understandable by practicing engineers and engineering students without specific training in materials science or manufacturing technologies. This allows the impact of this work to be on engineering practice and engineering education, in addition to driving additional academic research on these materials. This project helps to close the gap in knowledge and understanding between traditionally and additively manufactured materials, helping to expand the potential use of additively manufactured materials as a viable choice in mechanical and product development.

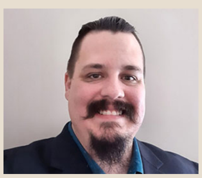
Emily Pentzer selected as editor-in-chief of new science journal

One of her newest achievements is not up there but still sits in high regard in her heart. Pentzer, an associate professor in the Department of Materials Science and Engineering and Department of Chemistry at Texas A&M University, was named editor-in-chief of the Royal Society of Chemistry's (RSC) newest journal, *RSC Applied Polymers.*

"With most awards, you get them, put up the plaque and move on. But with this, you get the honor, and then you get to do a lot of work," she said. "It's really an honor to be trusted with this opportunity."

The journal places a spotlight on the broad application of polymers and will specifically highlight new studies that can help members of the chemical sciences community learn from each other as they tackle some of the significant challenges facing the world today. The journal tackles energy harvesting and storage and addresses sustainability and water remediation concerns, from membranes for separations to bio-based adhesives and coatings.

Full story: **http://bitly.ws/CZJN**



Research tests element behaviors of engineered plastic

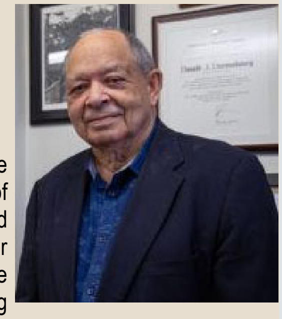
Dr. Albert Patterson, from the Department of Engineering Technology and Industrial Distribution at Texas A&M, collaborated with Dr. Iwona M. Jasiuk, Dr. James T. Allison and doctoral candidate Charul Chadha on the experiments.

MEAM, often known as fused filament fabrication, is a manufacturing process that involves extruding melted thermoplastic materials and polymer matrix composites through a nozzle in a series of elements — sometimes referred to as "roads," "beads" or "fibers" — to build layered parts based on a digital model or design.

Patterson also said the researchers gained insight into the mechanics of built materials by better understanding them as a combination of independent elements. This insight adds support for a new modeling perspective for some additively manufactured materials called the "beam/truss model," where each element is modeled as a beam, each layer as a truss consisting of several beams, and each part as a structure composed of many separate trusses. The findings will help drive design decisions and modeling of the process for macro-scale products and structured materials.

Full story: **http://bitly.ws/CZJN**

Chemist Donald Darensbourg Honored With 2023 SEC Faculty Achievement Award



"Dr. Darensbourg continues to add to an impressive list of honors earned during more than 40 years of service to Texas A&M, and we congratulate him," said Dr. Alan Sams, interim provost and vice president for academic affairs. "He epitomizes faculty excellence and this award not only recognizes his pioneering research but also how he engages students in the research enterprise. He demonstrates the transformational education that Texas A&M provides."

"It is a true honor to receive this recognition, for there are numerous faculty throughout the university who are very deserving of this acknowledgement," Darensbourg said. "I humbly accept and greatly appreciate receiving this award on behalf of my many former students and coworkers."

Darensbourg is known by colleagues to be a devoted teacher and mentor.

Full story: **https://bit.ly/41j0wMw**

Engineering faculty named University Distinguished Professors

Dr. Perla Beatriz Balbuena

Balbuena joined the chemical engineering department at Texas A&M as a full professor in 2004, where she holds the Mike O'Connor Chair I. She has been an affiliated faculty in the materials science and engineering department since 2006 and a joint professor of chemistry since 2016.

She is a fellow of the American Association for the Advancement of Science, the American Institute of Chemical Engineers and the Electrochemical Society. She received the Texas A&M Engineering Experiment Station Research Impact Award in 2020, The Association of Former Students Distinguished Achievements Award in Research in 2018 and the Engineering Genesis Award in 2017.

Full story: **https://bit.ly/41Gi0DK**

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Texas A&M ranks 10th in the nation for graduate engineering

The College of Engineering at Texas A&M University was ranked in the top 10 in the nation for its graduate engineering program, according to the 2024 rankings from *U.S. News & World Report.*

In the latest rankings, Texas A&M was ranked 10th overall nationally and 6th among public institutions in the latest *U.S. News & World Report* survey, "Best Graduate Engineering Schools 2024."

The College of Engineering's research expenditures ranked second only to the Massachusetts Institute of Technology, as reported in the survey. Texas A&M University's world-renowned engineering departments pride themselves on pushing the boundaries of discovery through research and education as they work together to create a better future for all.

Full story: **http://bitly.ws/DC4r**

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Polymer Specialty Certificate Updates

Students that have applied for the Polymer Specialty Certificate	87
Students that have received the Polymer Specialty Certificate	75

For more information, please visit: http://ptc.tamu.edu/polymer-specialty-certificate/

Have Questions?

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PTC Polymer Technology Consortia
Materials Science & Engineering

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