



uniformly dispersing short cylindrical micelles of a low-molecular-weight poly(ethylene oxide)-*b*-poly(butylene oxide) (PEO-PBO) diblock in commercial high-molecular-weight glassy PLLA. Introduction of these micelles into the PLLA results in a greater than tenfold increase in tensile toughness and notched Izod impact strength.

“Despite standard polymer physics, the attempt was to try and toughen PLA by creating the same type of nanoscale micelles that the group has been investigating for years in epoxy resins. This finding has the potential to be a facile and economical way to toughen PLA and perhaps produce low-density porous films,” says chief scientist Frank Bates.

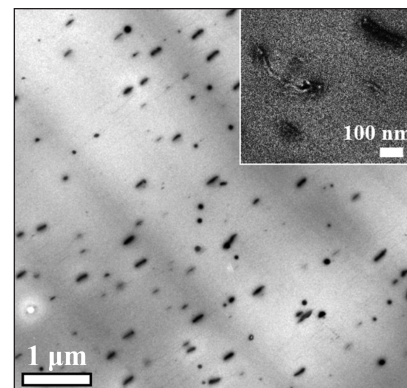
As reported in a recent issue of *ACS Macro Letters* (doi:10.1021/acsmacrolett.6b00063), Tuoqi Li, a graduate student in the group, synthesized a series of PEO-PBO diblock copolymers (a polymer with distinct blocks of monomers PEO and PBO grafted together to form a single copolymer chain), identified as EB1–3, as well as a PLLA-PBO diblock, identified as LB, by anionic polymerization with fixed composition but with varying total molecular weight. Blends of PLLA and both the diblock PLLA copolymers were then prepared by solvent and melt blending routes, followed by rapid cooling and aging for two days prior to characterization.

The resulting blend, identified as EB1/PLLA, showed a dispersion of the EB1 copolymer into small micelle-like

particles as shown in the figure. In general, increasing the overall molecular weight of the EB additives in PLLA led to coarser dispersions and larger domain sizes than those expected from the assembly of individual micelles. The blend prepared using EB1 exhibited the greatest improvement relative to neat PLLA with a 1300% increase in tensile toughness and a 2500% increase in strain at break. By adding 1.25 wt% and 5 wt% EB1 to the PLLA, the notched Izod impact strength (measured by impacting the specimen by an arm from a height, and measuring the amount of energy absorbed by the sample) could be improved by 600% and 1500%, respectively.

“This is an exciting advance by Bates and co-workers that shows how diblock polyether additives can have a profound influence on toughness and impact strength without degrading other properties,” explains Geoffrey Coates, an expert in defined structure polymers from Cornell University. He further says, “These additives have great potential to create poly(lactides) that have performance characteristics that match their already impressive environmental attributes.”

The favorable enthalpic dispersion of EB1 into bulk PLLA as a micelle microstructure was attributed to a negative Flory–Huggins interaction parameter, which means that the mixing is of an exothermic nature. Study of the tensile specimens before and after deformation suggested that the improved performance



Transmission electron microscope image of 5 wt% EB/PLLA blend showing, in the inset, the micelle structure at a higher magnification. Credit: *ACS Macro Letters*.

derives from the formation of micron and submicron holes, which are caused by cavitation of the rubbery core micelles. Along with this kind of cavitation, micromechanical mechanisms of crazing and shear yielding are believed to produce a synergistic toughening effect in the PLLA-EB1 blends.

This work represents a significant step toward developing a low-cost approach for toughening sustainable glassy PLLA materials based on a facile processing route. The controlled cavitation and void formation observed offers a new method for producing low-density porous materials with a host of potential applications. Future research would entail a more comprehensive study of the toughening mechanisms for the series of EB diblocks.

Rachana Acharya

Energy Focus

Carbon nanotubes improve radiation resistance of aluminum

The limited operating lifetimes of nuclear structural materials is due to embrittlement and porosity that occur in these materials under long-term radiation exposure near a reactor core. Carbon nanotube (CNT)-reinforced aluminum composite materials provide a possible solution to this problem. The addition of small quantities of CNTs to aluminum dramatically improves the material's

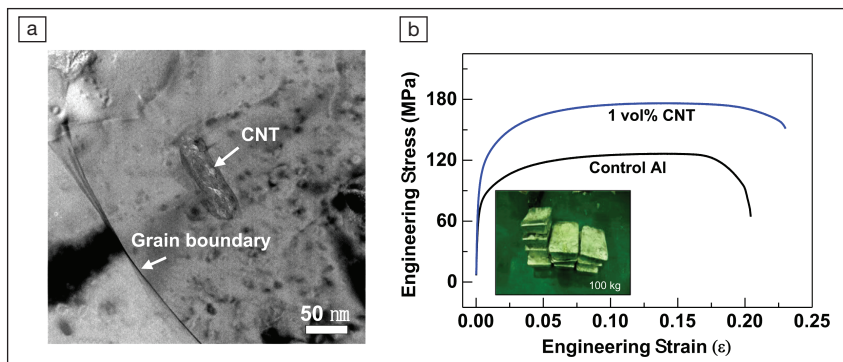
irradiation tolerance, suggesting potential applications in nuclear reactors, nuclear waste containers, nuclear batteries, and spacecraft. The dispersion of multi-walled carbon nanotubes in a metal matrix effectively mitigates radiation damage through additional internal interfaces for self-healing of radiation defects, and improves the mechanical properties by inhibiting dislocation propagation.

In a recent issue of *Nano Energy* (doi:10.1016/j.nanoen.2016.01.019), a research team led by Ju Li from the Departments of Nuclear Science

Engineering and of Materials Science Engineering at the Massachusetts Institute of Technology investigated the basic materials science of an aluminum/CNT composite. “The key technology of our research is the dispersion of the CNTs inside metal grains,” says Kang Pyo So, the lead author of this work. These CNTs facilitate the recombination of atomic-level defects, such as vacancies, interstitials, and dislocation loops, and may provide pathways for releasing helium instead of trapping helium along grain boundaries to cause embrittlement. CNTs transform

to aluminum carbide when radiated to a high dose of 72 dpa, but the one-dimensional nanomorphologies survive along with the self-healing interfaces that catalyze defect recombination.

In addition, this composite material exhibits improved mechanical strength and toughness as compared to the reference metal. The high-aspect ratio of CNTs creates obstacles for dislocation and crack propagation in the metal matrix. The standard tensile test of aluminum with 1% volume CNTs shows significant improvement in tensile strength without decreasing ductility as compared to the bulk Al specimen. The manufacturing process is also scalable. At less than two times the price of aluminum alloys, the team mass-produced over 100 kg of this composite material in the laboratory. “We can use this nanocomposite as a lightweight and long-term sustainable material in automotive vehicles, airplanes, and ships,” Kang Pyo says.



Dispersion of carbon nanotubes (CNTs) inside Al grain improves tensile strength without sacrificing ductility, where (a) shows a transmission electron micrograph of the CNT inside an Al grain and (b) shows the stress–strain curve (inset: 100 kg of the Al+CNT composite). Credit: *Nano Energy*.

“This work provides an insight to explore a new regime for designing materials under radiation applications, from previous approaches such as dispersing oxide nanoparticles into an Al matrix,” says Shimin Mao, an expert studying irradiation effects of materials

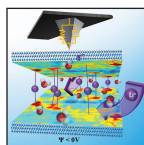
at the University of Illinois at Urbana-Champaign. “This will encourage other researchers in the field to implement more fundamental studies on nanocomposite-type radiation resistance materials.”

YuHao Liu

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Scanning probe microscopy reveals nanoscale pathways for ion transport in a future energy storage material

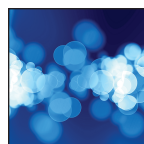
Melissa Fellet | *Materials Research Society* | Published: 15 April 2016



Scanning probe microscopy provides a nanoscale look at how ion storage impacts the mechanical properties of a future energy-storage material called MXene.

New sensor detects dangerous scentless Alkane fuels used in bombs

Susanna Pilny | *Red Orbit* | Published: 15 April 2016



For those of you who have natural gas in your home, the smell of rotten eggs is a sign you need to get out of there and call the proper authorities. But in other combustible materials like gasoline, airplane fuel, oil, or even homemade bombs, the key ingredient—alkane fuel—is extremely difficult to detect, meaning leaks or attacks are impossible to catch before it's too late.

Laureates call for cut to highly enriched uranium

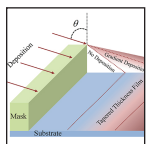
Peter Gwynne | *Physics World* | Published: 12 April 2016



A group of 35 Nobel laureates, including 16 physicists, has called on world leaders to reduce the use of highly enriched uranium (HEU) in naval nuclear propulsion and research reactors. In a letter addressed to national leaders at last week's Nuclear Security Summit in Washington DC, the laureates call for “serious technical studies” to transition naval reactors to using low-enriched uranium (LEU). They also call for a roadmap for converting or shutting down research reactors that use HEU, as well as the development of non-radioactive alternatives – such as cobalt-60 and caesium-137 – for use in medicine and research.

Glancing angle vapor deposition creates complex structures

Meg Marquardt | *Materials Research Society* | Published: 12 April 2016



Nanophotonics pushes the limits of several fields, from solar-cell technology to data processing. In order to tap into light's full potential at the nanoscale, researchers need to be able to create more diverse and complex structures. A team of researchers at Purdue University has developed an angled vapor deposition system that allows for more controlled deposition, for the creation of complex and novel quasi-three-dimensional (3D) structures, as reported in a recent issue of *MRS Communications*.