Live

Scalable Manufacturing Processes Equipped with Dispersion Control of Nanofillers for Energy Storage Applications

Professor Yong Lak Joo

School of Chemical and Biomolecular Engineering,
Cornell University, Ithaca NY 14853

Controlling the dispersion of nanofillers in a matrix has a significant effect on their properties, such as mechanical, optical, electrical and magnetic properties. Employing circumferentially uniform air flow through the sheath layer of the concentric coaxial nozzles, air-assisted electrospinning and electrospray utilize both high electric field and controlled air flow which can offer i) enhanced stretching of fluid jet and drops, and thus much higher throughput, and ii) better control of dispersion and configuration of nanofillers in a jet or droplet even at high loadings. The ability to tailor the distribution of various nanofillers (spherical SiO_2 and Si nanoparticles (NP) and rod/tube–like carbon nanotubes (CNTs), and carbon nanoribbons (GNRs)) in a polyvinyl alcohol (PVA) jet was demonstrated by varying air flow rates in gas-assisted electrospinning. The distribution and orientation of nanofillers in resulting nanofibers were measured by analyzing the transmission electron microscope (TEM) images. Our results reveal that two to three fold improvement in NP distribution can be obtained with the application of high, but controlled air flow. The substantial improvement in the orientation of CNTs and GNRs by additional controlled air flow was also observed, while GNRs exhibit better dispersion with retarded orientation than CNTs due to the increase in their flexibility caused by the unzipping process. These results are validated by the coarse-grained Molecular Dynamics (CGMD) study of nanofillers in a polymer matrix under elongational flow. The enhanced electrochemical performance by controlling dispersion and configuration of nanofillers in nanofibers has been demonstrated in the directly deposited, Li-ion battery anode application, exhibiting over 2,000 mAh/g of capacity which is about 1,000 mAh/g higher than the anode obtained by conventional electrospinning. The direct deposit approach has been extended to the air-controlled electrospray process to create a compact deposition of Si particles wrapped by graphene sheets, and the resulting anode of directly deposited Si/reduced graphene oxide exhibits about 1,500 mAh/g of capacity for 200 cycles without capacity loss. Finally, we demonstrate that the direct deposit approach based on air-controlled electrospray enables high sulfur loading in mesoporous carbon and sandwich-stacking of different graphene materials for high performance Li-sulfur and Li-air batteries, respectively.

Yong Lak Joo is a Professor in the School of Chemical & Biomolecular Engineering at Cornell University. He received his B.S. degree at Seoul National University in Korea in 1989, and received his Ph.D. in Chemical Engineering at Stanford University in 1993. From 1993 and 1999, he was a senior research engineer at Hanwha Chemical

Corporation in Korea. Prior to joining Cornell in 2001, Yong Lak Joo did two years of a postdoctoral research in the Department of Chemical Engineering at MIT.

His research focuses on the integration of molecular details into a macroscopic level in nanomaterials processing. In particular, he has recently laid the new foundation for experimental and theoretical studies on advanced, scalable nano-manufacturing processes based on the flow instability such as gas-assisted electrospinning and air-controlled electrospray. He is a fellow of American Institute of Chemical Engineers (AIChE). He received a 3M Faculty Award and is a recipient of a National Science Foundation CAREER Award and a DuPont Young Professor Award. He also received an Excellence in Teaching Award in College of Engineering, Cornell University.

When: Tuesday, October 25, 2016 at 11 am
Where: EP#252