Powder Technology and the Future of Chemical Engineering

Gregory S. Patience, P.Eng
Canada Research Chair, High Temperature, High Pressure Heterogeneous Catalysis

Modern society flourishes because of advances in powder technology that spans fields from food (flour, sugar, cheerios), cement, ceramics, chemicals, pharmaceuticals, and batteries. The emerging challenges for humanity will be to recycle the products of these advances rather than allowing them to accumulate in the environment. The feedstocks of the future will be biomass and waste. However, to compete with petroleum and existing infrastructure, emerging processes must be economic as consumers continue to favour low prices and convenience over conscience.

Micronization is one of the first steps to decrease the heterogeneity of waste and biomass, to make to make catalyst, and also to produce nano-particles for Li-ion battery materials. Slurrying these particles with substrates - enzymes, carbon, and silica follows in many processes. Our laboratory fabricates C-LiFePO4 nanoparticles and powders for cathode materials, synthesizes catalyst for processes that convert glycerol (from biodiesel) to acrolein, fructose to furan dicarboxylic acid, and wasted natural gas to Fischer-Tropsch fuels, and powders to depolymerize end of life polymers to monomers like polymethylmethacrylate to metahcacrylic acid. We spray dry the slurries in the next manufacturing step for catalysts to produce spherical microspheres from 20 µm to 200 µm. Finally, high temperature furnaces calcine these powder to activate them and to improve their attrition resistance to survive the mechanical stresses during transport or in reactors.

Our laboratory has integrated mechano-chemical techniques to decrease the processing times to produce particles. We introduced ultrasonic probes into a media mill with 2 mm zirconia media. With this innovation, we were able to micronize LiFePO4 powders at a 60 weight percent and reduce the particle size to less than 200 nm. We spray dried these powders to form microspheres and developed a recipe

To convert fructose solutions to value added chemicals, we developed technology in which we atomize a liquid solution into a catalytic fluidized bed operating at between 200 ^{o}C and 500 ^{o}C. Since the heat and mass transfer rates are faster than the caramelization rates, the hexoses react HMF and DFF. Reaction rates are orders of magnitude higher than liquid phase processes and deactivation rates due to furanic polymers are lower. Challenges facing these technologies include (1) densifying nanparticles for batteries; (2) reducing Ostwald ripening (precious metal sintering) and coke in reactors operating at high pressure; (3) atomizing sugars in large scale spargers; and (4) identifying reactor technology and catalyst to recycle end of use polymers.

Biography

Gregory Patience holds a Canada Research Chair in high temperature, high pressure heterogeneous catalysis and is professor of Chemical Engineering at Polytechnique Montreal. He published two books – Experimental Methods and Instrumentation for Chemical Engineers and Communicate Science Papers, Presentations and Poster Effectively – filed 14 patents and published 160 scientific articles. Together with process development, his research focuses on catalysis and gas-solids fluidization applied to biodiesel from waste fat and oils, (2) producing carboxylic acid from glucose, xylose and lignin, (3) converting waste natural gas to Fischer-Tropsch fuels, (4) deriving value added chemicals from glycerol, and (5) synthesizing carbon coated LiFePO4 for batteries.

Prof. Patience started his career at DuPont in 1990 after completing his PhD at Polytechnique Montreal. He helped develop fluidized bed catalyst in Delaware and joined the commercial team in 1996 in Asturias, Spain. In 2000, he moved to Lycra® and managed the Fibres Technology Laboratory in Geneva and was the Technology lead for new business development and circular knits. Professor Anil Mehrotra was his M.Sc. advisor at the University of Calgary (1987) and he finished his B.Sc. in 1983.

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