

1) “Living”/controlled radical polymerization

We work in the areas of atom-transfer radical polymerization (ATRP) aiming at (1) developing support systems for catalyst recycling, (2) developing continuous processes, and (3) elucidating radical mechanisms. The support systems included physical adsorption and chemical grafting of ATRP catalyst/ligand onto insoluble silica particles and soluble-but-recoverable polymer supports. We also developed a continuous packed-column reactor technology (C-SATRP) for making well-controlled block copolymers. In the fundamental side, we were the first group who observed radical intermediates in ATRP by ESR and thus provided direct support to the debated radical mechanisms. We also investigated the diffusion-controlled reactions in ATRP aimed at improving molecular weight control at high conversion. We collaborate with Professor Krzysztof Matyjaszewski, Carnegie Mellon, and Professor Steven Armes, Sussex, and Professors Michael Cunningham and Rubin Hutchinson, Queen’s, in some of the areas.

2) Olefin polymerization with single site type catalysts

We work in the areas of (1) preparation and characterization of long chain branched (LCB) polyethylene, and (2) control of polyethylene morphology by nano-tube particles. We made LCBed PEs in high temperature solution polymerization using a CSTR technology. The samples showed significant shear thinning properties. We investigated ethylene copolymerization with propylene and octene. By comparing the comonomer reactivities to that of in-situ generated PE macromonomer, we proposed a same-site branching mechanism, that is, PE macromonomer is incorporated into PE backbone chain at the same site as it is generated. We developed various methods for making more LCBs, that include binary catalyst systems and two-step processes. Recently, we work on using nano-tube particles as support for metallocene catalysts to prepare extended chain crystal PE fibers. A perfect ECC PE fiber is expected to have a mechanical strength competitive to steel. We collaborate with Professor Jerry Lin, Cincinnati, in the nanotube area.

3) Polymer grafting for non bio-fouling surfaces and polyelectrolytes for non-viral gene deliveries.

We graft bio-compatible polymers such as 2-methacryloyloxy ethyl phosphorylcholine (MPC) onto inorganic/organic surfaces by ATRP methods. These polymer-modified surfaces have good protein repulsion properties to avoid bio-fouling. We also work on preparing well-defined polyelectrolytes using ATRP for non-viral gene/drug delivery purposes. For example, polymer products of 2-(dimethylamino)ethyl methacrylate can complex with DNA or oligonucleotides that facilitates transfection. We collaborate with Professors John Brash and Yingfu Li, McMaster, and Professor E.T. Kang, NUS, in the bio areas.

4) Plastic microelectronics

We synthesize and functionalize semi-conductive polymers such as polythiophene for microelectronics applications. Our focuses are on the relationships of polymer chain structure, materials morphology, and carrier mobility and stability of performance of the materials. We particularly emphasize the interfacial problems associated with the materials. We collaborate with Professor Gianluigi Botton and Gu Xu in Materials and Dr. Beng Ong, Xerox in this area.

5) Modeling polymerization processes

We develop mathematical models for various polymerization processes. Recently, we focused on branched polymers as well as those produced by living/controlled radical polymerization processes. We collaborate with Professor Hidataka Tobita Fukui and Eduardo Vilvado-Lima UNAM in some of the areas.