Scale-up and Commercial Production of Emulsion Polymers

Day 1

AM

- Basics of creating and characterizing synthetic latices
  1. Particle nucleation and growth
  2. Control of particle size distribution
  3. Control of copolymer composition, MW, gel content
  4. Functional additives (esp. vinyl acids) and neutralization
  5. Colloidal stability
  6. Latex rheology, especially at high solids content
  7. Measurement of particle size, chemical composition, glass transitions, MFFT, acid distribution

PM

- Reaction process alternatives
  1. Batch reactors
     - *Ab initio* particle nucleation (I), growth (II) and final (III) periods
     - "Seeded" polymerizations
     - Copolymer composition drift, surfactant and initiator demands
     - Heat evolution profiles and heat transfer requirements
  2. Semi-batch reactors
     - Comonomer feed strategies (constant/variable rates, power feeds)
     - Effective monomer concentration in particles
     - Surfactant and initiator demands
     - Heat transfer requirements
  3. Continuous reactors
     - Residence time considerations
     - Number and size of reactors in series
  4. Temperature control characteristics of reactors
     - Jacketed reactors, cooling water limitations
     - Reflux operations, vapor velocity
     - Cooling capacity of monomer/emulsion feed streams

Day 2

AM

- Concepts and issues of scale up
  1. Comparisons of small and large reactors
     - Surface to volume ratio
     - Radial and vertical mixing
     - Potential for temperature and concentration gradients
  2. Dynamic similarity considerations of reactors
  3. Issues related to process type (batch, flooded, starve fed)
     - Reaction rate/time profiles, heat evolution
     - Free monomer content within reactor and vapor pressure
     - Phase distribution of functional monomers
     - Reactor entry point for monomer/emulsion feed stream

PM

- Fluid mixing characteristics and issues in large reactors
  1. Agitator types and purposes, tip speeds
  2. Fluid behavior near agitator blades
  3. Velocity distributions within the reactor
     - Effect on dispersing incoming monomers
     - Effect on energy transport to reactor walls
     - Computational fluid dynamics (CFD)
- Positioning feed stream entry points
- Agitator power requirements during reaction

Day 3

AM

- High solids latex production
  1. Optimization of polymer production capacity
  2. Latex viscosity and heat transfer
  3. Optimal particle size distribution
  4. Post-reaction neutralization of vinyl acid functional additives
     - Maximum concentration of base
     - Feed rate of base addition

Day 3

PM

- Residual monomer reduction – chemical and physical alternatives
- Avoiding secondary nucleation, particle aggregation and coagulum in scale-up
- Sensors for off/on-line measurements - latex surface tension and conductivity
- Scale-up criteria – what works best for different types of latices
- Identifying potential "show stoppers" or critical issues in a polymerization process
- Concepts in process ***scale-down***
    1. Designing lab and pilot scale experiments to investigate problems encountered in commercial scale operations
    2. Identifying potential large scale problems while still at the small scale

Day 4

AM

- ***Cap stone experience*** – interactive engagement in process design
    1. "Make it faster and cheaper, but don't degrade the quality!"
    2. What changes are possible? What are their likely effects on latex properties?
    3. Homogeneous particles, structured particles
    4. Formulation change possibilities (monomers, initiators, surfactants, functional additives)
    5. Process change possibilities (temperature profiles, semi-batch variations)