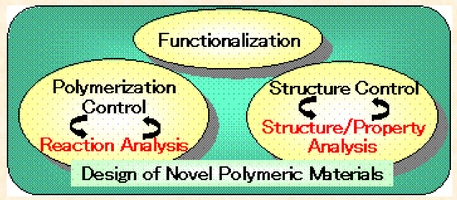
Design, Synthesis, and Characterization of Polymers for Biocompatible/Biodegradable/Biological Applications

Jamie M. Messman

Macromolecular Complex Systems, Center for Nanophase Materials Science, Oak Ridge National Laboratory, Oak Ridge Tennessee 37831-6197

Tel: 865-576-2394, Fax: 865-576-7956, E-mail: messmanjm@ornl.gov



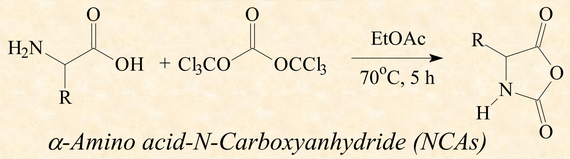
Specializing in well-defined polymers with ***control of molecular weight and architecture*** through anionic, cationic, ring-opening, controlled free-radical and condensation polymerization technologies.

Living Polypeptide Synthesis

Why Polypeptides?

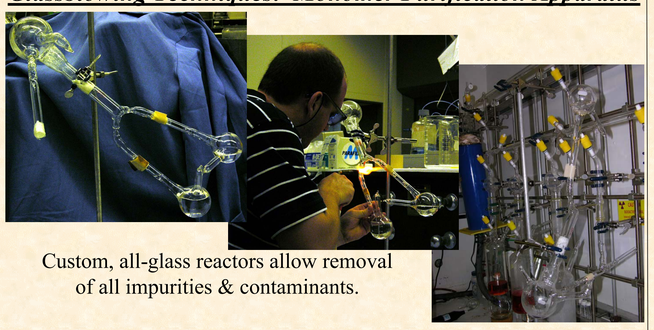
- Response to external stimuli
- Self-assembly: secondary structures α helix and β sheet
- Biomimetic
- Applications:
  - biotechnology (artificial tissues and drug delivery)
  - biomineralization (resilient, lightweight, ordered inorganic composites)
  - diagnostics (biosensors and medical analysis)

Monomer Synthesis



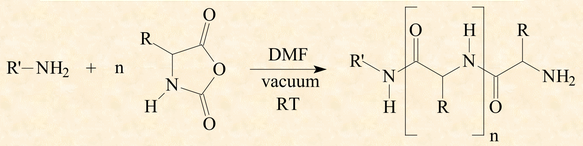
α-Amino acid-N-Carboxyanhydride (NCAs)

Glassblowing Techniques: Monomer Purification Apparatus

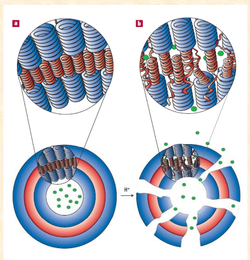


Custom, all-glass reactors allow removal of all impurities & contaminants.

Polymer Synthesis: High Vacuum Techniques

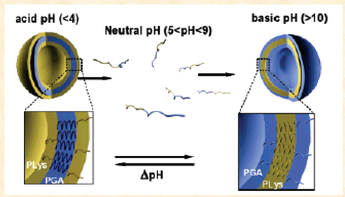


Smart Drug Carriers



Jones, R.A. *Nature Mater.* **2004,** *3,* 209.

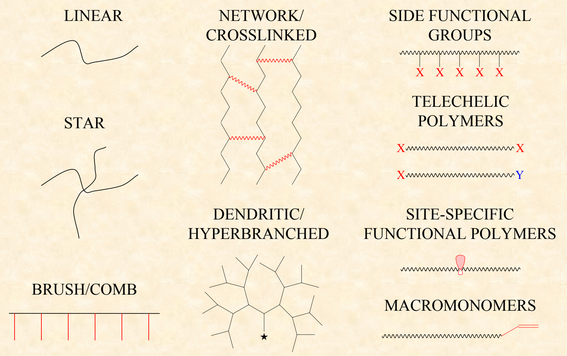
Self-assembly of Poly(L-glutamic acid)-b-poly(L-lysine)

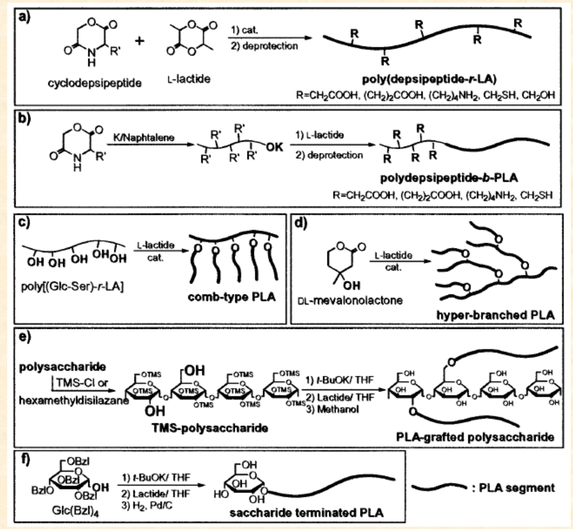


Rodriguez-Hernandez, J.; Lecommandoux, S. *J. Amer. Chem. Soc.* **2005,** *127,* 2026.

Controlled Ring-Opening Polymerization (ROP) of Lactone and Cyclic Carbonate Monomers

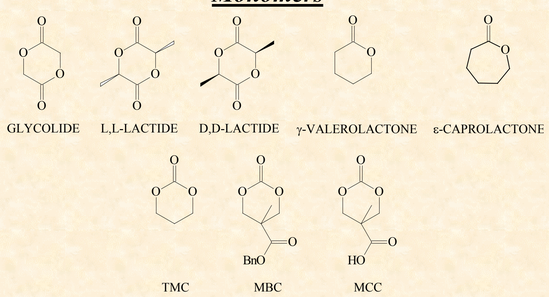
Opportunities for Controlled ROP



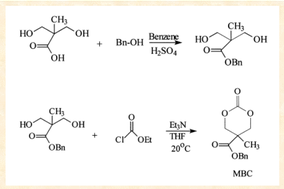


Ouchi, T.; Ohya, Y. *J. Polym. Sci.: Part A: Polym. Chem.* **2004,** *42,* 453.

Monomers



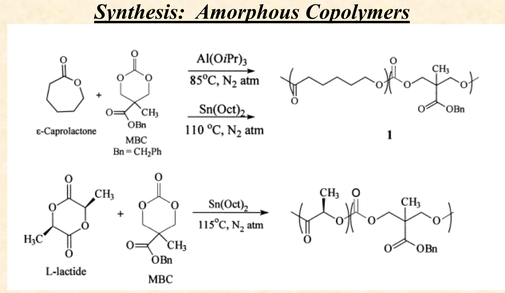
Custom Monomer Synthesis: MBC Synthesis



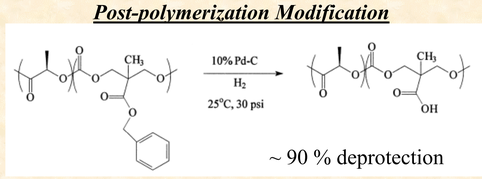
Polymer synthesis can be tailored for…
…predictable degradation rates/patterns
…specific applications (e.g., drug delivery systems)
…incorporation of multiple monomers (degradable, non-degradable, and **deuterated**)
…post-polymerization modification (**deuteration**)

Random Copolymers

Synthesis: Amorphous Copolymers



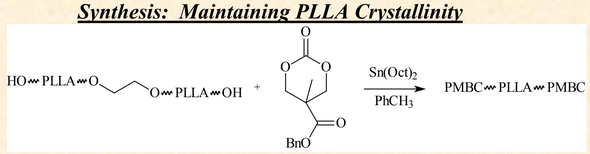
Post-polymerization Modification



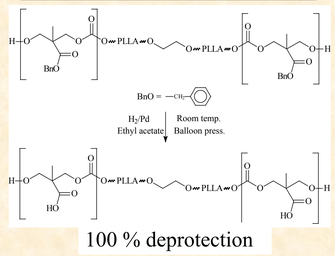
Storey, R.F. *et. al. J. Macromol. Sci.-Pure Appl. Chem.* **2001,** *A38(9),* 897.

Block Copolymers

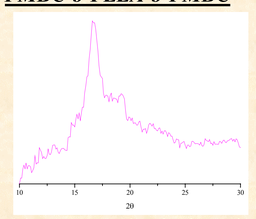
Synthesis: Maintaining PLLA Crystallinity



Post-polymerization Modification



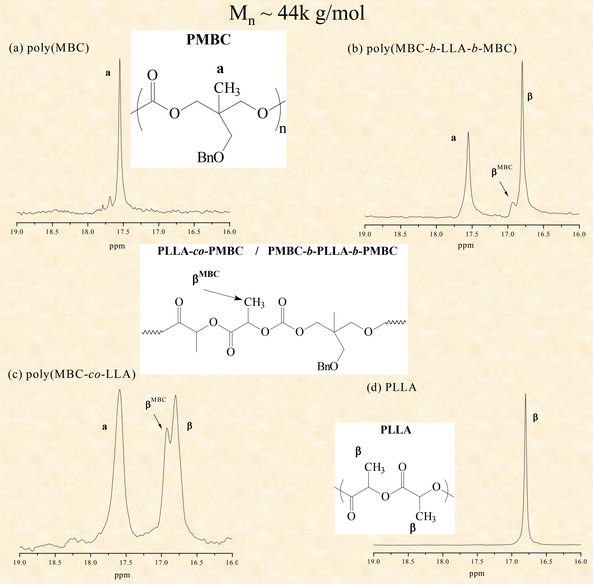
WAXD Profile of PMBC-b-PLLA-b-PMBC*



*Measurement made at Southern Miss

^{13}C NMR Characterization of Homo- and Copolymers

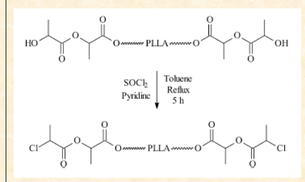
Copolymers: 57 mol % MBC *via* ^{1}H NMR, M_n ~ 44k g/mol



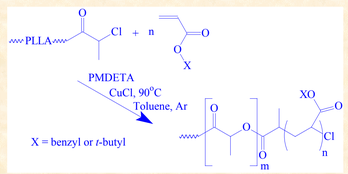
Novel Block Copolymer Synthesis Combining Polymerization Mechanisms in

Combining ROP and ATRP

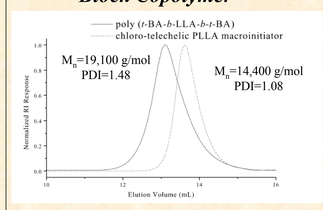
Chain-end Functionalization



PLLA as a Macroinitiator

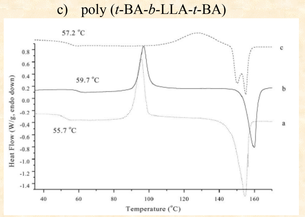


SEC Chromatograms of PLLA Macroinitiator and Block Copolymer



DSC Thermograms

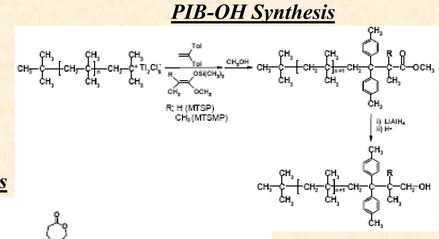
- hydroxy-telechelic PLLA
- chloro-telechelic PLLA
- c) poly (*t*-BA-*b*-LLA-*t*-BA)



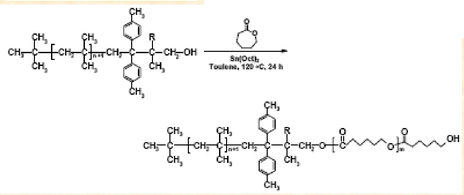
Messman, J.M. *et. al. Polymer* **2005,** *46,* 3628.

Combining Quasiliving Carbocationic and ROP

PIB-OH Synthesis



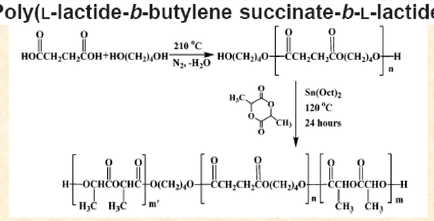
PIB-b-PCL Synthesis



Faust, R. *et. al. ACS Polym. Prepr.* **2002,** *43(2), 400.*

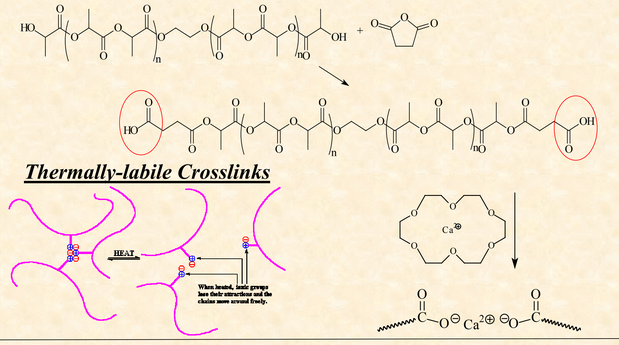
Combining Condensation and ROP

Poly(L-lactide-*b*-butylene succinate-*b*-L-lactide)



Ba, C. *et. al. Biomacromolecules* **2003,** *4,* 1827.

Ionomer Synthesis (Charged Polymers)



Thermally-labile Crosslinks

Acknowledgments

Research sponsored by the Division of Materials Sciences and Engineering, Office of Basic Energy Sciences, U.S. Department of Energy, under contract DE-AC05-00OR22725 with Oak Ridge National Laboratory, managed and operated by UT-Battelle, LLC.

JMM supported by an appointment sponsored by the ORNL Postdoctoral Research Associates Program administered jointly by the Oak Ridge Institute for Science and Education and ORNL.

Office of Science U.S. DEPARTMENT OF ENERGY

Office of Basic Energy Sciences — Serving the Present, Shaping the Future

CNMS Oak Ridge National Laboratory — Center for Nanophase Materials Sciences