

Relating Polyethylene Micro-Structural with Macro-Mechanical Properties and Modelling

Joy Cheng, Alexander Penlidis
Department of Chemical Engineering

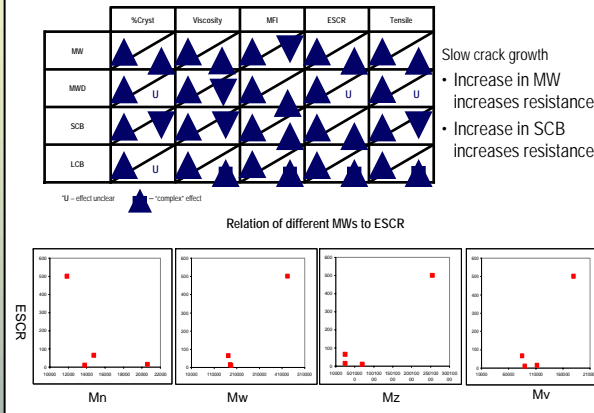
Institute for Polymer
Research (IPR)

José Alvarado-Contreras, Maria Anna Polak
Department of Civil Engineering

Research Objectives

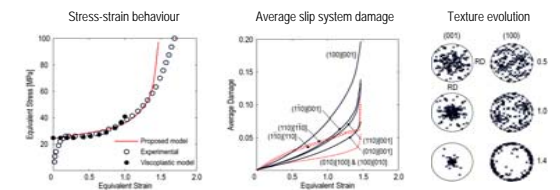
- Investigate relationships between chemical and mechanical properties for polyethylene
- Establish limiting property regions with respect to different effects
- Ascertain correlations for combination of variables (combined effects)
- Modify the existing viscoplastic constitutive models for micromodelling of crystalline polyethylene to incorporate slip system damage

Chemical - Mechanical Correlations

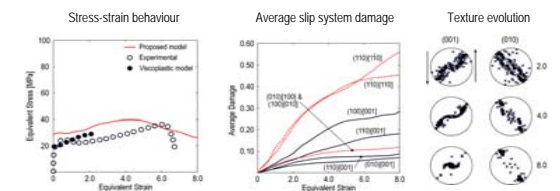


Simulations

Uniaxial tension case



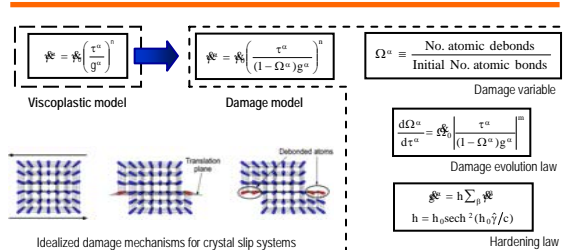
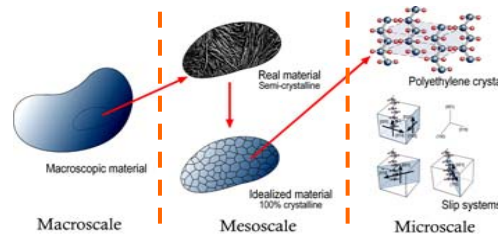
Simple shear case



Methods and Results

Test Methods	Material Properties
Gel Permeation Chromatography (GPC)	Molecular weight and distribution Long chain branching indicators
Differential Scanning Calorimetry (DSC)	Percentage crystallinity
Crystallization Analysis Fractionation (CRYSTAF)	Short chain branching and its distribution
Nuclear Magnetic Resonance (¹³ C-NMR)	Short/Long chain branching
Notch Constant Load Test (NCLT)	Environmental Stress Cracking Resistance (ESCR)
Tensile creep	Tensile properties
Capillary rheometry	Molecular weight and distribution Long chain branching level
Oscillating shear analysis	Long chain branching, shear modulus, shear viscosity

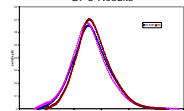
Micro-mechanical Modelling



Concluding remarks

- Material property mapping has been carried out for several industrial high density polyethylene resins.
- Preliminary property correlations for chemical-mechanical properties of polyethylene have been developed. Refinements/more testing are underway.
- A micromechanical model considering progressive slip system degradation has been proposed to predict stress-strain behaviour, damage, and texture evolution in crystalline polyethylene.
- The governing constitutive equations are formulated considering the material microstructure.

GPC Results



C13-NMR Results

	PE1	PE2	PE3
SCB (wt%)	20.89	3.33	2.86
LCB (wt%)	1.18	1.48	1.18

CRYSTAF Results

Parameter	Value
Crystallinity (%)	65.24
Crystallite size (nm)	12
Crystallite thickness (nm)	12
Crystallite width (nm)	12
Crystallite height (nm)	12

Property map for blow molding resins

