

Fourteenth Annual  
Intensive Short Course on  
POLYMERIZATION Chemistry  
and  
Reaction Engineering  
featuring  
metallocene catalysis and  
emulsion/suspension PROCESSES

Monday, June 7  
to  
Friday, June 11  
1999

Directed by

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McMaster Institute for Polymer Production Technology,  
McMaster University

and

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Department of Chemical Engineering  
University of Waterloo

to be held at

PORTO CARRAS  
Porto Carras, Sithonia, Halkidiki  
GREECE

# POLYMER REACTION ENGINEERING

Monday, June 7

to

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## PROGRAMME

Monday, June 7

Morning CHAIN-GROWTH POLYMERIZATION MECHANISMS AND KINETICS  
Session:  
9:00-12:30

An introduction to free radical and ionic (heterogeneous and homogeneous Ziegler-Natta and metallocene catalysis) polymerization kinetics.

Topics include:

- Linear, branched and crosslinked chains via free-radical mechanisms
- Linear and branched chains via ionic mechanisms (heterogeneous and homogeneous Ziegler-Natta and metallocene catalysis)
- Stockmayer's bivariate distribution--instantaneous property methods

Afternoon ADVANCED POLYMERIZATION KINETICS  
Session  
5:00-8:00

Topics include:

- Identification of multiple active site types (GPC, TREF/NMR, TREF/GPC/NMR)
- Identification of active site performance
- Long chain branching
- Ziegler-Natta and metallocene catalysis

Tuesday, June 8

Morning EMULSION / DISPERSION / SUSPENSION PROCESSES  
Session  
9:00-12:30

Topics include:

- Styrenics, PVC

- Batch, semi-batch and continuous operation
- Relevant thermodynamics and surface chemistry
- Particle nucleation/growth
- Ionic/steric stabilization
- Particle size distribution and molecular weight distribution

Afternoon POLYOLEFINIC PROCESSES  
Session  
5:00 – 8:00

Topics include:

- Molecular, rheological and solid state properties which are relevant to production, processing and end use applications of polyolefins (LDPE, HDPE, LLDPE, polypropylene, and copolymers)
- Effects of short and long chain branching and molecular weight distributions
- Effects of main process variables on productivity and polymer properties
- Models of polyolefin production processes and plant data comparisons. Examples will include free radical high pressure processes (tubular and autoclave reactors) & heterogeneous catalytic processes (slurry and gas phase)

Wednesday, June 9

Morning PRINCIPLES OF POLYMER REACTOR MODELLING AND KINETIC  
DATA  
Session COLLECTION  
9:00 – 12:30

In this section, ideas from all previous lectures (i.e. physico-chemical phenomena operative in polymerization systems) will be incorporated into a mathematical model. Steps for the development of a polymerization model will be outlined, and applications/ uses of models will be discussed. Important modern aspects on parameter estimation and the optimal design of experiments in aid of meaningful kinetic data collection will also be highlighted.

Topics include:

- Batch, semi-batch and continuous operation
- Dynamic modelling of reactor systems
- Population balance equations for particle size and molecular weight
- Screening and factorial designs for data collection
- Sequential and non-linear design of experiments
- Evolutionary operation
- Model discrimination issues

Wednesday afternoon is available for study, questions or other personal pursuits. We hope that the tradition will continue this year as well. In our annual soccer game last year the "course" team beat the "hotel" team 6 - 5. Bring your soccer shoes! Let's win again !

Thursday, June 10

Morning Session  
MODERN SPECIAL TOPICS  
9:00 – 12:30

Topics include:

- Advances in initiators
- Bulk/solution/emulsion terpolymerization
- Reactivity ratio estimation
- Monte Carlo methodology/applications
- Reactive processing
- Measurement of long chain branching (GPC/VISC/LALLS)

Afternoon Session  
CHEMICAL COMPOSITION DISTRIBUTION IN POLYOLEFINS:  
CHARACTERIZATION TECHNIQUES  
5:00 – 8:00

Topics include:

- Review of chemical structure
- Composition - molecular weight relationships
- TREF: Temperature Rising Elution Fractionation
- CRYSTAF: Crystallization Analysis Fractionation is a new technique for the analysis of composition distribution in semi crystalline polymers, and more specifically for the analysis of branching distribution in polyethylene and tacticity in polypropylene resins.

Friday, June 11

Morning Session  
MONITORING, DYNAMICS AND CONTROL OF POLYMERIZATION  
PROCESSES  
9:00 – 12:00

A good understanding of the reaction mechanisms and of the dynamic behaviour of the reactor system is essential to ensure safe and stable operation and achieve tight product quality control.

Topics include:

- Overview of current control practices
- Sensors for monitoring reactor behaviour
- Energy balance and rate control
- Control of product properties
- Model uses to combine on-line and off-line data
- Kalman filtering and inferential control

- Software sensors and multivariable statistics
  - Optimal reactor grade changes
  - Advanced linear and non-linear control
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- 12:00 ADJOURNMENT

## GENERAL INFORMATION

### COURSE FEES

Please send e-mail to [jpr@uwaterloo.ca](mailto:jpr@uwaterloo.ca) for information on registration fees. A discount is available for multiple participants from one company. The course fee includes registration, room for five nights, breakfast and dinner for five days, beverage breaks and course notes.

### CANCELLATION

An administration fee of 15% will be charged for cancellations received before June 1, 1999. NO REFUNDS after that date.

### COURSE NOTES

The course notes have recently been updated and expanded and are included in the cost of registration. Copies are available for purchase by non-participants. Notes will be given to participants at 8:50 am just before lectures start.

### RECEPTION

An informal reception and wine and cheese welcoming party will be held on Sunday evening (8:00 pm), June 6, 1999. The reception will be followed by dinner.

### HOUSING

The course will be held at the Meliton hotel of the PORTO CARRAS complex, SITHONIA, HALKIDIKI, GREECE. The participants will be accommodated for five days, and this is included in the cost of registration.

Porto Carras is a delightful luxury holiday resort set in one of the most unspoiled and picturesque regions of Greece. There are more than 30 secluded sandy coves; sport facilities include an 18-hole golf course, tennis, horseback riding and various types of water sports. If you wish to extend your visit, the management assures us that you can obtain special rates.

### MEALS

Breakfast, dinner and beverage breaks are included in the cost of registration (breakfast and dinner, Sunday evening through Friday morning).

### TRANSPORTATION

The Porto Carras resort is located approximately 100 kilometers south-east of Thessaloniki International Airport. There are direct flights to Thessaloniki from all major

airports. Barring large currency fluctuations, taxi fare for the 1-1/2 hr ride is expected to be less than \$95 US in the summer of 1999.

More details about the area, its location, or possibilities to extend your visit are available upon request.



## SPOUSES & ACCOMPANYING PERSONS

The cost for spouses or accompanying persons is \$400 US. This includes a double room with breakfast and dinner for five days, and all events. Attendance at the lectures and the course notes are not included.

## LECTURERS

Possible lecturers include:

- Dr. A.E. Hamielec, Professor Emeritus and Director of McMaster Institute for Polymer Production Technology, Department of Chemical Engineering, McMaster University, Hamilton, Ontario, Canada.
- Dr. A. Penlidis, Professor and Director of the Institute for Polymer Research, Department of Chemical Engineering, University of Waterloo, Waterloo, Ontario, Canada.
- Dr. T. A. Duever, Associate Professor, Department of Chemical Engineering, University of Waterloo, Waterloo, Ontario, Canada
- Dr. J. B. P. Soares, Assistant Professor, Department of Chemical Engineering, University of Waterloo, Waterloo, Ontario, Canada
- Dr. B. Monrabal, Polymer Characterization S.A., Valencia Parc Technologic, P.O. Box 176, E-46980 Paterna, Spain

## IN-HOUSE COURSES

Drs. Hamielec, Penlidis and Soares are available to conduct in-house courses specifically tailored to your needs and requirements. Secrecy agreements could be signed permitting the consideration of highly relevant material.

Further information on this course or other courses may be obtained from Professor A. Penlidis at:

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