

Polymer Valley News

The Newsletter of the Akron Section of the Society of Plastics Engineers
Our 45th Year of Education and Service to the Plastics Industry

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Costs, Schedules, Reservations

Member	\$20.00
Member and Guest	\$25.00
Retiree	\$10.00
Student	\$10.00

Registration	11:30 a.m.
Lunch	12:00 p.m.
Presentation	12:30 p.m.

Call Cathy Herrin before noon,
Oct. 20 in order to receive above
prices, and specify any dietary
restrictions.

After Oct. 20, add \$5.00 to above
prices

(330) 849-5173 T; (330) 849-5589 F
cathy.herrin@santoprene.com

Coming Up:

- Next meeting – Nov. 15
- Board meeting Oct. 11, 5:30 p.m.
at Americhem

Technical Meeting

Monday, October 25, 2004

Tangier Restaurant

532 West Market Street

Akron, Ohio

The Changing Global Plastics Marketplace

By Michael Day, President
Michael Day Enterprises



A look at the significance of the US polymer industry, with a thought-provoking glimpse of how the industry evolved in the past 50 years, from essentially a monopoly enjoyed by the western democracies to a truly global industry today.

An overview of the political, economic and demographic factors which are responsible for today's global polymer situation.

Can we respond to our reduced world competitiveness and trigger a technological revolution to put the US polymer industry back into a true leadership position?

See page 4 for
Mr. Day's biography

Oct., 2004, Page 1



President's Message

Greetings,

I want to thank our members for the tremendous turn out at this month's SPE meeting. Dr Anna Ploplis Andrew's presentation on her TPO research was well received, and highlights some new and exciting areas being explored in the world of polymers. Continued research from dedicated scientists like Dr. Andrews continues to explore the options that can change the way we utilize and process plastics in the future.

September's SPE activities are almost over and October's events will soon be upon us. I wanted to remind all of you that our friends in the Cleveland Section are sponsoring a TOPCON on Profitable Quality Injection Molding Systems on October 11-12.

The Akron Section will be welcoming Michael Day's presentation on the Changing Global Plastics Industry.

We encourage you to continue to contact your board members on topics and subject matters of interest to our Section, and invite you to take part in our monthly activities.

Hope to see you at our October meeting.

Best Wishes,
Joe Mattingly, President

NEW!

Introducing Twin Screw University™

“COMPOUNDING 101”

Twin Screw Extrusion Training Seminars and Workshops

Location! Location! Location! Twin Screw University's "Compounding for Profits" training seminars and hands-on workshops are conveniently located near compounders to minimize travel expense and downtime. Operators, engineers and supervisors return to the workplace armed with techniques to immediately improve quality, production rates and yield.

Dates

October 19-20, 2004

Location

Akron Polymer Training Center, Akron, OH
Contact: Tayba Tahir (330) 972-8661
Email: tahir@uakron.edu

This two-day seminar focuses on optimization of process parameters and extruder configurations for most compounding applications. Enrollment is limited, so register early. ***Don't miss out on this opportunity to improve the productivity of your compounding resources!***

For information on other seminar and workshop locations, call Extrusion Engineering International, Inc. (973) 895-4088 or visit our website, www.b4uextrude.com.



Map to Tangier Restaurant 532 West Market Street Akron, Ohio

From North, Cleveland or Cleveland West - Route 71 South to Route 18 East (Market Street) to Tangier. Or Route 77 South to Ghent Road exit. Turn right onto Ghent Road. Proceed to W. Market Street (Route 18) and turn left to Tangier.

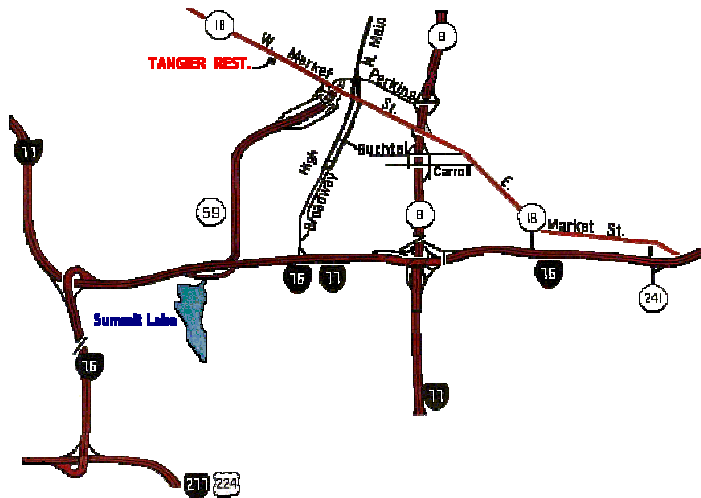
Cleveland East - Route 271 South to Route 8 South. Exit at Perkins Street. Turn right onto Perkins Street to High Street. Turn left onto High Street. Proceed to Market Street. Turn right onto Market Street.

From the South: Canton - Route 77 North to Perkins Street exit. Turn left onto Perkins Street. Proceed on Perkins Street to High Street. Turn left onto High Street. Proceed on High Street to Market Street. Turn right onto Market Street to Tangier.

From the East: Youngstown - Route 76 West to Broadway Street exit. Straight onto Broadway Street. (one way Street North) Proceed on Broadway Street to Market Street. Turn left onto Market Street to Tangier.

From the West - Route 76 East or Route 77 South to Route 59 North. Proceed on Route 59 to Market Street exit. Turn left onto Market Street. Proceed on Market Street to Tangier.

You may zoom in



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Michael Day, Biography of Speaker

Michael Day resides in Wadsworth, Ohio with his wife of 27 years, the former Jana Kay Meek.

The couple has 4 children, Britni who is 23 years old and currently working and studying in Chicago, Brian, a senior student at Wadsworth High School and twins Jason and Trevor who are juniors at the same school.

In his spare time Day, who is a resident alien of British descent, enjoys watching the various sporting activities of his children. He also enjoys travel, reading and playing tennis and golf.



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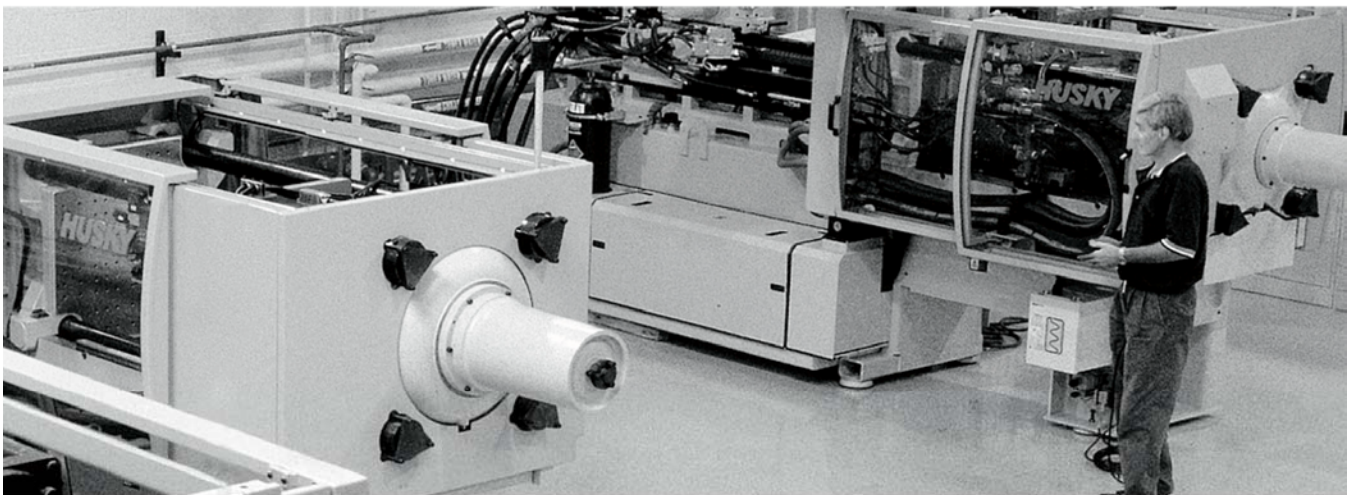
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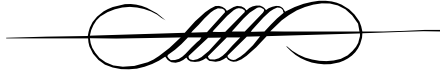
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1963-1964	Edward L. Hillier	1986-1987	Harry J. Barth
1964-1965	John R. Russell	1987-1988	Judith A. Fallon
1965-1966	John R. Russell	1988-1989	William E. Tosco
1966-1967	Clyde H. Jones	1989-1990	Robert Wegelin
1967-1968	Alan Corry, Jr.	1990-1991	Geraldine R. Stromquist
1968-1969	Bernard M. Saffian	1991-1992	Spencer Keiser
1969-1970	Harold R. Schick	1992-1993	Robert Wegelin
1970-1971	Robert G. Hills	1993-1994	Tony Dean
1971-1972	John J. Satterfield	1994-1995	Wayne Decamp
1972-1973	Alexis M. Gross	1995-1996	Melanie Stewart
1973-1974	Francis J. Maurer	1996-1997	Kevin Hershfield
1974-1975	Leverett A. Anderson, Jr.	1997-1998	Dave Schultz
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1976-1977	Richard L. Fleshman	1999-2000	Gary Taylor
1977-1978	David Curtis	2000-2001	Kevin Malpass
1978-1979	John A. Zelek, Jr.	2001-2002	Ken Sharp
1979-1980	Gerald W. Whitnable	2002-2003	Joe Pfeiffer
1980-1981	Kathleen N. Bechter	2003-2004	Robert Wegelin
1981-1982	Victor E. Giuffrida	2004-2005	Joe Mattingly

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Programs for 2004 / 2005

Sept. 20	“Novel Impact Modification in a TPO System” Ferro Corp., Dr. Anna Andrews --Tangier Restaurant	Jan. 24	Nanocomposite program Featured speaker, Prof. Josh Wong , who is working in expanded graphite flake reinforcement for plastics -- University of Akron
Oct. 25	“The Changing Global Plastics Marketplace” Michael Day Enterprises Michael Day, President , lunch -- Tangier Restaurant	Feb. 28	Program by Berstorff
Nov. 15	Demag Plastics Group , tour of facility in Strongsville, OH -- Dinner at local restaurant	March 21	Still open
Dec. 13	Social Program – still open -- Hower House, buffet	April 18	Vendor Night / Auction -- Martin Center
		May 23	Awards Banquet -- Martin Center



The University of Akron

The University of Akron Institute of Polymer Engineering

Polymer Processing and Testing Services

Don't want to invest in expensive equipment at this time? Don't know what equipment is best? Only need the use of the equipment for a short period of time?

Perhaps the best answer to these questions is to contract our polymer processing and testing services.

UA's Institute of Polymer Engineering works with all types of clients in the polymer industry, large companies and small firms, well-established businesses and start-ups. Companies turn to the Institute for assistance because they do not have the capabilities (equipment or personnel) to conduct their own research and testing.

The Institute of Polymer Engineering has a wide variety of specialized equipment needed for polymer processing, characterization, analysis and testing. Some of that equipment is listed here below.

To further discuss your needs, please contact Dr Lloyd Goettler at (330) 972-7467 lagoett@uakron.edu or Cameron Fraser at (330) 972-6008 cfraser@uakron.edu

Analysis and Testing

- x-ray
- scanning electron microscopy
- atomic force microscopy
- optical microscopy
- laser microscopy
- TGA
- DSC
- FT-IR
- DMA
- APA
- stress strain testing
- rheology
- biaxial stretching

Polymer Processing

- single-screw extruding
- twin-screw extruding
- film casting
- film blowing
- fiber spinning
- injection molding
- compression molding
- vacuum molding
- blow molding
- compounding

Sample Preparation

- microtoming
- vacuum drying
- sputter coating
- particle size reducing



Minutes of Board Meeting – Sep. 13, 2004

Call to Order: 5:30 p.m. at Americhem.

Present: Joe Mattingly, Johanna Baena, Cameron Fraser, Joe Pfeiffer, Gary Taylor, Lloyd Goettler, Amruth Puttarudraiah

NOTE: ACTION ITEMS – IN BOLD

Minutes: To be approved via email after slight modification.

Treasurer: Balance as of meeting date \$30,052.53. Check to TOPCON 2005 has been written.

Awards 2004 Update: Need a chair for this year. Photos of last year's event are in process.

Student Chapter: Best student ANTEC paper was from University of Akron. The new president should be in attendance of the next board meeting. New activities are in the planning stages.

Newsletter: Need all reports by the 29th, we also need a technical article.

Membership: Report submitted - see Newsletter for details.

Councilor's report: None submitted.

Education Committee: Essay contest planning meeting needs to be scheduled within the next three months. We need to define committee members, please contact Kathy Perevosnik.

Education Foundation: None submitted. We did report receiving notification of an IRS penalty for late filing.

Website: Web site doing well.

Program: Work in process, October meeting date changed to the 25th. December meeting consideration is a tour of Hower House. Vendor Auction night is to return to old format, chair needs to be identified.

Spring Golf: Need a chair. Committee members so far are Bud Seymour and Dave Katz.

Old Business: Firelands merger is being dropped. Access meeting was not attended.

New Business: Stephen Cheng is a recent transfer and is presenting in January. Stephen is the new chair of the Department of Polymer Science at the University of Akron.

Closing Comments: Next board meeting will be October 11th @ 5:30 @ Americhem.



Membership Report – Sept., 2004

Akron SPE, Section S42

Activity for August

Current total is **396** paid members.

4 New members, sent welcome email

Transfers in from other sections, added to email distribution

19 renewed

New Members

- Jude France, United Polychem
- Terry Friel Double H Manufacturing (Marion, Ind.)
- Laura Prexta, Americhem
- Timothy Sullivan, Ashland Specialty Chemical

Membership News from National

- Total membership is up over last year for 2nd month in a row.
- Total membership is at 18,921 (over 700 increase from last year).
- Acquisition mailing from headquarters with follow up emails resulted in over 180 new members.
- Emails, tip covers and renewal invoices are being sent to lapsed members.
- Use most recent applications, on line, or available from National through email
- Encourage use of change of address information and forms to keep records updated at National
- AIM actions increase membership 64 out of 177 referrals have joined since last month. Conversion rate of 36% is positive.



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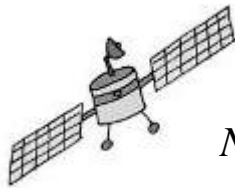




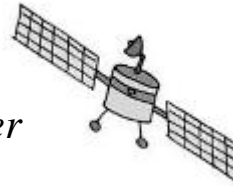
57th Annual

HONORS & AWARDS BANQUET

THURSDAY, NOVEMBER 4, 2004
Guy's Party Center, 500 East Waterloo Rd



Dr Geoffrey Landis
Scientist
NASA Glenn Research Center



“Exploring Mars”

Honorary Banquet Chairman

Joseph S Kanfer
Chief Executive Officer
GOJO Industries, Inc



Distinguished Award of Council

Mayor Donald L Plusquellic
City of Akron, Ohio

ACCESS Award

Jan Ruthenburg



Master of Ceremonies

Gary Johnson, PE
President, Finkbeiner, Pettis and Strout

Cash Bar: 5:30 pm
Dinner: 6:30 pm
Tickets: \$25.00
Students: \$15.00

Purchase tickets by October 22, 2004
No tickets will be sold at the door
Contact Terri Cairo @ (330) 535-8835 or
Dan Jones @ djones@akron.k12.oh.us

ACCESS, Akron Public Library, 807 West Market Street, Akron, OH 44303

Akron Section Board of Directors

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TOPCON

PROFITABLE QUALITY INJECTION MOLDING SYSTEMS

Cleveland, Ohio October 11-12, 2004

**Sponsored by the Cleveland Section
and the Injection Molding Division
of the Society of Plastics Engineers**

Corporate Sponsors:
IMS Company, Bayer Materialscience,
Krauss Maffei, DuPont

Conference Site: Embassy Suites Cleveland - Rockside (Independence)

Conference Theme

The goal of the TOPCON is to supply practical information to owners of small molding operations and to plastics engineers at both custom and captive molders, by highlighting proven technology and systems that improve molding operations, resulting in improved part quality, higher prime yield, higher efficiency and better profitability.

Hotel Accomodations

Embassy Suites Cleveland – Rockside (Independence) \$99/ night special conference rate. Make Reservations directly with the hotel at (216) 986-9900. *Mention this conference to get the \$99 rate.*

Information

For information on the conference, sponsorships or exhibits call Henry Forsythe at (216) 447-7370

Monday – 11 Oct 2004

Registration 7:30 to 8:30

Session I: Machine Technology (Chair: Jeff Dininger, Visteon)

M Barr Klaus, Electric Injection Services:

How to get the most out of your electric injection molding equipment

Jim Moran and J. Krage, Engel Machinery:

Innovative Processing Technologies for Today's Challenging Molding Market

Lee Prettyman, Glycon: **Maximizing Equipment Performance**

Peter Lipp, Krauss Maffei: **Increased Productivity and ROI**

Using Inline Compounding Technology and Automation

Larry Doyle, Demag: **Think Global, Act Local**

Monday Afternoon

Session II: Plant Operations (Chair: Gary Casterline, Delphi Corp.)

Chuck Mansfield, Delphi Corp: **Integrated Injection Molding Manufacturing System**

Joe Portelli, FANUC Robotics America:

How to Successfully Implement Robots into Plastics Manufacturing

Nathan Kitts, Star Automation Inc.: **What is new in the field of robotic part removal?**

John Hahn, MGS Mfg.Group: **Multishot Tooling Considerations -**

An Engineering Case Study

David Kazmer, University of Massachusetts Lowell:

The Economics of Lights Out Manufacturing

Combined evening meeting and dinner with Cleveland Section SPE

Tuesday – 12 Oct 2004

Session III: Processing Technology (Chair: Brad Johnson, Penn State-Erie)

Frank Long & Mike Schrieber, DVT Corporation:

Advancements in Machine Vision for Injection Molding

Terry Good, Maguire Products, Inc.:

Advancements in Drying Technology - The Benefits of Vacuum Drying

Susan Montgomery, Priamus System Technologies LLC:

Advanced Process Control Solutions for Injection Molding

Al Duff, Moldflow Corporation: **Automating Process Set-up and Control**

Karl Bauer, RJG Technologies, Inc.:

An Update on Instrumentation and Data Acquisition in Injection Molding

Lunch: Keynote Speaker - TBA

Tuesday Afternoon

Session IV: Mold Technology (Chair: Jerry Blayne, Noveon Corp.)

David T. Baker, Eas Mold & Die Change Systems:

Taking The Mystery Out Of Quick Mold Change

Payton Lewis, P. R. Lewis Consulting: **Highly Conductive Cavities Combine Variable Mold Temperature To Create More Efficient Molding**

Harry Raimondi, Bales Mold Service: **Coatings & Finishes For Mold Repair & Maintenance**

John Beaumont, Beaumont Runner Technologies Inc.: **Troubleshooting And Controlling Imbalances In Multicavity Hot & Cold Runner Molds**

ADVANCE REGISTRATION

Advance registration discount by September 1, 2004 only. Make check (US funds) payable to SPE/IMD Cleveland TOPCON, or fill out credit card information. Mail with registration (separate copies if multiple attendees) to:

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Email: _____

Notes or Special Accomodations Needed:

SPE Member _____ SPE ID# _____

Non Member _____ Student _____

	Advance	On-Site
SPE Member:	\$365	\$465
*Non-Member	\$465	\$565
Student (full-time)	\$125 (ID required)	

No of Registrations _____

Check Total _____ USD Credit Card Total _____ USD

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* Non-member cost includes 1-year SPE membership.

Cancellation charge is \$50. No cancellations after September 18, 2004

CONFERENCE PROGRAM

Sunday - 10 Oct 2004

Registration 2:00 p.m. to 5:00 p.m.

Monday - 11 Oct 2004

Registration 7:30 to 8:30

Session I - Machine Technology

Moderator - Jeff Dininger, Visteon Corp

- 8:30 **How to Get the Most Out of Your Electric Injection Molding Equipment**
M. Barr Klaus, Electric Injection Services
- 9:10 **Innovative Processing Technologies for Today's Challenging Molding Market**
Jim Moran and J. Krage, Engel Machine
- 9:50 **Maximizing Equipment Performance**
Lee Prettyman, Glycon

10:30 - 10:45 Break

- 10:45 **Increased Productivity and ROI Using Inline Compounding Technology and Automation**
Peter Lipp, Krauss Maffei
- 11:25 **Think Global, Act Local**
Larry Doyle, Demag

12:00 Lunch

Speaker - R. Groleau, RJG
What the Molding Industry Needs to Do to Stay Alive in the Next Decade

Session II - Plant Operations

Moderator- Gary Casterline, Delphi Corp.

- 1:30 **Integrated Injection Molding Manufacturing System**
Chuck Mansfield, Delphi Corp
- 2:20 **How to Successfully Implement Robots into Plastics Manufacturing**
Joe Portelli, FANUC Robotics America

3:10 - 3:30 Break

- 3:30 **What is New in the Field of Robotic Part Removal**
Nathan Kitts, Star Automation, Inc.
- 4:15 **Multishot Tooling Considerations - An Engineering Case Study**
John Hahn, MGS Mfg. Groups
- 4:55 **The Economics of Lights Out Manufacturing**
David Kazmer, University of Massachusetts Lowell
- 5:30 End of Session

5:45 to 6:30 Mixer

6:30 Cleveland Section SPE meeting/dinner
Speaker - Roger F. Jones, Franklin International LLC.
Surviving Globalization

Tuesday - 12 Oct 2004

Session III - Processing Technology

Moderator - Brad Johnson, Penn State-Erie

- 8:30 **Advancements in Machine Vision for Injection Molding**
Frank Long & Mike Schrieber, DVT Corporation
- 9:15 **Advancements in Drying Technology - The Benefits of Vacuum Drying**
Terry Good, Maguire Products, Inc.

10:00-10:15 Break

- 10:15 **Advanced Process Control Solutions for Injection Molding**
Susan Montgomery, Priamus System Technologies, Inc.
- 10:45 **Automating Process Set-up and Control**
Al Duff, Moldflow Corporation
- 11:30 **An Update on instrumentation and Data Acquisition in Injection Molding**
Karl Bauer, RJG Technologies, Inc.

12:15- 12:45 Lunch

Session IV - Mold Technology

Moderator- Jerry Blayne, Noveon Corp

- 1:30 **Improving Profitability Through Thermally Efficient Inserts (and Conformal Cooling)**
Chuck Azzopardi, DME
- 2:00 **Taking the Mystery Out of Quick Mold Change**
David T. Baker, EAS Mold & Die Change Systems
- 2:30 **Highly Conductive Cavities Combine Variable Mold Temperature to Create More Efficient Molding**
Payton Lewis, P.R. Lewis Consulting

3:00 - 3:15 Break

- 3:15 **Coatings & Finishes for Mold Repair and Maintenance**
Harry Raimondi, Bales Mold Service
- 4:30 **Controlled Melt Rotation for Eliminating Shear Induced Flow Imbalance in Hot Runner Systems**
John Beaumont, Beaumont Runner Technologies, Inc.

5:15 Conference Ends



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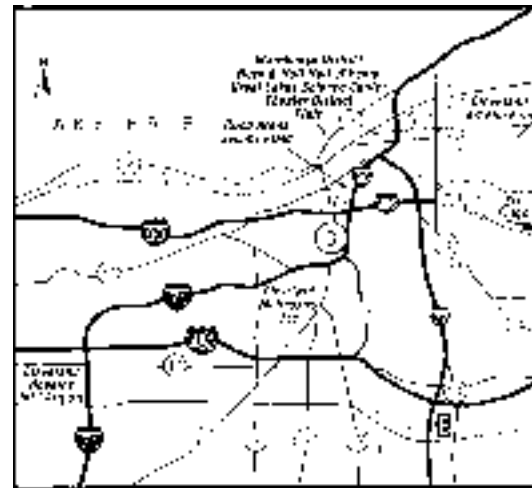
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SOLID-STATE POLYIMIDE FOAMING FROM POWDER PRECURSORS: EFFECT OF PARTICLE MORPHOLOGY ON THE DIFFUSIVE PHENOMENA.

*Camilo I. Cano and R. Byron Pipes
Dept. of Polymer Engineering - The University of Akron
Akron, OH 44325-0301*

Abstract from a paper presented at ANTEC 2004 [Ref. No. 8].

Introduction

Polyimide foams have been developed to meet the need for lightweight cellular materials with exceptional mechanical, chemical and electrical properties. A solid-state foaming process starting from powdered precursor is employed owing to the fact that the high glass transition and melt temperatures of polyimides makes them unsuitable for melt processing. The precursor consists of a solid-state solution of a poly(amic acid) with a volatile solvent (i.e. blowing agent) that is further transformed into the polyimide by thermal treatment (imidization). Solid-state powder foaming is governed by transport phenomena within the particle and its surrounding environment. The precursor subjected to a temperature increase and containing embedded blowing agent will undergo heat and mass transport until suitable conditions for nucleation exist somewhere in the particles. These optimum conditions for nucleation will depend on temperature and concentration profiles in the precursor particles. Therefore the study of diffusive phenomena is required.

Background

Different methods have been developed for manufacturing polyimide foams [1-5]. Recently, polyimide foams made from solid-state solutions of poly(amic acid) have been obtained by using blowing agent solvents such as THF, Glyme or Dioxane, that complex by hydrogen bonding to the diacid-diester and later to the poly(amic acid) structure [4]. This method has also been used to produce hollow polymeric mesostructures (microspheres) of diameters from 100 to 1500 μm , that act as the foam unit cell [5] (Figure 1). The morphology of these mesostructures is believed to depend on factors such as the morphology of the initial particles (size and shape), the blowing agent content and the heating rate.

Experiments

Precursor particles made from the poly (amic acid) of 3,3',4,4'-Benzophenonetetracarboxylic dianhydride, (BTDA) and 4,4'-Oxydianiline (ODA) were manufactured with different particle sizes ranging from 75 microns to 300 microns. The details of the manufacturing of the

precursor are discussed elsewhere [3,6]. The transformation from the solid precursor particle into the polyimide microstructure was recorded with an Olympus ZX-12 stereo microscope, a INSTEC heating stage and a Diagnostic Instruments SPOT digital camera. TGA experiments were conducted in a 2050 TA Instruments TGA with constant nitrogen flow. Ramp heating routines at constant heating rates were used in all the experiments.

Results and Analysis

Precursor particles were subjected to different heating rates and their behavior was recorded. The effect of heating rate on the final morphology of mesostructures is presented in figure 2. A higher heating rate provides an amicable environment for multiple bubble growth to occur in the particles independent of their lockedness (i.e. presence or not of a second phase), by allowing supersaturation conditions over the complete particle. On the other hand, a lower heating rate may allow diffusion towards the outside of the particle to be significant before favorable levels of supersaturation can be reached thus limiting the possible locations for bubble growth in the particle. Experiments done on different particle size samples under the same heating rate, show that larger precursor particles have a higher probability of multiple bubble growth. The opposite was observed with particles below a certain size (normally less than 100 μm) where similar thermal treatment shows growth in only a small fraction of particles.

Based on these preliminary observations, microstructure growth is thought to have a special dependence on the specific surface, S_v , (i.e. surface to volume ratio) of the precursor particles. The specific surface depends on two morphological characteristics: particle size and shape. As the dimensions of a particle increase, the S_v decreases according to the following expression for polyhedra:

$$S_v = K \frac{1}{b}$$

where b is the characteristic dimension of the solid (i.e. the circumsphere of a polyhedra) (Figure 3). The constant, K , is shape-dependant and characteristic to each geometry providing a sense of "blowability". The higher the value of the constant K , the more difficult it will be to obtain

microstructures from precursors with small dimensions since most of the blowing agent will diffuse out of the particle before favorable conditions for bubble growth occur.

Correlation of the observations of particle size effect to quantitative data was done through thermo-gravimetric analysis (TGA) following the evolution of volatiles throughout a thermal cycle for two different particle sizes. TGA was performed on a sample of powder below 75 μ m and a sample in the range from 106 μ m to 180 μ m (Figure 4). A low heating rate (ramp heating at 5°C/min from room temperature to 300°C) was used. The weight loss curves show a slight change in weight percent loss between the two samples, with the greatest total weight percent loss for the larger particle size sample. The derivative of the weight loss with time (i.e. desorption rate) offers a most interesting view of the concurrent phenomena.

In figure 4 three different “evolution” zones can be identified as: room temperature to ~80°C (Zone I), ~80°C to ~140°C (Zone II), and ~140°C to ~300°C (Zone III). The temperatures shared by each adjacent pair of evolution zones can be understood as activation temperatures and can be compared to some important properties for the system. These properties are the boiling point of THF (i.e. 66°C) and glass transition temperature of the plasticized PAA [7] (which has a very broad range depending on the solvent content), which would suggest an activation due to blowing agent vaporization, as well as, the increase in diffusion due to higher free volume upon relaxation of the polymer chains. Another interesting feature can be seen from the temperature between zones II and III (i.e. ~140°C) where the evolution behavior becomes similar for both samples. The sudden increase in evolution of volatiles at this high temperature may be related to the peak of desorption of condensation byproducts (i.e. water) from the imidization of the poly(amic acid) chains. The fact that volatile evolution is almost the same for different particle size above ~140°C would indicate a separation between morphology-dependant desorption (i.e. below 140°C) and kinetic-dependant desorption (i.e. above 140°C).

It is important to note that the temperature boundaries which separate the different evolution zones are dependant on each specific sample and its inherent properties. These properties are solvent content and molecular weight, as well as, process dependant parameters such as heating rate, particle size, shape, and the fact that bubble growth took place or not during the heating.

Concluding Remarks

From initial observations of the solid-state foaming process of individual precursor particles, it was evident that the thermal treatment and the precursor morphology influenced the growth behavior and the final morphology of the mesostructures. Increased morphological complexity

will be achieved under higher heating rates and larger particle sizes by increasing the number of bubbles. The opposite will occur by decreasing particle size down to a critical dimension where bubble growth will cease to occur. The close relation between “blowability” of the particle and specific surface indicates an important effect of the morphology on the diffusive phenomena that takes place as the particle is heated.

Analysis of the volatile evolution behavior during a thermal treatment cycle similar to those used in a typical foaming experiment evidences the existence of several activation temperatures (and corresponding “evolution zones”) at which volatile evolution increases. These activation temperatures are believed to be closely related to material properties of the system.

References

1. J. Gagliani, “Polyimide Foams”, U.S. Patent 4'332,656, (1982).
2. J. Gagliani, “Development of Polyimide Foams with Blowing Agent”, U.S. Patent 4'506,038, (1985).
3. E.S. Weiser, T.F. Johnson, T.L. St.Clair and Y. Echigo, “Polyimide Foams for Aerospace Vehicles”, *High Perf. Polym.*, 12 (2000) p. 1
4. E.S. Weiser et al., “Polyimide Precursor Solid Residuum”, US Patent 6'180,746, (2001).
5. E.S. Weiser, B.W. Grimsley, R.B. Pipes and M.K. Williams, “Polyimide Foams From Friable Balloons”, *Proceedings of the 47th International SAMPE Symposium and Exhibition*, May 12-16, (2002). p. 1151.
6. C.I. Cano, R.B. Pipes and E.S. Weiser, “High Temperature Polymeric Microspheres and Foams: Liquid Phase Models”, *SPE ANTEC Tech. Papers*, (2003), p. 1835.
7. S.I. Kim, P.K. Kim and M. Ree, “Investigation of Glass Transition Behaviors in Aromatic Poly(amic acid) Precursors With Various Chain Rigidities by Oscillating Differential Scanning Calorimetry”, *Polymer*, 39, (1998), p. 6489.
8. C.I. Cano, R.B. Pipes. “Solid-state polyimide foaming from powder precursors: Effect of particle morphology on the diffusive phenomena.”, *SPE ANTEC Tech. Papers*, (2004). p. 2631.

Figures

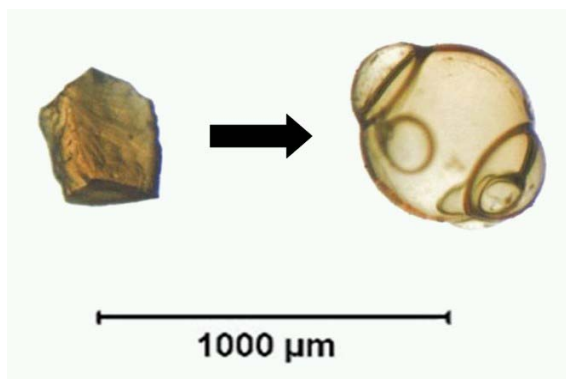


Fig. 1 Precursor particle and its corresponding microstructure.

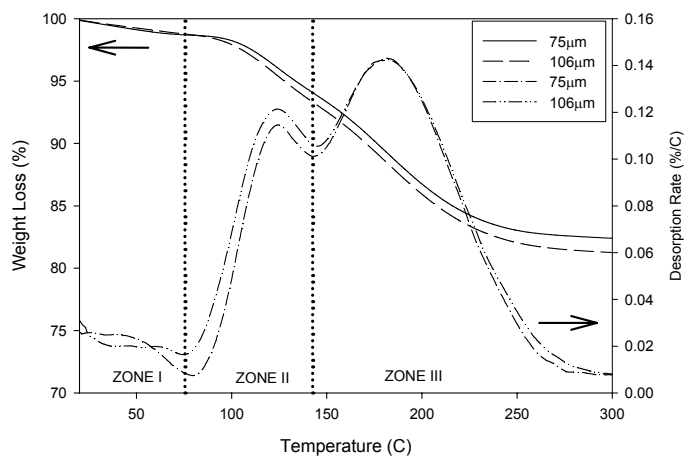


Fig. 4 TGA of precursor particles showing evolution zones. Heating rate of 5 °C/min.

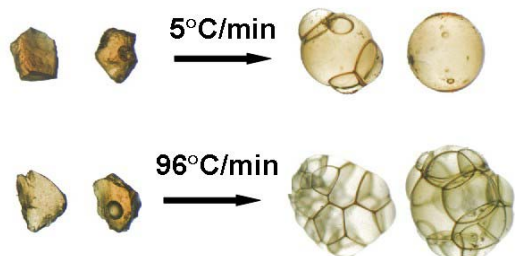


Fig. 2 Effects of heating rate and precursor morphology on final mesostructure morphology.

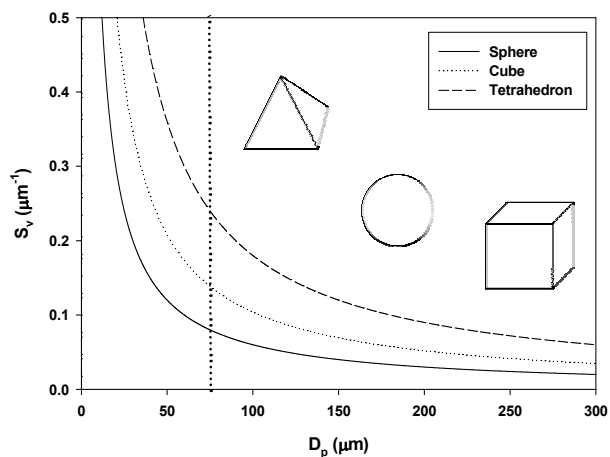


Fig. 3 Specific Surface, S_v , for several geometries

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