G) Candidate's Curriculum Vita, Publication List and Self-Evaluation

Gregory Beaucage, Professor Office: 513 556-3063
Department of Chemical and Materials Engineering Lab: 513 556-5152
University of Cincinnati Fax: 513 556-3773
Cincinnati, OH 45221-0012 e-mail: beaucag@uc.edu
http://www.eng.uc.edu/~gbeaucag/BeaucageResearchGroup.html

Education/Research Positions.

University of Cincinnati, Cincinnati, OH, 45221 ***Associate Professor***, Department of Chemical and Materials Engineering,
2000 to present

ETHZ, Zurich Switzerland 8/2003 to 8/2004 sabbatical leave funded by Swiss National Science Foundation and Dupont Corporation.

University of Cincinnati, Cincinnati, OH, 45221 ***Assistant Professor***, Department of Materials Science and Engineering,
1994 to 2000.

Sandia National Laboratory, Albuquerque, NM 87185, ***Staff Member***, Organic Materials Group 1815. Cooperative research agreements with U.S. industrial partners.
1993-1994

Sandia National Laboratory, Albuquerque, NM 87185; ***Post Doctoral Fellow***, Organic Materials Group with ***Dale W. Schaefer***, Group 1703. Characterization of multi-component materials using scattering. Development of scattering theory in these systems.
1991-1993

1991 University of Massachusetts, Amherst, MA 01003 ***Ph.D. Polymer Science and Engineering***. Advisor: ***Richard S. Stein***. Dissertation: *A Morphological, Mechanical and Thermodynamic Investigation of the Isotactic-PVME/PS Polymer Blend.*

1982 University of Rhode Island, Kingston, RI 02881 ***B.S. Chemical Engineering***; Rhode Island State Scholarship, Phi Beta Kappa, Phi Kappa Phi, High Distinction.

1980 University of Rhode Island, Kingston, RI 02881 ***B.S. Zoology***; Rhode Island State Scholarship , Phi Beta Kappa, Phi Kappa Phi, Tau Beta Pi, Highest Distinction

Publications: Total of 109 peer reviewed publications, see publication list.
Publications fall into 5 Main Areas (with selected examples):

Nanostructured Materials and Fractals: In situ studies of nano-structural growth dynamics using SAXS. Work has also focused on aerosol synthesis of nano-structured ceramics using sol-gel chemistry, *Aerosol Gel Reactor*. Application of small-angle scattering to characterization of nano-structure in a wide range of materials including pyrolytic silica, titania and carbon, layered silicates, zeolites. Extensive work has involved structure property relationships for polymer/ceramic nanocomposites. Recently we have worked on spray flame synthesis of supported gold catalysts and in situ anomalous x-ray scattering measurements for characterization of the growth dynamics of supported gold nano-clusters in spray flames.

Probing the dynamics of nanoparticle growth in a flame using synchrotron radiation Beaucage G, Kammler HK, Mueller R, Pratsinis SE, Narayanan T. *Nature Materials* **3** (6): 370-374 (2004).

Rational design of reinforced rubber Kohls DJ, Beaucage G *Curr. Opin. Solid St. M.* **6**(3), 183-194 (2002).

Structural analysis of polydimethylsiloxane (PDMS) modified silica xerogels. Guo L., Hyeon-Lee J, Beaucage G *J. Non-Crystalline Solids* **243** 61-69 (1999).

Morphological development in PDMS/TEOS hybrid materials. HyeonLee J, Guo L, Beaucage G, MacipBoulis MA, Yang AJM *J. Polym. Sci., Polym. Phys.* **34**(17), 3073-3080 (1996).

Morphology of polyethylene-carbon black composites. Beaucage G, Rane S, Schaefer DW, Long G, Fischer D *J. Polym. Sci. Polym. Phys.* **37**, 1105-1119 (1999).

Aero-Sol-Gel Synthesis of Nanostructured Silica Powders Hyeon-Lee J, Beaucage G, Pratsinis SE *Chemistry of Materials* **9**(11) 2400-2403 (1997).

Polymer Thermodynamics and Chain Structure: Application of light, x-ray and neutron scattering to issues of polymer/polymer miscibility and phase separation kinetics. Studies of the structural basis for shifts in miscibility with tacticity. Investigations of the structural basis for chain conformation and persistence in PDMS and poly(hydroxyalkonates), examples of flexible and rigid chain polymers respectively with the goal of developing a structural basis to long chain polymer thermodynamics. Development of a thermodynamic model for the structure of equilibrium swollen polymer gels. The model has been verified using small-angle neutron scattering. Description of branched structure in polyolefins, cyclics, hyperbranched polymers, and star polymers using scaling description and small angle neutron scattering coupled with NMR and other characterization techniques.

Investigating the Molecular Architecture of Hyperbranched Polymers Kulkarni AS and Beaucage G, *Macromol. Rap. Comm.* **28**, 1312-1316 (2007).

Macroscopic polymer analogues. Beaucage G, Sukumaran S, Rane S *J. Polym. Sci Pol. Phys.* **36**(17), 3147-3154 (1998).

Persistence Length of i-Poly(Hydroxy-Butyrate). Beaucage G, Rane S, Sukumaran S, Satkowski MM, Schechtman LA, Doi Y *Macromolecules* **30**, 4158-4162 (1997).

Symmetric, Isotopic Blends of Poly(dimethylsiloxane). Beaucage G, Sukumaran S, Clarson SJ, Kent MS, Schaefer DW *Macromolecules* **29**(26), 8349-8356 (1996).

A structural model for equilibrium swollen networks. Sukumaran SK, Beaucage G *Europhysics Letters* **59**(5), 714-720 (2002).

Tacticity effects on polymer blend miscibility. 2. Rate of phase separation. Beaucage G, Stein RS *Macromolecules* **26**(7), 1609-1616 (1993).

Tacticity effects on polymer blend miscibility. Beaucage G, Stein RS, Hashimoto T, Hasegawa H *Macromolecules* **24**(11), 3443-3448 (1991).

Semicrystalline Polymers: Studies of the development of correlated lamellar structure in a wide range of semi-crystalline polymer using small-angle x-ray scattering. We have focused on quantification of lamellar orientation in processed polymers such as polymer films and correlation of 3-d orientation with properties such as gas transport in polymer films. This work has also been extended to polyolefin/layered silicate nano-composites. Recent work has involved in situ studies of machine direction orientation (MDO) post processed films using in situ x-ray scattering at CHESS and SSRL.

Integrated Mechanism for the Morphological Structure Development in HDPE Melt-Blown and Machine-Direction-Oriented (MDO) Films Bafna A, McFaddin D, Beaucage G, Merrick-Mack J, Mirabella FM *J. Polym. Sci. Polym. Phys.* **45** 1834-1844 (2007).

A review of modeling approaches for oriented semi-crystalline polymers. Breese DR, Beaucage G *Curr. Opin. Sol. St. Matls. Sci.* **8** 439-448 (2004).

3D Hierarchical orientation in polymer-clay nanocomposite films Bafna A, Beaucage G, Mirabella F *Polymer* **44** (4), 1103-1115 (2003).

Optical properties and orientation in polyethylene blown films. Bafna A, Beaucage G, Mirabella F. *J. Polym. Sci, Pol. Phys.* **39**(23), 2923-2936 (2001).

Morphological study of HDPE blown films by SAXS, SEM and TEM: a relationship between the melt elasticity parameter and lamellae orientation. Prasad A, Shroff R, Rane S, Beaucage G *Polymer* **42**(7), 3103-3113 (2001).

Nano-Structured, Semicrystalline Polymer Foams. Beaucage G, Aubert JH, Lagasse RR, Schaefer DW, Rieker TP, Ehrlich P, Stein RS, Kulkarni S, Whaley PD *J. Polym. Sci., Part B: Polym. Phys.* **34**(17), 3063-3072 (1996).

Polymer Interfacial Properties: Developed a technique to measure the glass transition in polymer films using the ellipsometer. Several papers have also been published pertaining to chain conformation in thin films using neutron reflectivity. Application of the ellipsometer to study the dynamics of polymer films in thermal quench studies. The relaxation time and viscosity of thin films can be determined in this measurement. Results indicate that polymers in confined geometries deviate kinetically from bulk chains with WLF features reminiscent of tactic analogues in very thin films.

Ellipsometric study of the glass transition and thermal expansion coefficients of thin polymer films. Beaucage, G, Composto R, Stein RS, *J. Polym. Sci., Part B: Polym. Phys.* **31**(3) 319-326 (1993).

Relaxation of polymer thin films in isothermal temperature-jump measurements Beaucage G, Banach MJ, Vaia RA *J. Polym. Sci., Pol. Phys.* **38**(22), 2929-2936 (2000).

Scattering Theory: Developed the unified scattering function which is widely used in studies of complex nanostructured materials (more than 300 combined citations). The unified function describes hierarchical structures such as are seen in mass fractal aggregates and polymeric systems.

Determination of branch fraction and minimum dimension of mass-fractal aggregates Beaucage G., *Physical Review E* **70**(3) (2005).

Particle size distributions from small-angle scattering using global scattering functions. Beaucage, G. Kammler HK, Pratsinis SE, *J. Appl. Cryst.* **37**, 523-535 (2004).

Small-Angle Scattering from Polymeric Mass Fractals of Arbitrary Mass-Fractal Dimension. Beaucage G *J. Appl. Crystallogr.* **29**, 134-146 (1996).

Approximations leading to a unified exponential/power-law approach to small-angle scattering. Beaucage G *J. Appl. Crystallogr.* **28**(6), 717-728 (1995).

Fractal analysis of flame-synthesized nanostructured silica and titania powders using small-angle X-ray scattering. Hyeon-Lee J, Beaucage G, Pratsinis SE *Langmuir* **14**(20), 5751-5756 (1998).

Current Students (5 Graduate Students, 1 funded REU Undergraduate, 1 funded RET High School Teacher)

Amit Kulkarni (MS 6/2004; PhD Expected 9/2007): Spinodal decomposition in hybrid materials, PDMS/Silica nanocomposites.
PhD branching in disordered materials, polymers and ceramics. Funded by P&G, Intel, Equistar.
GE Plastics Evansville IN (10/2007).

Ryan Breese (MS 8/2004): PhD studies on oriented polymer film structure/property relationships. Funded by Equistar and now Eclipse Film Technologies which Ryan is the President.

Ramnath Ramachandran: PhD studies branching and persistence effects on rheology in polyolefins. Funded by Equistar.

Mangesh Champhekar: MS Studies concerning ultra oriented polyolefin/clay nano-composites.

Sachit Chopras: PhD studies flame-made nanoparticles for nano-catalysts and other applications. Funded by NSF CTS.

Undergraduate Research Assistant (NSF REU Student): Stephanie Berger, Carbon coated silica for solar cell applications.

High School Teacher (NSF RET Participant): Edwin Segbefia Princeton High School Physics Department. Flame-made hematite nano-particles for arsenic remediation in drinking water.

Graduated Students/Post Doc

Amit S. Kulkarni: (MS 6/2004; PhD Expected 9/2007): Spinodal decomposition in hybrid materials, PDMS/Silica nanocomposites.
PhD "Nature of Branching in Disordered Materials"
Funded by P&G, Intel, Equistar.
GE Plastics Evansville IN (10/2007).

Harshad Chavan: (MS 2006) studies orientation in polymer films, piezoelectric for applications in biomedical devices.

Doug Kohls, (PhD 2006, MS 2002): "*ASG* Process for Nano-Powders and Their Applications"
Funded by NSF and P&G.
Currently, *Assistant Research Professor Department of Chemical and Materials Engineering University of Cincinnati.* Formerly*, Research Scientist GE Plastics Philadelphia, PA.*

Ayush Bafna (PhD 2004, MS 2002): PhD studies pertain to the importance of structural orientation on properties in polyolefin/layered silicate nano-composites. MS pertained to orientation in processed semi-crystalline polymers. Funded by Equistar Corporation.
Dow Chemical Freeport TX.

Nikhil Agashe (PhD 2004, MS 2001): In situ studies of the growth of nanomaterials in flames. Funded by NSF and Sun Chemical Corporation. MS degree pertained to fractal structure and optical properties of organic pigments.
GE Plastics Evansville Indiana.

Suresh Murugesan (PhD Chemistry Department 2003): Development of magnetically responsive, in situ filled elastomers for MEMS applications. Funded by bio-MEMS DARPA Project.
Texas Research Institute.

S. Sukumaran, (PhD 2002, MS 1999) Applications of Fractal Concepts to Complex Materials, funded by Argonne National Laboratories, PRF and P&G Paper Division. Studies pertained to theoretical and experimental considerations of equilibrium and non-equilibrium hierarchical structures on the molecular to macroscopic scales. Strongest contribution pertains to the structure of equilibrium swollen networks but also contributed in micellar systems, and a variety of other areas.
Max Planck Institute for Polymer Research, Mainz, Germany.

G. Skillas, Post-Doc from ETH Zurich, Studies of polymer dispersed reinforcing fillers using SAXS and 2d-IR. Funded by Swiss Government as well as P&G. Currently a research scientist at Degussa in Hanau Germany (manufacturer of pyrolytic ceramics).
GMX division of Degussa, Hanau, Germany.

S. Rane (PhD 1999) "Processing of Semi-Crystalline Polymers"
, funded by Equistar Corporation and P&G MVL.
GE Plastics, Colombus IN.

J. Hyeon-Lee (PhD 1998)"Nano-structured Materials via Sol-Gel and Aero-Sol-Gel Synthesis", funded by NSF (formerly by P&G MVL and Cabot Corporation). Currently Research Scientist,
Samsung Research Institute, Seoul, South Korea.

Ling Guo (MS 1997) "Polymer Reinforced Ceramic Super-Insulators"
funded by P&G, MVL and Armstrong Corporation.
P&G Miami Valley Laboratories (Central Research Division).

Gregory Rossi (MS 2002): Dispersion of nano-materials/ceramics in polymers through chemical modification. Funded by Wright Patterson Airforce Base, Materials Directorate.
Patent Lawyer, Cincinnati OH.

Jim (Jinhui) Chen (MS 1999): Production of titania-silica mixed oxides for epoxidation catalysis funded by NSF.
PhD Northwestern University Catalytic Chemistry 2005.

Graduate Advisor (own): ***Dr. Richard S. Stein***, Emeritus Professor of Polymer Science and Engineering, University of Massachusetts, Amherst, MA. Member NAS and NAE.

Current Funding:

National Science Foundation
PI: G. Beaucage
Project: ***Spray Jet Flames for Supported Gold Catalysts: New Catalysts by Design***
1. Award Number: 0626063
2. Award Duration: 36 Months
3. Starting Date: 09/01/06
4. Termination Date: 08/31/09
5. Current award amount: $ 250,002

National Science Foundation
PI: G. Beaucage
Project: ***Research Experience for Teachers***
1. Award Number: Supplemental to 0626063
2. Award Duration: 36 Months
3. Starting Date: 03/08/07
4. Termination Date: 08/31/09
5. Current award amount: $10,000

National Science Foundation
PI: G. Beaucage
Project: ***International Research and Education in Engineering (IREE)***
1. Award Number: Supplemental to 0626063
2. Award Duration: 36 Months

3. Starting Date: 08/30/07
4. Termination Date: 08/31/09
5. Current award amount: $46,750

Equistar Corporation
PI: G. Beaucage
Project: ***Branching Studies of Polyolefins***
1. Award Number: Contract
2. Award Duration: 12 Month (renewable to 36 Months)
3. Starting Date: 05/01/07
4. Termination Date: 04/30/08 (renewable to 04/30/10)
5. Current award amount: $150,000 (renewable $50,000/year for 3 years)

Past Funding: National Science Foundation, Department of Energy, DARPA, Equistar Corporation, Sun Chemical, P&G Corporation, Dupont Corporation, Swiss National Science Foundation, Equistar Chemicals, Sandia National Laboratories, Airforce Research Laboratories.

Facilities, Other Resources and Equipment:

- **Facilities:**

410 Rhodes Hall Laboratory is a 600 square foot research laboratory primarily focusing on scattering and polymer characterization instruments.

551 Engineering Research Center (ERC) Laboratory is a 300 square foot research laboratory with a hood, suitable for chemical synthesis. A light scattering camera is also housed in this lab as well as two polymer processing machines and a polymer film gas permeability tester.

Other Space: Space is being used (at the courtesies of Prof. D. W. Schaefer and Prof. R. Roseman) in the basement of the ERC for the 2D IR camera and in Rhodes 4'th floor for the TM Long Stretching instrument due to space constraints in other labs.

Office: Beaucage's office is located in 492 Rhodes Hall with student desks in the labs.

- **Equipment:**

Polymer Processing Equipment:

Collin Teach Machine Direction Orientation Unit On loan from Collin GmbH (http://www.drcollin.de/en/index_en.html). Lab scale polymer film stretching machine.

Brabender 50 gm Extruder Located in ERC 551 Lab. Film blowing attachment and home made take-up tower as well as mixing head. Home made fiber spinning apparatus. (See http://www.eng.uc.edu/~gbeaucag/Classes/Processing.html for pictures and video of this equipment. Equipment was donated by Dow Chemical and P&G to Beaucage, is very old but functional.

TM Long Stretch Polymer Film Biaxial Stretcher from Inventure Labs www.inventurelabs.com. Donated from P&G Polymer Processing Center Beckett Ridge Laboratories to Beaucage. Instrument is for static and dynamic precision biaxial deformation of polymer films. This instrument will be used to study post blowing/casting nano-composite orientation located in 410 Rhodes Hall.

Scattering Equipment

12 kW Rigaku rotating anode X-ray source with three small angle X-ray scattering cameras located in 410 Rhodes Hall laboratory of Beaucage with:

A pinhole camera with a 2-D detector focusing optics automatic sample changer. Instrument has been widely used in published SAXS studies. 0.5 to 50 nm size resolution, absolute intensity capability.

Kratky SAXS camera, capable of wider q-range compared to pinhole camera. Data is slit smeared requiring desmearing making results less reliable. 0.1 to 100 nm resolution.

Bonse-Hart USAXS camera currently not functional. 1 nm to 1 micron resolution.

Two static light scattering cameras and optical components.

Pinhole small-angle light scattering camera with 2D CCD camera located in 410 Rhodes Hall laboratory of Beaucage. Camera is enclosed in a dark box with vertical alignment, 20 mW HeNe laser, adjustable attenuator, polarizers pinhole optics, hot stage capabilities, scattering is projected on a screen and imaged with a Princeton Instruments 2D CCD detector. 0.6 to 100 micron resolution.

Ultra-small angle light scattering camera located in 551 Engineering Research Center laboratory of Beaucage. 30 mW HeNe laser, step scan goniometer with fiber optics connection to PMT and computer. Unique optics for USALS measurements, 1 micron to 1 cm resolution.

Assorted optics, optical tracks, 5 mW HeNe laser, stepper motors and motor controller.

P&G has recently donated two new x-ray scattering cameras and x-ray sources that are being setup in 410 Rhodes. This donation is worth about $750,000 and includes a 15 kW rotating anode x-ray generator, 2D pinhole SAXS camera, a compact Kratky camera, a 12 kW fixed target generator with an automated Bonse-Hart camera. The donation also includes an image plate detector for use with the pinhole camera for 2D XRD measurements that can be obtained simultaneously with SAXS measurements and peripheral equipment and computers for data reduction and sample preparation.

Other Equipment:

Dupont Instruments 912 Differential Scanning Calorimeter in the 410 Rhodes Lab.

Polymer Melt Rheometer: Rheometerics Dynamic Analyzer RDA II in the 410 Rhodes Lab.

TA Instruments Dynamic Mechanical Analyzer DMA 983 in the 410 Rhodes Lab.

Mocon Oxytran 2/20 O_2 Permeability Tester for films and membranes in the 551 ERC Laboratory.

Dynamic IR instrument, which couples a dynamic mechanical analyzer with IR birefringence measurements thorough a series of lock-in amplifiers for polymer dynamic studies housed in the ERC basement laboratories of Dale Schaefer due to space constraints. The instrument has a high resolution dispersive IR spectrometer.

4 Pyrolytic reactors with 6 mass flow controllers, assorted tubing, heat tape, neutralizers, filter banks and exhaust pump located in the 551 Engineering Research Center Laboratory of Beaucage.

Other Resources:

Beaucage is a collaborator and consultant with Lyondell Corporation in Cincinnati, the number 3 producer of polymers in the US. Lyondell's polymer processing research facility frequently collaborates with Beaucage.

Beaucage is also a long term collaborator and consultant with Procter & Gamble Corporation polymer processing and babycare divisions as well as with the fabric softener group, detergent group and research division at Miami Valley Laboratories.

Beaucage is PI on a long term user agreement with ESRF for in situ SAXS studies using beam line ID02. The work is in collaboration with T. Narayanan of ESRF and with S. E. Pratsinis of ETHZ. The agreement guarantees access to the synchrotron facilities for several weeks per year and is renewable after 3 years. The user agreement currently has 1 year remaining.

Beaucage also has a working arrangement with two beam lines at the Advanced Photon Source in Chicago at the UNICAT and at the DNDCAT user facilities.

SAXS measurements have also been conducted at CHESS (Cornell University), at SSRL (Stanford University) and at ELETTRA in Trieste, Italy. Beaucage is also a

founding member of the user group for the LSU SAXS facility at the LSU synchrotron.

Beaucage is on the board of advisors for the Intense Pulse Neutron Source (IPNS) at Argonne National Laboratories and has access to neutron scattering facilities at Argonne as well as good relations with NIST, ILL in Grenoble France, LANCE at Los Alamos and the Swiss Spellation Neutron Source (SINQ) at PSI in Villigen Switzerland. Additionally, Beaucage is a founding member of the LENS neutron facility at Indiana Universities Cyclotron Facility.

Courses Taught (12 courses all web based):

see http://www.eng.uc.edu/~gbeaucag/BeaucageResearchGroup.html for full course contents
(web page has about 167,000 hits since 1999 (more than 60 independent IP hits per day)

X-ray Diffraction (http://www.eng.uc.edu/~gbeaucag/Classes/XRD.html)

4 credits: 3 hours lecture, 3 hours lab (4 sections).

Web based course and lab with no required text, web book serves as text.

Course gives undergraduates and graduates (non-credit) an introduction to experimental applications of scattering and diffraction techniques in materials science. Course emphasizes the meaning of inverse space through experimental examples, the signature of crystalline and amorphous correlations in inverse space, form factor for simple structures and disordered materials in small angle x-ray, neutron and light scattering. Labs include light scattering and optical microscopy, polymer structural analysis using XRD and SAXS, crystallographic analysis of metals and ceramics, orientation studies using XRD, diffraction techniques in TEM, and small-angle x-ray scattering. Students become proficient in the use of a single-axis Phillips diffractometer.

Polymer Processing (http://www.eng.uc.edu/~gbeaucag/Classes/Processing.html)

4 credits: 3 hours lecture, 3 hours lab (6 sections). (listed as two courses 3 credit lecture and 1 credit polymer lab)

Web based course and lab with no required text, web book serves as text.

Course is aimed at materials engineering undergraduates with no background in rheology though it has been listed as a dual level graduate elective and undergraduate required course. Students are introduced to basic concepts of rheology as they apply to polymer melts with emphasis on concepts crucial to polymer processing unit operations. Labs use research equipment donated to our group and Jim Borieo's injection molding instrument to produced polymer mixtures, extruded streams, blown films, and injection molded parts. Processing parameters are compared with product and the relationships are coupled through predictions of rheological theory. Tours of local polymer processing facilities at Equistar, P&G, International Paper, US Precision Lens, and Sun Chemicals are included in the course as optional compliments to the lab and lecture. Students become familiar with polymer processing equipment and terminology and develop an understanding of the technical and scientific basis of common problems in the processing polymers.

Polymer Properties (Physics I) (http://www.eng.uc.edu/~gbeaucag/Classes/Properties.html)

3 credit required graduate course. 3 hours lecture.

Web based course with no required text.

Course adds to the fundamentals introduced in Jim Borieo's introductory graduate course targeting "Physical" Polymer Science (in analogy to Physical Metallurgy). The major discoveries in Polymer Physics, post 1970, are summarized along with necessary background information. The course is designed for graduate students intending to pursue research in Polymer Science as a career. Students learn to find research papers using internet search tools, to critically read research papers and to develop and present their scientific opinions concerning papers related to polymer physics, although the tools learned are widely translatable. The course is partly intended as a preparatory course for the oral PhD qualifier examination in Polymer Science.

Polymer Dynamics (Physics II) (http://www.eng.uc.edu/~gbeaucag/Classes/Physics.html)

3 credit graduate elective course (undergraduates by petition). 3 lecture hours.
Web based course with no required text.
Polymer dynamics provides a basis for understanding the dynamic response of anelastic materials. Students are introduced to the mechanical features and measurements that signify anelasticity. The concept of physical relaxation and mathematical tools to understand relaxation in simple, dilute systems are presented. Complications related to entanglement and hydrodynamic effects are discussed towards the end of the course. Students become familiar with dynamic mechanical analysis and dynamic light and neutron scattering.

Mechanics of Materials (http://www.eng.uc.edu/~gbeaucag/Classes/MechanicsofMaterials.html)

3 credit undergraduate required course. 3 lecture hours.
Web based course with no required text.
This course provides tools to understand the mechanical behavior of polymers, ceramics and metals. The course centers on an expansion of the discussion of continuum mechanics and constitutive equations begun in the prerequisite introductory mechanics course. Mechanics of Materials focuses on a tensoral description of stress, strain and strain rate. The course considers both dynamic and static behavior and the coupling of these in viscoelastic materials. Comparison between the approaches to mechanics in polymers, metals and ceramics is a corner stone of this course. Students learn to describe stress, strain and strain rate in materials using tensors, compare and contrast mechanical energy absorption mechanisms in metals, polymers and ceramics. Describe fracture and failure in polymers, metals and ceramics. Describe the mechanical response of simple composite systems.

Nanostructured Powders (http://www.eng.uc.edu/~gbeaucag/Classes/NanoPowder.html)

3 credit graduate elective course (undergraduates by petition). 3 lecture hours.
Web based course with no required text.
This course was developed under NSF funding to address the absence of fundamental courses and texts in nanomaterials. The course first deals with the fundamentals of non-equilibrium thermodynamics and physical chemistry associated with the synthesis of nanomaterials. Homogeneous nucleation and surface nucleation as well as coagulation and Ostwald ripening are covered. The course then makes a comparison between solution growth and growth in aerosols with some details concerning vapor phase growth. The end of the course is a critical survey of specific nano-materials such as carbon nanotubes, fumed ceramics, layered silicates, fullerenes and the like with the aim of distinguishing real advantages of the nanoscale from unsupported claims.

Polymer Morphology (http://www.eng.uc.edu/~gbeaucag/Classes/Morphology.html)

3 credit dual level elective course. 3 lecture hours with lab demonstrations.
Web based course with no required text.
Polymer Morphology explores the details of structures commonly encountered in polymeric materials. The course covers both well understood morphologies as well as more applied, less well understood morphologies important to industrial applications. The approach involves a hierarchical description of morphology. Atomic level structure, is often governed by thermodynamics and chemistry. The colloidal scale, which dominates polymeric materials, depends on a combination of kinetics and thermodynamics.

Macroscopic scale structures generally are dominated by kinetic effects. The relationship between these levels of structure are used to develop a full picture of the complex morphology of polymeric materials. The course is by nature topical reflecting the broad scope of morphologies seen in polymeric systems including: semi-crystalline phases, liquid/liquid phases, and immiscible phases of organic polymers and inorganic fillers.

Polymer Analysis (http://www.eng.uc.edu/~gbeaucag/Classes/Analysis.html)

3 credit dual level elective course. 3 lecture hours with lab demonstrations.

Web based course with no required text.

The focus of this course is analysis and characterization of polymers and plastics. Analysis of polymeric systems is essentially a subtopic of the field of chemical analysis of organic materials. Because of this, spectroscopic techniques commonly used by organic chemists are at the heart of Polymer Analysis, e.g. infra-red (IR) spectroscopy, Raman spectroscopy, nuclear magnetic resonance (NMR) spectroscopy and to some extent ultra-violet/visible (UV/Vis) spectroscopy. In addition, since most polymeric materials are used in the solid state, traditional characterization techniques aimed at the solid state are often encountered, x-ray diffraction, optical and electron microscopy as well as thermal analysis. Unique to polymeric materials are analytic techniques which focus on viscoelastic properties, specifically, dynamic mechanical testing. Additionally, techniques aimed at determination of colloidal scale structure such as chain structure and molecular weight for high molecular weight materials are somewhat unique to polymeric materials, i.e. gel permeation chromatography, small angle scattering (SAS) and various other techniques for the determination of colloidal scale structure. Students learn the technical basis of common analytic techniques used in polymer research and plastics product development and process control.

Polymer Characterization (http://www.eng.uc.edu/~gbeaucag/Classes/Characterization.html)

3 credit required graduate course (undergraduate by petition). 6 hours lab, 8 sections.

Web based course with no required text.

Students are presented with 7 physical chemistry-type labs pertaining to polymer analysis each week and are given 6 days to complete the write-up (generally 20 to 30 pages). Extensive web notes and previous experimental results are available on the web. The course includes a group project involving reverse engineering of a plastic product and a required computer program pertaining to polymer analysis. Students are required to maintain an industrial-type lab notebook. Students learn skills needed to perform experimental work in a research or industrial laboratory as well as being introduced to common analytic techniques used in polymer science and in the plastics industry.

Introduction to Polymer Science

(http://www.eng.uc.edu/~gbeaucag/Classes/IntrotoPolySci.html)

3 credit undergraduate course.

Web based course with no required text.

Introduction to Polymer Science is the first part of a three course sequence for undergraduates in Materials Science and Engineering. The course focuses on synthetic chemistry of polymers and coincides with an organic chemistry course and lab taught in the chemistry department. The course presents classroom demonstrations of simple polymerization and gelation reactions and uses these demonstrations as a stepping off point for the introduction of the basic synthetic chemistry of polymers. Grading involves a weekly quiz of some difficulty with the option to replace the quiz grade with computer

programs and other projects outside of class. Most students complete 3 to 5 projects used to improve their course grade.

Introduction to Chemical and Materials Engineering, I and II.

(http://www.eng.uc.edu/~gbeaucag/Classes/IntroCME.html and http://www.eng.uc.edu/~gbeaucag/Classes/IntroCME_101.html)

1 credit undergraduate course (taught in the Fall as CME 100 and in the Spring as CME 101)

Web based course with no required text.

Intro. to CME is a Freshmen year class intended to improve retention of students in the Chemical and Materials Engineering Program. Typically more than half of the entering Freshmen class of about 80 students fail to return for their Sophomore year. This is partly due to the difficulty of the CME curriculum, which is the most difficult of the Engineering disciplines at Cincinnati. The course is composed of a series of lectures by invited speakers from the CME field including Faculty, professional engineers in the Cincinnati area, upperclassmen and graduates of the CME program in order to improve the students understanding of the CME field. The course includes a mandatory help session for students below a 3.2 GPA run by graduate and undergraduate students in the CME department.

Morphology of Complex Materials.

(http://www.eng.uc.edu/~gbeaucag/Classes/MorphologyofComplexMaterials.html)

3 credit dual level elective course. 3 lecture hours with lab demonstrations.

Web based course with no required text.

Morphology of Complex Materials describes the similarities between materials displaying a structural hierarchy. The course begins with a discussion of protein structure as the model system for structural hierarchy. A comparison is then made with structural hierarchy in synthetic polymers, especially polymers in solution. The hierarchy of semi-crystalline polymers is then explored with a discussion of structural orientation. Finally structural hierarchy in inorganic and carbonaceous aggregates are detailed with an emphasis on the relationship between structural hierarchy and physical properties and synthetic conditions. Finally, students apply this view of materials science to materials of their choice in class presentations

Academic Committees

Current Committees:

Undergraduate Curriculum co-Chair Materials Engineering
Undergraduate Studies co-Director Materials Engineering
Undergraduate Curriculum Committee Chair, Materials Engineering
ACCEND Program Advisor Chemical and Materials Engineering
Freshmen Advisor Materials Engineering
Undergraduate Student Outreach and Recruitment Committee
Student Awards and Recognition Committee
Undergraduate Student Liason Committee Chair
Co-op Liason Committee
College Academic Standards Committee
College Transfer Council Committee

Past Committees:
Departmental By Laws Committee
PhD Qualifier Committee
Chemical and Materials Engineering Department Head Search Committee
MS committees 5/year (have served in Electrical Engineering and Materials Science and Engineering)
PhD committees 4/year (have served in Chemistry, Electrical Engineering, Chemical Engineering and Materials Science and Engineering as well as 3 PhD committees in Process Engineering at ETHZ, Zurich Switzerland)
Undergraduate Curriculum Committee

External Committees

Vice Local Chair for the National (ANTEC) Meeting of Society of Plastics Engineers, 2007.
Coordinator of Student Affairs ANTEC Meeting 2007.
Chairman of Small-Angle Scattering Group of the American Crystallographic Association
Organizing American Crystallography Association Scattering Sessions for 2005 meeting
Advisory board and review panel for Intense Pulsed Neutron Source, Argonne National Laboratory, Argonne Illinois
Advisor Indiana University Low Energy Neutron Source (LENS) Bloomington Indiana http://www.iucf.indiana.edu/neutronsource/
Active reviewer for *PRL, J. Appl. Cryst., J. Polym. Sci. Polym. Phys., Polymer, Macromolecules, J. Nanoparticle Research*, typically review 15 papers per year. NSF, PRF, Swiss NSF, ETH and NIST proposal reviews.

Invited Presentations of note (past 5 years)

American Chemical Society Meeting Boston 8/2007. Synthetic and Biological Macromolecules for Emerging Nanotechnologies.
41st Course International School of Solid State Physics 52nd IUVSTA Workshop: Structure and Dynamics of Free and Supported Nanoparticles using Short Wavelength Radiation Erice Sicily: July 22-26 2007.
National Institute of Standards and Technology (NIST), Reactor Division July 2007.
Society of Plastics Engineers, ANTEC May 2007
Procter & Gamble, Miami Valley Laboratories February 2007.
Spring Course on Semiconducting Nanoparticles: Synthesis and Structure. Universitat Duisburg-Essen. May 2007 (http://www.uni-duisburg-essen.de/nanotronics/springcourse2007.shtml)
AIChE Nanoparticle Characterization San Francisco 2006.
7'th International Aerosol Conference Minneapolis MN 9/2006
Gordon Research Conference on Composites
ESRF, Grenoble France
APS, Argonne National Laboratories
Swiss Light Source, Paul Scherrer Institute
ETHZ, Department of Physics
ETHZ, Process Engineering Department
Department of Physics, Indiana University, Bloomington Indiana
Denver X-ray Conference
American Crystallography Association

Collaborators: (past 3 years)

Dr. S. E. Pratsinis, Department of Mechanical and Process Engineering, ETHZ, Zurich, Switzerland.
Dr. K. Boulouchos, Department of Mechanical and Process Engineering, ETHZ, Zurich, Switzerland.
Dr. J. van Bokhoven, Department of Chemistry, ETHH, Zurich Switzerland.
Dr. T. Trevoort, Materials Science, ETHZ, Zurich Switzerland.
Dr. D. W. Schaefer, Dept. of Materials Science and Engineering, University of Cincinnati.
Dr. J. E. Mark, Dept. Chemistry, University of Cincinnati.
Dr. F. Mirabella, Equistar Chemical, Cincinnati, OH.
Dr. V. Galiatsatos, Equistar Chemical, Cincinnati, OH.
Dr. J. Ilavsky, UNICAT, APS, Argonne National Laboratories, Argonne Illinois.
Dr. H. K. Kammler, Clarion Technologies, Basel Switzerland.
Dr. T. Narayanan, ESRF ID02, Grenoble France.
Dr. P. Thiyagaran, IPNS, Argonne National Laboratories, Argonne Illinois
Dr. S. K. Sukumaran, Polymer Institute, Mainz Germany (Former Graduate Student).
Dr. D. Wieckhusen & Gerhard Muhrer, Novartis Corporation, Basal Switzerland.

Member ACS, AIChE, MRS, APS, American Crystallography Association.

Publications G. Beaucage

Total publications listed below: 113 (as of 8/2007). (Links to submitted and in press papers can be found at http://www.eng.uc.edu/~gbeaucag/CV/LinksToPDFs.html.)

2007

Physical Relationship Between Reinforcement and Orientation in Clay Nanocomposites. Bafna A, Beaucage G, Mirabella F submitted *J. Polym. Sci. Polym. Phys. 2007*

Integrated Mechanism for the Morphological Structure Development in HDPE Melt-Blown and Machine-Direction-Oriented (MDO) Films Bafna A, McFaddin D, Beaucage G, Merrick-Mack J, Mirabella FM in press *J. Polym. Sci. Polym. Phys.* **45** 1834-1844 (2007).

Modeling the Mechanical Properties of Highly Oriented Polymer Films: A Fiber/Gel Composite Theory Approach Breese DR, Beaucage G Submitted *J. Polym. Sci. Polym. Phys.* 2007.

Towards resolution of ambiguity for the unfolded state of proteins. Beaucage G submitted *Biophysical Journal* 9/2007.

Nanomaterial growth dynamics in jet flames Jossen R, Beaucage G, Heine MC, Narayanan T and Pratsinis SE Submitted *Adv. Mat.* 9/2007

Dimensional Description of Cyclic Polymers Kulkarni AS and Beaucage G Submitted *Phys. Rev. Lett.* 9/2007.

Small Angle X-ray Scattering Study of Phase Separation Kinetics in Segmented-Polyurea Kulkarni AS, Beaucage G, Wilkes GL, Das S, Yilgor I Submission planned in the near future *Macromolecules*.

Chapter *Chain Structure Characterization*, A. S. Kulkarni and G. Beaucage in *Characterization of Synthetic Polymers* Edited by J. M. Chalmers and R. Meier John Wiley & Sons 2007 in press.

Investigating the Molecular Architecture of Hyperbranched Polymers Kulkarni AS and Beaucage G, *Macromol. Rap. Comm.* **28**, 1312-1316 (2007).

In situ study of aggregation of soot particles in an acetylene flame by small-angle x-ray scattering. Sztucki M, Narayanana T, Beaucage G *J. Appl. Phys.* **101** 114304 (2007).

4 Chapters in *Polymer Data handbook 2e* edited by J. E. Mark *Polypyrrole;Polyquinolin; Polythiophene; Poly(p-xylylene)* 2007. Oxford University Press, NY, NY.

2006

Quantification of branching in disordered materials. Kulkarni AS, Beaucage G *J. Polym. Sci. Polym. Phys.* **44** 1395-1405 (2006).

An investigation of the properties of poly(dimethylsiloxane)-bioinspired silica hybrids. Patwardhan S, Taori VP, Hassan M, Agashe, NR, Franklin JE, Beaucage G, Mark JE, Clarson, SJ *Euro. Polym. J.* **42** 167-178 (2006).

2005

Neutron scattering from equilibrium-swollen networks. Sukumaran SK, Beaucage G, Mark JE, Viers B *Eur. Phys. J. E* **18** 29-36 (2005).

In situ studies of nano-particle growth dynamics in premixed flames. Kammler HK, Beaucage G, Kohls DJ, Agashe N, Ilavsky J, Pratsinis SE *J. Appl. Phys.* **97**(5) 054309 (2005).

A review of modeling approaches for oriented semi-crystalline polymers. Breese DR, Beaucage G *Curr. Opin. Sol. St. Matls. Sci.* **8** 439-448 (2004).

Novel mesoporous mixed Nb-M (M = V, Mo, and Sb) oxides for oxidative dehydrogenation of propane. Yuan L, Bhatt S, Beaucage G, Guliants VV, Mamedov S, and Soman RS *J. Phys. Chem. B* **109** 23250-23254 (2005).

How does surface modification aid in the dispersion of carbon nanofibers? Zhao J, Schaefer DW, Shi D, Lian J, Brown J, Beaucage G, Wang L, and Ewing RC *J. Phys. Chem. B* **109** 23351-23357 (2005).

Reaction-induced phase separation controlled by molecular topology. Kulkarni A, Beaucage G. *Polymer* **46** 4454–4464 (2005).

2004

Probing the dynamics of nanoparticle growth in a flame using synchrotron radiation Beaucage G, Kammler HK, Mueller R, Pratsinis SE, Narayanan T. *Nature Materials* **3** (6): 370-374 (2004).

Determination of branch fraction and minimum dimension of mass-fractal aggregates Beaucage G., *Physical Review E* **70**(3) 031401 (2004).

Particle size distributions from small-angle scattering using global scattering functions. Beaucage, G. Kammler HK, Pratsinis SE, *J. Appl. Cryst.* **37**, 523-535 (2004).

Non-agglomerated dry silica nanoparticles. Mueller R, Kammler HK, Pratsinis SE, Vital A, Beaucage G, Burtscher P *Powder Tech.* **140** (1-2): 40-48 (2004).

Structure of flame-made silica nanoparticles by ultra-small-angle X-ray scattering Kammler HK, Beaucage G, Mueller R, Pratsinis SE *Langmuir* **20** (5), 1915-1921 (2004).

Structure of arylene-bridged polysilsesquioxane xerogels and aerogels. Schaefer DW, Beaucage G, Loy DA, Shea KJ, Lin JS *Chemistry of Materials* **16** (8), 1402-1410 (2004).

Sol-gel condensations to form polytetrahydrofuran networks and their elastomeric behavior. Hassan MK, Abdel-Sadek GG, Beaucage G, Mark JE, Sharaf MA *J. Macromol. Sci.-Pure Appl. Chem.* **A41** (1), 1-13 (2004).

Disposable Smart lab on a chip for point-of-care clinical diagnostics. Ahn CH, Choi JW, Beaucage G, Nevin JH, Lee JB, Puntambekar A, Lee JY *Priceedings of the IEEE* **92** (1), 154-173 (2004).

In-situ catalyst generation and controlled hydrolysis in the sol-gel precipitation of zirconia and titania particles in poly(dimethylsiloxane). Murugesan S, Sur GS, Mark JE, Beaucage G *J. of Inorganic and Organomet. Polym.* **14** (4): 239-252 (2004).

Synthesis, characterization and molecular weight studies of certain soluble poly(3-alkylthiophene) conducting polymers. Oztemiz S, Beaucag G, Ceylan O, Mark HB *J. Sol. St. Electrochem.* **8** 928-931 (2004).

2003

3D Hierarchical orientation in polymer-clay nanocomposite films Bafna A, Beaucage G, Mirabella F *Polymer* **44** (4), 1103-1115 (2003).

The effect of external electric fields during flame synthesis of titania. Kammler HK, Jossen R, Morrison PW, Pratsinis SE, Beaucage G *Powder Tech.* **135,** 310-320 Sp. Iss. (2003).

A functional on-chip pressure generator using solid chemical propellant for disposable lab-on-a-chip. Hong CC, Murugesan S, Kim S, Beaucage G, Choi JW, Ahn CH *Lab on a Chip.* **3**(4), 281-286 (2003).

Preparation and characterization of some unusually transparent poly(dimethylsiloxane) nanocomposites. Rajan GS, Sur GS, Mark JE, Schaefer DW, Beaucage G *J. Polym. Sci. Part B Polym. Phys.* **41**(16), 1897-1901 (2003).

Structure-property relationships for poly(dimethylsiloxane) networks in situ filled using titanium 2-ethylhexoxide and zirconium n-butoxide. Murugesan S, Mark JE, Beaucage G *Synthesis and Propperties of Silicones and Silcone-Modified Materials, ACS Symposium Series* 838, 163-169 (2003).

Analysis of average particle size in flame-made oxide nanoparticles using ultra small-angle x-ray scattering and nitrogen adsorption. Kammler, H. K.; Beaucage, G.; Mueller, R.; Pratsinis, S. E. *Chemie-Ingenieur-Technik* **75**(8) 1138-1139 **(**2003).

A disposable plastic biochip cartridge with on-chip power sources for blood analysis Choi J-W, Puntambekar A, Hong C-C;, Gao C, Zhu X, Trichur R, Han J, Chilukuru S, Dutta,M, Murugesan,S, Kim,S, Sohn,Y-S, Nevin,JH.; Beaucage,G, Lee J-B, Ahn CH *Proceedings of the IEEE Micro Electro Mechanical Systems (MEMS)* 447-450 (2003).

A functional on-chip pressure generator using solid chemical propellant for disposable lab-on-a-chip. Hong C-C, Murugesan S, Kim S, Beaucage G, Choi, J-W, Ahn, CH *Proceedings of the IEEE Micro Electro Mechanical Systems (MEMS)* 16-19 (2003).

2002

Bottom-up synthesis of polymer nanocomposites and molecular composites: Ionic exchange with PMMA latex. Rossi GB, Beaucage G, Dang TD, Vaia R *Nano Letters* **2**(4), 319-323 (2002).

Non-agglomerated Fumed Silica Nano-particles. Muller R, Vital A, Kammler HK, Pratsinis SE, Beaucage G *Chemie Ingenieur Technik* **74**(5), 543-544 (2002).

Relation of the fractal structure of organic pigments to their performance Skillas G, Beaucage G, Agashe N, Kohls DJ *J. Appl. Phys.* **91**(9), 6120-6124 (2002).

Rational design of reinforced rubber Kohls DJ, Beaucage G *Curr. Opin. Solid St. M.* **6**(3), 183-194 (2002).

Fabrication and characterization of planar and channel polymer waveguides. III. Compositional distribution and solute loss in polymer thin films. Banach MJ, Clarson SJ, Beaucage G, Benkoski J, Mates T, Kramer EJ, Vaia RA *J. Appl. Polym. Sci.* **86**(8), 2021-2024 (2002).

A structural model for equilibrium swollen networks. Sukumaran SK, Beaucage G *Europhysics Letters* **59**(5), 714-720 (2002)

Surface modification of cyclic olefinic copolymers for bio-mems microfluidic devices. Ahn C, Kim S, Chao H, Murugesan S, Beaucage G *Materials Research Society Symposium - Proceedings* **729** 131-136 (2002).

Disposable smart plastic biochips for clinical diagnostics. Ahn CH, Choi J-W, Kim, S, Sohn, Y-S, Puntambekar,A, Murugesan,S, Beaucage G, Nevin JH *Materials Research Society Symposium-Proceedings* **729** 29-38 (2002).

2001

PEO-PPO-PEO block copolymer micelles in aqueous electrolyte solutions: Effect of carbonate anions and temperature on the micellar structure and interaction. Sukumaran S, Beaucage G, Mao GM, Thiyagaran P *Macromolecules* **34**(3), 552-558 (2001).

Morphological study of HDPE blown films by SAXS, SEM and TEM: a relationship between the melt elasticity parameter and lamellae orientation. Prasad A, Shroff R, Rane S, Beaucage G *Polymer* **42**(7), 3103-3113 (2001).

Carbon coated silica for elastomer reinforcement Kohls DJ, Beaucage G, Pratsinis SE, Kammler HK, Skillas G. *Materials Research Society Symposium-Proceedings* **661** 941-952 (2001).

Optical properties and orientation in polyethylene blown films. Bafna A, Beaucage G, Mirabella F. *J. Polym. Sci, Pol. Phys.* **39**(23), 2923-2936 (2001).

2000

Multilevel structure of reinforcing silica and carbon. Schaefer DW, Rieker T, Agamalian M, Beaucage G *J. Appl. Crystallogr.* **33**(1), 587-591 Part 3 (2000).

Relaxation of polymer thin films in isothermal temperature-jump measurements Beaucage G, Banach MJ, Vaia RA *J. Polym. Sci., Pol. Phys.* **38**(22), 2929-2936 (2000).

1999

Structural analysis of polydimethylsiloxane (PDMS) modified silica xerogels. Guo L., Hyeon-Lee J, Beaucage G *J. Non-Crystalline Solids* **243** 61-69 (1999).

Morphology of polyethylene-carbon black composites. Beaucage G, Rane S, Schaefer DW, Long G, Fischer D *J. Polym. Sci. Polym. Phys.* **37**, 1105-1119 (1999).

Dependence of silica particle sizes on network chain length, silica contents and catalyst concentrations in in situ-reinforced polysiloxane elastomers. Breiner JM, Mark JE, Beaucage G *J. Polym. Sci. Poly. Phys.* **37**(13), 1421-1427 (1999).

Structure and growth kinetics of zirconium hydrous polymers in organic solutions. Singhal A, Beaucage G, Harris MT, Toth LM, Keefer KD, Lin JS, Hu MZC, Peterson JR, *J. Non-cryst. Solids* **246**(3), 197-208 (1999).

Glassy polystyrene composites having zeolite 13X or vycor as a dispersed inorganic phase. Maaref S, Frisch HL, Rajan GS, Beaucage G *J. Macromol. Sci. Pure.* **36**(12), 1895-1906 (1999). (Correction: *J. Macromol. Sci. Pure.* **37**(5) 525-525 (2000).)

Aero-sol-gel reactor for nano-powder synthesis. Beaucage G, Hyeon-Lee J, Kohls DJ, Pratsinis SE *J. Nanoparticle Research* **1** 379–392 (1999).

Some attempts to force poly(dimethylsiloxane) chains through zeolite cavities to improve elastomer reinforcement. Pu Z, Mark JE, Beaucage G *Rubber Chem. Tech.* **72**, 138-151 (1999).

Kinetics of morphological development in elastomer modified silica xerogels. Beaucage G, Guo L, Hyeon-Lee J *Rubber Chem. Tech.* **72**, 130-137 (1999).

Rane , S, Beaucage G 4 Chapters in *Polymer Data handbook* edited by J. E. Mark *Polypyrrole;Polyquinolin; Polythiophene; Poly(p-xylylene)* 1999. Oxford University Press, NY, NY.

1998

Fractal analysis of flame-synthesized nanostructured silica and titania powders using small-angle X-ray scattering. Hyeon-Lee J, Beaucage G, Pratsinis SE *Langmuir* **14**(20), 5751-5756 (1998).

Isotatic polypropylene foams crystallized from compressed propane solutions. Whaley PD, Kulkarni S, Ehrlich P, Stein RS, Winter HH, Beaucage G *J. Polym. Sci., Part B: Polym. Phys.* **36**(4), 617-627 (1998).

Macroscopic polymer analogues. Beaucage G, Sukumaran S, Rane S *J. Polym. Sci Pol. Phys.* **36**(17), 3147-3154 (1998).

Structural Investigation of a Surfactant-Templated Silica Aerogel by Small-Angle Scattering. Rieker TP, Anderson MT, Sawyer PS, Rane S, Beaucage G in *Nanostructured Powders and Their Industrial Application* eds. G. Beaucage, J. E. Mark, G. T. Burns, D-W Hua, Materials Research Society, Warrendale PA, 95-102 (1998).

Synthesis of Nanostructured Silica Powders by a Room-Temperature Aerosol Process. Hyeon-Lee J, Beaucage G, Pratsinis SE in *Nanostructured Powders and Their Industrial Application* eds. G. Beaucage, J. E. Mark, G. T. Burns, D-W Hua, Materials Research Society, Warrendale PA, 115-122 (1998).

Preparations, structures and properties of polysiloxane-silica composites prepared from a variety of hydrolyzable precursors Breiner JM, Mark JE, Beaucage G in *Nanostructured Powders and Their Industrial Application* eds. G. Beaucage, J. E. Mark, G. T. Burns, D-W Hua, Materials Research Society, Warrendale PA, 275-286 (1998).

1997

Crystal Structures of Monodisperse Colloidal Silica in Poly (Methyl acrylate) Films. Jethmalani JM, Ford WT, Beaucage G *Langmuir* **13**(13), 3338-3344 (1997) and *Langmuir* **13**(20), 5515-5515 (1997).

Growth and Structure of Zirconium Hydrous Polymers in Aqueous Solutions. Singhal A, Toth LM, Beaucage G, Lin JS, Peterson J *Journal of Colloidal and Interface Science* **194**(2), 470-481 (1997).

Persistence Length of i-Poly(Hydroxy-Butyrate). Beaucage G, Rane S, Sukumaran S, Satkowski MM, Schechtman LA, Doi Y *Macromolecules* **30**, 4158-4162 (1997).

Aero-Sol-Gel Synthesis of Nanostructured Silica Powders Hyeon-Lee J, Beaucage G, Pratsinis SE *Chemistry of Materials* **9**(11) 2400-2403 (1997).

1996

Small-Angle Scattering from Polymeric Mass Fractals of Arbitrary Mass-Fractal Dimension. Beaucage G *J. Appl. Crystallogr.* **29**, 134-146 (1996).

Symmetric, Isotopic Blends of Poly(dimethylsiloxane). Beaucage G, Sukumaran S, Clarson SJ, Kent MS, Schaefer DW *Macromolecules* **29**(26), 8349-8356 (1996).

Interpenetrating and pseudo-interpenetrating polymer networks of poly(ethyl acrylate) and zeolite 13X, Frisch HL, Maaref S, Xue Y, Beaucage G, Pu Z, Mark JE *J. Polym. Sci., Part A: Polym. Chem.* **34**(4), 673-677 (1996).

Morphological development in PDMS/TEOS hybrid materials. HyeonLee J, Guo L, Beaucage G, MacipBoulis MA, Yang AJM *J. Polym. Sci., Polym. Phys.* **34**(17), 3073-3080 (1996).

Nano-Structured, Semicrystalline Polymer Foams. Beaucage G, Aubert JH, Lagasse RR, Schaefer DW, Rieker TP, Ehrlich P, Stein RS, Kulkarni S, Whaley PD *J. Polym. Sci., Part B: Polym. Phys.* **34**(17), 3063-3072 (1996).

Small angle X-ray scattering investigations of zeolite-penetrated poly(ethyl acrylate) composites. Pu ZC, Mark JE, Beaucage G, Maaref S, Frisch HL J. Polym. Sci., Polym. Phys. **34**(15), 2657-2660 (1996).

Pseudo interpenetrating polymer networks and interpenetrating polymer networks of zeolite 13 X and polystyrene and poly(ethyl acrylate). Frisch HL, Xue YP, Maaref S, Beaucage G, Pu ZC, Mark JE *Macromolecular Symp.* **106**, 147-166 (1996).

From small angle x-ray scattering to reflectivity: instrumentation and sample study. Hua DW, Beaucage G, Kent MS, *J. Mater. Res.* **11**(2), 273-276 (1996).

The in-situ generation of silica reinforcement in modified polydimethylsiloxane elastomers. Prabakar S, Bates SE, Black EP, Ulibarri TA, Schaefer DW, Beaucage G, Assink RA *Mater. Res. Soc. Symp. Proc.* **435**(Better Ceramics through Chemistry VII: Organic/Inorganic Hybrid Materials), 469-474 (1996).

In-situ generation of silica reinforcement in modified polydimethylsiloxane elastomers. Prabakar S, Bates SE, Black EP, Ulibarri TA, Schaefer DW, Beaucage G, Assink RA *Materials Research Society Symposium Proceedings* **435** 469-474 (1996).

Origin of porosity in arylene-bridged polysilsesquioxanes. Schaefer DW, Beaucage G, Loy DA, Ulibarri TA, Black E, Shea KJ, Buss RJ *Materials Research Society Symposium Proceedings* **435** 301-306 (1996).

Solvent effects on silica domain growth in silica/siloxane composite materials. Ulibarri TA, Bates SE, Black EP, Schaefer DW, Beaucage G, Lee MK, Moore PA, Burns GT *International SAMPE Technical Conference* **27** 560-567 (1995).

1995

Approximations leading to a unified exponential/power-law approach to small-angle scattering. Beaucage G *J. Appl. Crystallogr.* **28**(6), 717-728 (1995).

Neutron Reflectivity Studies of End-Grafted Polymers. Mansfield TL, Iyengar DR, Beaucage G, McCarthy TJ, Stein RS, Composto RJ *Macromolecules* **28**(2), 492-499 (1995).

Origin of Porosity in Resorcinol-Formaldehyde Aerogels. Schaefer DW, Pekala R, Beaucage G *J. Non-Cryst. Solids* **186** 142-148 (1995).

Structural analysis of silica aerogels, Hua DW, Anderson J, Di Gregorio J, Smith DM, Beaucage *G J. Non-Cryst. Solids* **186** 142-148 (1995).

Sol-gel-derived silica-siloxane composite materials. Effect of reaction conditions in polymer-rich systems. Black EP, Ulibarri TA, Beaucage G, Schaefer DW, Assink RA, Bergstrom DF, Giwa-Agbomeirele PA, Burns GT *ACS Symp. Ser.* **585**(Hybrid Organic--Inorganic Composites), 237-246 (1995).

Multiple size scale structures in silica-siloxane composites studied by small-angle scattering. Beaucage G, Ulibarri TA, Black EP, Schaefer DW *ACS Symp. Ser.* **585**(Hybrid Organic--Inorganic Composites) 97-111 (1995).

Characterization of Porosity in Ceramic Materials by Small-angle Scattering: Vycor Glass and Silica Aerogel. Schaefer DW, Beaucage G, Brow RK, Olivier BJ, Rieker T, Hrubesh L, Lin JS, in *Modern Aspects of Small-Angle Scattering*, H. Brumberger Ed., Kluwer Academic Publishers, Netherlands 299-305 (1995).

1994

Structural studies of complex systems using small-angle scattering: a unified Guinier/power-law approach. Beaucage G, Schaefer DW, *J. Non-Cryst. Solids* **172-174**(Pt. 2), 797-805 (1994).

Time-of-Flight Secondary Ion Mass Spectrometry of Deuterated Linear Poly(dimethylsiloxane). Zhang X, Stuart JO, Clarson SJ, Sabata A, Beaucage G *Macromolecules* **35**, 2716-2724 (1994).

Light scattering from random coils dispersed in a solution of rod-like polymers. Jamil T, Russo, PS, Negulescu I, Daly WH, Schaefer DW, Beaucage G *Macromolecules* **27**(1), 171-178 (1994).

Crystallinity of Fully Aromatic Thermotropic Polyesters of 3,3'-bis(Phenyl)-4,4'-Biphenol and 1, 1'-Binaphthyl-4,4'-Diol. Bhowmik PK, Beaucage G *J. Polym. Sci., Part B: Polym. Phys.* **32**, 1023-1031 (1994).

Structure and Topology of Silica Aerogels During Densification, Schaefer DW, Olivier BJ, Ashley C, Beaucage G, Fischer DA *J. Non-Cryst. Solids* **172-174** (Pt. 1), 647-655 (1994).

Pore morphology study of silica aerogels. Hua DW, Anderson J, Hereid S, Smith DM, Beaucage G *Mater. Res. Soc. Symp. Proc.* **346**(Better Ceramics through Chemistry VI), 985-990 (1994).

General Routes to Porous Metal Oxides via Inorganic and Organic Templates. Roger C, Hampden-Smith MJ, Schaefer DW *J. Sol-Gel Sci. Technol. **2***, 67-72 (1994).

Mechanical behavior and morphology of tactic poly(vinyl methyl ether)/polystyrene blends, Beaucage G Stein RS *Polymer* **35**(13), 2716-2724 (1994).

Phase separated polymer alloys with reduced brittleness. Beaucage G, Stein *RS US Patent 533,828* (1994).

1993

Ellipsometric study of the glass transition and thermal expansion coefficients of thin polymer films. Beaucage, G, Composto R, Stein RS*, J. Polym. Sci., Part B: Polym. Phys.* **31**(3) 319-326 (1993). Citations 47.

Tacticity effects on polymer blend miscibility. 2. Rate of phase separation. Beaucage G, Stein RS *Macromolecules* **26**(7), 1609-1616 (1993).

Tacticity effects on polymer blend miscibility. 1. Flory-Huggins-Staverman analysis. Beaucage, G, Stein RS, Koningsveld R *Macromolecules* **26**(7), 1603-1608 (1993).

Tacticity effects on polymer blend miscibility. 3. Neutron scattering analysis. Beaucage G, Stein RS *Macromolecules* **26**(7), 1617-1626 (1993).

Multiple size scale structures in silica/siloxane composites studied by small-angle scattering. Beaucage G, Schaefer DW, Ulibarri T, Black E *Polym. Mater. Sci. Eng.* **70**, 268-269 (1993).

Sol-gel derived silica/siloxane composite materials: The effect of loading level and catalyst activity on silica domain formation. Black EP, Ulibarri TA, Beaucage G, Schaefer DW, Assink RA, Bergstrom DF, Giwa-Agbomeirele PA, Burns GT *Polym. Mater. Sci. Eng.* **70**, 382-383 (1993).

1992

A SANS Study of In situ Filled Polydimethylsiloxane. Schaefer DW, Ulibarri TA, Beaucage G, *Sub-Micron Multi-Phase Materials*, Ed. R. H. Baney, Materials Research Society Symposium Proceedings **274**, Materials Research Society, Pittsburgh, PA, 85-90 (1992).

Molecular weight dependence of domain structure in silica-siloxane molecular composites. Ulibarri TA, Schaefer DW, Beaucage G, Olivier BJ, Assink R *Mater. Res. Soc. Symp. Proc.* **274** (Submicron Multiphase Materials) 91-95 (1992).

The volume fraction profile of terminally adsorbed polymers. Composto RJ, Mansfield T, Beaucage G, Stein RS, Iyengar DR, Mc Carthy TJ, Satija SK, Ankner JF, Majkrzak CF *Mater. Res. Soc. Symp. Proc.* **248** (Complex Fluids), 407-412 (1992).

Neutron reflectivity study of concentration profile of polystyrene polymer brushes. Satija SK, Ankner JF, Majkrzak CF, Mansfield T, Beaucage G, Stein RS, Iyengar DR, McCarthy TJ, Composto RJ *Polym. Mater. Sci. Eng.* **67**, 159-160 (1992).

1991

Tacticity effects on polymer blend miscibility. Beaucage G, Stein RS, Hashimoto T, Hasegawa H *Macromolecules* **24**(11), 3443-3448 (1991).

Structure of Combustion Aerosols. Schaefer DW, Olivier BJ, Beaucage G, Hurd AJ, Ivie JJ, Herd CR *J. Aerosol Sci.* **22**, Suppl. 1, S447-450 (1991).

Polymer blend miscibility and phase separation kinetics analyzed using Flory-Huggins-Staverman Theory. Stein RS, Beaucage G, Berard MT, Koningsveld R *Polymer Preprints* Division of Polymer Chemistry, American Chemical Society **32** 475-476 (1991).

Editorial:
Nanostructured Powders and Their Industrial Application editors G. Beaucage, J. E. Mark, G. T. Burns, D-W Hua, Materials Research Society, Warrendale PA, (1998).

Jorunal of Nanoparticle Research Issue 1(2) 1999 guest editors S. E. Pratsinis, G. Beaucage

Summary/Plans (Self-Evaluation):

Beaucage's career efforts have focused on understanding nanomaterials with engineering applications such as polymers and ceramic aggregates. Such nanomaterials often display complex hierarchical structure and Beaucage has pioneered efforts at application of scattering techniques to describe these structures. Work has focused in three main topical areas, ceramic aggregate structure, polymer and network structure and the structure of semi-crystalline plastics especially in processed films in association with Equistar, Sun Chemicals and P&G. He has made contributions to the field of small-angle x-ray and neutron scattering through the development of scattering functions that are of a global nature allowing the unification of a broad range of materials with common and general descriptive tools. Beaucage has a strong publication record including more than 100 publications including a paper in Nature Materials with several papers having more than 100 citations.

A state of the art small angle x-ray scattering, SAXS, and light scattering facility has been developed at Cincinnati with more than 1 million dollars in equipment (replacement cost) representing one of the top laboratory x-ray scattering facilities in the US. He is also a user of synchrotron and neutron facilities in the US and in Europe. SAXS is a primary tool for the characterization of nanomaterials and the orientation of nano-structures in processed materials. Cincinnati has a long tradition of expertise in small-angle scattering with Paul J. Flory, Joon Roe, Jim Mark and Dale Schaefer having been or currently being faculty at Cincinnati. Beaucage's teaching effort has followed his research interests with a range of courses focusing on polymer science, ceramic nanopowders and x-ray diffraction. He has also recently initiated a first year undergraduate course, CME 100 and CME 101 that introduces new students to the Chemical and Materials Engineering Field with the aim of increasing retention of students through their sophomore year. Beaucage has also served on a number of academic committees and external committees especially in the small angle scattering field. He was past chair of the Small Angle Scattering Interest Group for the American Crystallographic Association and is a member of the advisory board for the Intense Pulse Neutron Source at Argonne National Laboratory. Beaucage has been the advisor for 8 PhD and 8 MS students at the University of Cincinnati.

Scholarship: Beaucage's current work involves synthesis of nano-structured oxides for oxidation catalysis under NSF funding as well as studies of branching structure for polyolefins using neutron scattering funded by Equistar Corporation. Developing work includes studies of diesel soot in engine exhaust streams using in situ SAXS in collaboration with K. Boulouchos at ETHZ, studies of protein structure during folding and unfolding using SAXS and SANS as well as continued collaborative efforts at understanding the fundamental mechanisms at play in the nucleation and growth of nanomaterials in flame reactors with workers at ETHZ. These are subjects of recently submitted proposals and white papers to DOE, NSF, the American Chemical Society and NIH. Over the past year a spray flame reactor has been developed and production of supported gold catalysts, iron oxide and carbon coated titania has proceeded with a graduate student, a female undergraduate REU (NSF funded) student and a minority RET (NSF funded) high school physics teacher. NSF has also funded an International Research and Education in Engineering (IREE) grant to send the graduate student and undergraduate to ETHZ in Zurich for 6 months to continue collaborative work on spray flame synthesis of supported catalysts with one of the top catalyst groups in the world. During this stay further work at the European Synchrotron Research Facility and at Paul Scherrer Institute's Swiss Light Source are planned.

Under Equistar Corporation funding Beaucage and his graduate student Amit Kulkarni (expected graduation 9/2007) have recently developed a new framework for understanding branched materials based on a scaling description. The approach is of broad scope and has been applied to ceramic nano-aggregates, weakly branched polyolefins (with Equistar), hyperbranched polymers, cyclic and star macromolecules as well as biomaterials. The model can be applied to x-ray or neutron scattering measurements to determine the mole fraction of a complex structure involved in coordinated bonding such as disulfide linkages in proteins, crosslinks in a network or branched chains in an aggregate. When coupled with nuclear magnetic resonance (NMR) measurements for polymers it is possible to create an average structural model for topologically complex molecules. Although this work pertains to a somewhat involved physics it is of great importance to industry as evidenced by corporate funding from Equistar Corporation and invited talks on this subject at the 7'th International Aerosol Conference in Minneapolis, at the American Institute of Chemical Engineers Meeting in San Francisco in the nanoparticulate group last year as well as an invited talk on this subject at the Society of Plastics Engineer's ANTEC meeting last spring. An invited talk on these branching studies is also scheduled for the Spring American Chemical Society meeting in New Orleans 2008 for a session focusing on Branching in Polyolefins organized by the petrochemical industry. One of two graduate students working on this project, Amit Kulkarni, will complete his degree in September and will work at GE Plastics in Evansville IN having received job offers from Exxon Research in Annandale NJ and Intel in Phoenix AZ in addition to the GE offer. The mean starting pay for Beaucage's recent PhD students is $93,000.

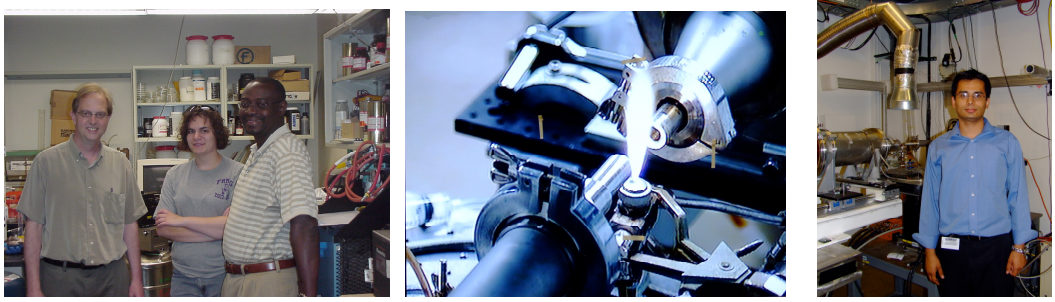
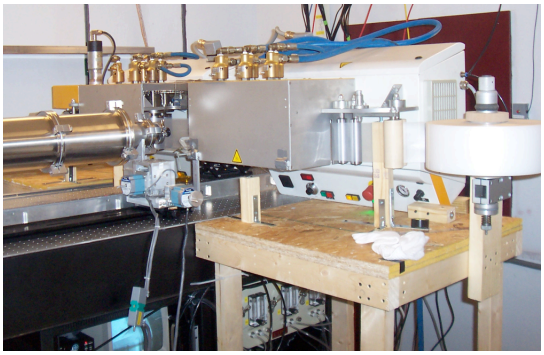


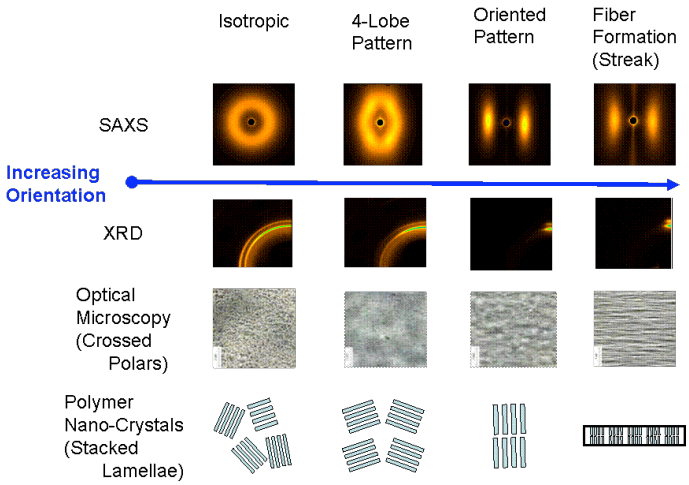
Figure 1. a) Greg Beaucage, Stephanie Berger (REU Student), Edwin Segbefia (RET Teacher), b) Spray flame for supported gold catalysts. c) Graduate student Sachit Chopra with flame spray pyrolysis setup at the Advanced Photon Source, Argonne National Laboratories.

For a number of years Beaucage's efforts in collaboration and funded by local companies have targeted fundamental understanding of the structure property relationships for processed plastics. Collaborators have included Procter & Gamble's Miami Valley Central Research Lab, Winton Hill Baby Care Products, and Beckett Ridge Plastics Processing Center, Equistar Chemical's Central Research Laboratory in Cincinnati and Sun Chemicals Central Research Lab in Ivorydale. UC efforts have been important in the development of Nodax (www.nodax.com) biodegradable polymers by P&G through an understanding of the chemical architecture-morphology-property relationships using SAXS. In work with Sun Chemical, UC researchers were the first to describe the relationship between pigment aggregate structure and color for organic pigments used in plastics in work conducted at the Advanced Photon Source in Chicago (Argonne National Laboratories) and highlighted in their annual report. The majority of publications in processed polymers have been in collaborative work with Equistar Corporation.

5 graduate students have incorporated at least some of this work in their thesis and dissertations. For example, Ayush Bafna, studied the orientation and interaction of dispersed layered-silicate nanomaterials in polyethylene films. The work involved x-ray scattering and diffraction studies of processed films with the goal of understanding the structure-property relationships of superposed hierarchical structures that are oriented in processing. These materials present significant challenges in terms of understanding the relationship between nano-structured polymer crystallites and nano-silicate dispersions. It is hoped that these natural source nano-fillers can significantly enhance transport and mechanical properties in these films. Currently Bryan Reese has investigated polymer nanostructural evolution in drawn polymer films used for plastic bottle labels, and food packaging for NASA space flights among many other applications. Ryan has completed a MS degree and is working towards a PhD expected in 2008. While working on his PhD Breese has started a company, *Eclipse Film Technologies*, aimed at applying technologies partly developed in his MS and PhD work. The company has polymer production facilities in Fairfield and currently employs 5 technical and office support personnel. Breese has also conducted the first in situ x-ray scattering measurements during machine direction orientation of polymer films at CHESS synchrotron facility at Cornell University and at the SSRL synchrotron at Stanford University. Ryan's work shows for the first time dramatic crystalline transitions in orientation and size on the nanoscale during a processing operation. This morphological change is directly related to enhanced mechanical and transport properties in these films allowing for engineering of the film drawing operation.



(a)



(b)

Figure 2. a) MDO instrument at CHESS, Cornell University, December 2006. b) Small-angle x-ray scattering (SAXS), x-ray diffraction (XRD), optical micrographs and schematic of nano-structure during in situ measurements of MDO of polyethylene films form the work of R. Breese.

Sponsored Research Services at UC indicate that Beaucage submitted 7 proposals in 2005, 13 proposals in 2006 and 5 proposals in 2007 to date not including a number of informal proposals in 2007 to industries including Equistar, Cabot, Goodyear, Dow Corning, Dow Chemical, Novartis, and government agencies at the National Institute of Standards and Technology and the Army. Of these proposals 4 have been funded with two pending at NSF and one at the Petroleum Research Fund of the American Chemical Society. Current plans call for submission of three proposals to NSF in the fall and a white paper to the Department of Energy.

The main areas for proposed work are development of nano-structured oxides for engineering applications in photocells and in water treatment. Prevention of nanometer size soot formation in diesel engines using in situ x-ray scattering from diesel exhaust, in collaboration with K. Boulouchos at ETHZ in Zurich. Development of SAXS for understanding protein folding. Development of our understanding of topology form SANS and SAXS measurements on complex macromolecules such as hyperbranched, cyclic and long chain branched polymers. There are also plans to develop an industry based x-ray scattering beamline at the Advanced Photon Source in Chicago by coupling industrial and NSF funds. Such a facility would be advantageous to UC in terms of access to synchrotron facilities as well as in terms of university prestige.

Service: Beaucage has organized sessions for the Materials Research Society, American Chemical Society, American Institute of Chemical Engineers, American Physical Society and American Crystallographic Association. He is currently organizing a one-day session for the spring meeting of the American Crystallographic Association pertaining to small-angle scattering from nanomaterials. This past spring he was Vice Local Chair for the National (ANTEC) Meeting of the Society of Plastics Engineers as well as Coordinator of Student Affairs. He has served in the past as chairman of the Small-Angle Scattering Group of the American Crystallographic Association and has been a member of the Advisory Board for the Intense Pulsed Neutron Source at Argonne National Laboratory for 8 years. He is also an active reviewer for a number of journals and for several national and international funding agencies.

Beaucage has given 9 invited presentations in the past year including a short course in Duisburg Germany in May and a lecture at the International School of Solid State Physics in Erice Sicily in July. He has also given an invited lecture on nanocomposites at the Composites Gordon Conference in Ventura California in 2002. He has served as a consultant to Dupont, Dow Chemicals, Dow-Corning, Procter & Gamble, Equistar, Sun Chemicals, Novartis, Zimmer Corporation and Goodyear. He has also served as an expert witness on several litigations.

At Cincinnati, Beaucage has served on a variety of committees and has recently been appointed co-Director of Undergraduate Program in the Chemical and Materials Engineering Department. He has been a member of the PhD qualifier committee in CME all but 2 years of his tenure at Cincinnati. He has served as Committee Chair for 8 PhD students and 8 Masters Students and has served as a member of committee for a large number of MS and PhD students in the CME, Electrical and Computer Engineering, Chemical Engineering, and Chemistry Departments as well as a member of 3 PhD committees at the ETHZ in Zurich Switzerland.

Beaucage has longstanding as well as new collaborations with workers in Europe and in the US active in the nanomaterials and polymer fields. This includes collaborative work on studies of Diesel exhaust using in situ SAXS with Boulouchos at ETHZ, studies of supported gold catalysts with Van Bokhoven at ETHZ, work on flame synthesis of nanomaterials with Pratsinis at ETHZ, studies of nanocomposite elastomers with Heinrich at Dresden, studies of semicrystalline polymers with Tervoort at ETHZ, branched polyolefins with Sukumaran at the University of Leeds in England and SAXS studies on a variety of systems with Narayanan at the European Synchrotron Research Facility in Grenoble France. Beaucage also collaborates with Dale Schaefer, Donglu Shi, Jim Mark at Cincinnati in the nanocomposite and scattering fields and with Thiyagaran at IPNS, Argonne National Laboratory on neutron scattering studies of micellar and vesicle systems.

Teaching: Beaucage has developed a wide range of courses at UC both undergraduate and graduate which have been posted on an open web page that has been accessed by 167,000 separate IP hits averaging 65 new IP hits per day. The web page includes the entire content of 13 courses including course notes, quizzes with answer sheets, projects with example solutions, computer programs, laboratory exercises and data. Several of the courses were supported by NSF funding, especially a course on Nanopowders which deals with the formation of nanomaterials. The current NSF grant supports the development of a new course on the formation of nanostructured oxide catalysts in collaboration with Jeroen van Bokhoven at ETHZ. Beaucage is also collaborating with Edwin Segbefia to develop a high school science course that involves production of nanomaterials in flames and use of these materials as absorbents for arsenic in drinking water as well as for formation of ferrofluids. Segbefia is a minority high school physics teacher at Princeton High School in Cincinnati. The course module is based on the NSF funded Research Experience for Teachers (RET) work conducted by Edwin at Cincinnati and includes TEM and x-ray and neutron scattering data collected by Segbefia at the Advanced Photon Source, Argonne National Laboratories in Chicago and at the National Institute of Standards and Technology in Maryland. Students will produce nanomaterials at their high school laboratory and will be given the opportunity to explore the structure using TEM at Cincinnati. Beaucage has also developed a sequence of two first year 1 credit courses for Freshmen in the Chemical and Materials Engineering (CME) Department with the aim of introducing the students as early as possible to the department and the field. This has had success at retaining students in the CME program.