

# Curriculum Vitae of Bridgette M. Budhlall

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## Education

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**Ph.D. 2000      Polymer Science and Engineering**  
LEHIGH UNIVERSITY  
Emulsion Polymers Institute. Iaccoca Hall, 111 Research Drive, Bethlehem, PA. 18018  
Research Advisor : Dr. Mohamed El-Aasser  
Ph.D. Dissertation: "Grafting Reactions in the Emulsion Polymerization of Vinyl Acetate using Poly(Vinyl Alcohol) as Emulsifier"  
GPA : 3.37 out of 4.00

**B.Sc. 1992      Natural Science (Hons.)**  
THE UNIVERSITY OF THE WEST INDIES  
St. Augustine, Trinidad & Tobago. West - Indies.  
Major : Chemistry; Minor : Analytical Chemistry, Biochemistry and Food Technology

## Research Experience

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**Jan 2007      ASSISTANT PROFESSOR**  
Department of Plastic Engineering, University of Massachusetts, Lowell. MA.

**Jan-Dec 2006      RESEARCH ASSISTANT PROFESSOR**  
Dept. of Chemical and Biomolecular Engineering, North Carolina State University.

**2003-2005      SENIOR RESEARCH CHEMIST**  
AIR PRODUCTS & CHEMICALS, Inc., Corporate Science & Technology Center.

- Developed formulated immersion fluids for Immersion lithography. This will be a new product offering for electronic materials. Immersion lithography is currently being rigorously pursued by semiconductor industry as an extension for existing lithography technology, because it enables much smaller resolution with much cheaper process modification. Water has been considered as the liquid of choice for 193nm. Alternative fluid with higher refractive index would extend 193nm immersion lithography even further. Additives in immersion liquid may be critical for performance because they provide much-needed wetting on both resist and optical element surfaces and help eliminate nanobubbles formed by resist out-gassing or surface entrainment.

2002-2003

**CDP (Career Development Program) CHEMIST**

AIR PRODUCTS & CHEMICALS, Inc., GEG, GAD – Advanced Technology, Catalytic Reaction Solutions.

- Supported the Monolith Loop Reactor, MLR, a new innovative catalyst. The MLR is a novel integrated monolith catalyst reactor system. This fixed bed technology can be retrofitted onto existing commercial slurry-catalyst stirred tank reactors. Skills applied include applied reactor engineering, kinetics and hydrogenation for process optimization.
- Responsible for the initial start-up and conducting of hydrogenation reactions in a Hazard Evaluation Laboratories (HEL), High Throughput Experimental (HTE), reactors to achieve a greater understanding of the performance limits and lifetime of commercial and experimental catalysts. Contributed to the physical attributes of the system design to ensure ease of use and successful implementation. Conducted rapid screening experiments of various chemistries including, Nitrobenzene to Aniline, p-Nitrophenol to p-Aminophenol and Glucose to Sorbitol using a precious metals (eg. Pd, Pt & Ru) on ceramic monoliths.
- Setup of an HPLC and conducted liquid chromatography analysis of synthetic products of catalytic hydrogenations performed in the HTE and Corporate Research MLR laboratories. Responsible understanding of our customer needs and expectations, the planning and execution of the appropriate experiments, and an interpretation and communication of the results, both orally and written.

2000-2002

**CDP CHEMIST**

AIR PRODUCTS & CHEMICALS, Inc., Corporate Science & Technology Center.

- Synthesized candidate fluorocarbon materials that served as platforms from which to design 157nm photoresists materials.
- Characterized the properties of these fluorinated structures by specific testing protocols to determine their competitive viability in markets utilized for photoresists materials.
- Participated on team to explore and develop novel polymer systems for microelectronics applications, including polymer for use as light emitting diodes (p-LEDS) and conducting polymers in general.

1999-2000

**CDP CHEMIST**

AIR PRODUCTS & CHEMICALS, Inc., Polymer Chemicals Technology.

- Developed a fundamental understanding of the role of Poly(vinyl alcohol) plays in stabilizing emulsion polymers used in APCI worldwide business.
- Employed advanced polymer characterization techniques to identify subtle differences in polyvinyl alcohol.
- Proposed, tested, and validated mechanisms whereby polyvinyl alcohol functions to stabilize emulsion polymers.
- Employed this understanding to develop superior grades of polyvinyl alcohol and superior emulsion polymers.
- Expanded these concepts to test the stabilization of emulsion polymers with other water soluble polymers, polymeric and nonionic surfactants.
- Supervised polymer experiments and directed laboratory activities.

1992-1994

**RESEARCH AND DEVELOPMENT CHEMIST**

SRA INTERNATIONAL / HANDY EQUIPMENT CO. LTD.

Morvant Industrial Estate, Morvant. Trinidad and Tobago. West-Indies.

- Developed a large particle size, high molecular weight, Vinyl acetate homopolymer emulsion useful for a wide variety of applications for adhesives.
- Developed an internally elastized Vinyl Acetate-Butyl Acrylate copolymer that provides excellent machinability, speed of grab and set, and affords adhesion to non-porous surfaces.
- Developed Styrene-acrylic latexes via emulsion copolymerizations, where the main objective was to achieve a decorative paint base emulsion.
- Developed a Vinyl-acrylic latex for Pressure Sensitive adhesive application, exhibiting a good balance of peel, tack and shear while maintaining a good balance of adhesive and cohesive properties at a glass transition temperature ( $T_g$ ) of  $-34^\circ\text{C}$ .
- Developed and modified Urea and Melamine Formaldehyde Thermosetting Resins suitable for use in the Woodworking and Furniture construction industry.
- Supervised polymer experiments and directed laboratory activities. Also supervised plant operations when laboratory products were scaled up to the pilot plant and then to the industrial-scaled plant.

Sum 1991

**RESEARCH AND DEVELOPMENT ASSISTANT**

CARIB GLASSWORKS, CO. LTD.

Champs Fluers, Trinidad and Tobago. West-Indies.

- Investigated the feasibility of using blast furnace slag from the Iron and Steel Company of Trinidad and Tobago (ISCOTT) as a glass batch raw material.
- Investigated and determined the cause of high silicon dioxide in both the flint and amber glass and batch analysis.

## Teaching Experience

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- 1996-1999 Graduate Teaching Assistant, Laboratory Assistant**  
LEHIGH UNIVERSITY, Emulsion Polymers Institute; Department of Chemical Engineering.
- Supervision of approximately 20 graduate level students during a Polymer Science and Engineering Synthesis and Characterization 3-hour laboratory period each week.
  - Administered extra help classes; made lesson plans, study guides and held review sessions.
  - Supervised polymer experiments and directed laboratory activities.
- 1996-1999 Graduate Teaching Assistant, Teaching and Laboratory Assistance**  
LEHIGH UNIVERSITY, Department of Chemistry, Seeley Mudd, Bethlehem. PA.
- Organized and taught a 50-minute lecture once a week to approximately 30 freshman Chemistry students.
  - Administered extra help classes; made lesson plans, study guides and held review sessions.
  - Graded quizzes, homework, and exams.
  - Supervised chemistry experiments and directed laboratory activities during a 3-hour laboratory period to approximately 30 students each week

## Leadership Experience

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- 1999-2005 Participant, Diversity Leadership Team & Women in Business groups.**  
AIR PRODUCTS AND CHEMICALS, INC.,
- Active participant in diversity groups and advocate for women and minority career advancement at Air Products.
  - Developed mission statements and vision statement and annual goals for Diversity teams.
  - Organized Diversity speakers/presenters.
- 2000-2003 Ph.D. Council representative on Career Development Program Council.**  
AIR PRODUCTS AND CHEMICALS, INC.,
- Active participant on CDP Council.
  - Responsible for organizing Network Lunches with PhDs and Executives .
  - Act as a primary contact point for HR and PhDs on CDP Program.
- 1998-99 Experimenter in CHOICES Program for middle-school girls.**  
LEHIGH UNIVERSITY, Department of Chemical Engineering, Bethlehem. PA.
- Planned and developed polymer experiments for demonstration.
  - Conducted and executed experiments
  - Presented results to more than 60 seventh and eight-grade girls from local area middle schools.

**1995-1999**      **Exec. Board Member, Emulsion Polymers Institute Graduate Student Association.**  
LEHIGH UNIVERSITY, Emulsion Polymers Institute, Department of Chemical Engineering, Bethlehem. PA.

- Elected by fellow graduate students to supervise various student activities at the Institute.
- Served as liaisons between administrative bodies and graduate students in the Dept. of Chemical Engineering.
- Acquired information from and disseminated information to the Graduate Student Community in Polymer Science and Engineering and the Dept. of Chemical Engineering.
- Appointed as the ChE graduate student representative of the **Graduate Student Council** to serve as Graduate Members of the Graduate and Research Committee, Educational Policy Committee, and other university bodies as the need arise.
- Organized PhD Defense and Graduation parties, outings, and other social activities for the Institute.

➤ *The **Graduate Student Council** served to approve and present resolutions to the Graduate and Research Committee, Educational Policy Committee, other university bodies, the Provost, President of the University, or the Board of Trustees of the University.*

**2001**      **Judge of Lehigh Valley Science Research Competition – March 17<sup>th</sup>, 2001**

- Served as a Judge of senior high school students of over 475 projects.
- Performed evaluation of projects and conducted relative assessments of projects and interviewed students.

**2002**      **Judge of Lehigh Pennsylvania Junior Academy of Science - February 23<sup>rd</sup>, 2002**

- Served as a Judge of 7<sup>th</sup> to 12<sup>th</sup> Grade students of over 960 projects.
- Performed evaluation of projects and conducted relative assessments of projects and interviewed students.

## Scholarships and Awards

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- 1998**      • TICONA AWARD, - *received for excellence in research in Polymer Science and Engineering*
- 1998**      • KEN EARHART AWARD, - *received for most excellent research in the Emulsion Polymers Institute.*
- 1996**      • HENRY MASON AWARD, - *received for the best overall score in the Polymer Science and Engineering Ph.D. Qualifying examination.*
- 1995**      • SRA INTERNATIONAL / HANDY EQUIPMENT CO. LTD SCHOLARSHIP.- *Full Tuition and Living Expenses*

## Analytical Instrumentation Experience

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- Reaction Calorimeter (Mettler RC1), GC, GPC, HPLC, CHDF, FTIR, DSC, TGA, NMR (360 and 500 MHz), Nicomp particle size analysis (light scattering), Instron tensile strength analysis, Dynamic Rheometrics RDA II, Rheovibron, Dilute Solution Viscometry, DLS, SLS, AFM, TEM, Contact Angle Analyzer, Wilhemy Plate Surface Tensiometer.

## Patents

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- P. Zhang, B.M. Budhlall, G.E. Parris, L. Cox; “*Immersion Fluids for Immersion Lithography Applications*”, U.S. Patent, issued **2005**.
- P. Zhang, B.M. Budhlall, G.E. Parris, L. Cox; “*Immersion Fluids for Immersion Lithography Applications*”, EU. Patent, issued **2005**.

## Research Publications

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- “*High Refractive Index Immersion Fluids for 193nm Immersion Lithography*” B. Budhlall, G. Parris, P. Zhang, X. Gao, Z. Zarkov, B. Ross, S. Kaplan, J. Burnett, *SPIE Microlithography*, **2005**, 5754-58.
- “*A Monolith Catalytic Process for Producing Sorbitol -- Catalyst Development and Evaluation.*” R. Broekhuis, B. Budhlall, and A. Nordquist, *Ind. & Eng. Chem. Res.*, **2004**, 43 (17), 5146-5155.
- “*Characterization of Partially Hydrolyzed Poly(vinyl alcohol). Effect of Poly(vinyl alcohol) Molecular Architecture on Aqueous Phase Conformation*”. B. M. Budhlall, K. Landfester, E.D. Sudol, V. L. Dimonie and M. S. El-Aasser, *Macromolecules*, **2003**, 36 (25), 9477-9484.
- “*Atomic Force Microscopy Studies of the Film Surface Characteristics of Poly(vinyl acetate) Latex Prepared with Poly(vinyl alcohol).*” B. Budhlall, O. Shaffer, E.D. Sudol, V. Dimonie and M. S. El-Aasser, *Langmuir*, **2003**, 19 (23), 9968-9972.
- “*Role of Grafting in the Emulsion Polymerization of Vinyl Acetate I: Effect of Degree of Poly(vinyl alcohol) Blockiness on the Kinetics and Mechanism of Grafting*”. B. Budhlall, E.D. Sudol, V. Dimonie and M. S. El-Aasser, *J. Polymer Science; Part A-1: Polym. Chem.*, **2001**, 39, 3633-3654.
- “*Characterization of Partially Hydrolyzed Poly(vinyl alcohol) I : Sequence distribution of Poly(vinyl alcohol) via <sup>13</sup>C and <sup>1</sup>H-NMR and a reversed-phased gradient elution HPLC technique*”. B. Budhlall, K. Landfester, D. Nagy, E.D. Sudol, V. Dimonie and M. S. El-Aasser, *Macromolecular Symposia*, **2000**, 155, 63-64.
- “*Characterization of Partially Hydrolyzed Poly(vinyl alcohol)*”. B. Budhlall, K. Landfester, D. Nagy, E.D. Sudol, V. Dimonie and M. S. El-Aasser, *ACS Polym Mat. Sci. Eng.*, **1999**, 80, 550-551.

## Papers Presented at Scientific Meetings (Oral Presentations)

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- **2005 International Society of Optical Engineering (SPIE) Microlithography Conference**, San Jose, CA., March 3<sup>rd</sup>, 2005. “*High Refractive Index Immersion Fluids for 193nm Immersion Lithography*” B. Budhlall, G. Parris, P. Zhang, X. Gao, Z. Zarkov, B. Ross, S. Kaplan, J. Burnett.
- **2004 International SEMATECH 157nm & Immersion Lithography Symposium**, Vancouver, CA., August 3<sup>rd</sup>, 2004. “*Thermodynamic and Kinetic Stability of Nanobubbles at the Water-Solid Interface: A Modeling and AFM Study.*” B. Budhlall, X. He, I. Hyder, S. Metha, G. Parris.

- **2004 International SEMATECH 157nm & Immersion Lithography Symposium**, Vancouver, CA., August 2-5, 2004. “*New Immersion Fluid for 193nm Immersion Lithography*” B. Budhlall, G. Parris, P. Zhang, X. Gao, B. Ross, and I. Hyder.
- **2003 Catalyst Society of Metropolitan New York Spring Symposium**, Pennsylvania, March 21<sup>st</sup>, 2003, “*High-throughput monolithic catalyst testing: A fully automated approach to process optimization and catalyst life testing.*” R. Broekhuis and B. Budhlall.
- **2001 Gordon Research Conference**, Polymer Colloids, Tilton, New Hampshire: July 1-6, 2001, “*Fundamental Study of Surfactants in Emulsion Polymerization: Effect of Surfactant type on Particle Size.*”
- **Air Products & Chemicals, 2001 Annual R&D Conference**. Topic Company Confidential.
- **American Chemical Society 74<sup>th</sup> Colloid and Surface Science Symposium**, Bethlehem, Pennsylvania: June 19-21, 2000, “*Role of Grafting in the Emulsion Polymerization of Vinyl Acetate I: Effect of Degree of Poly(vinyl alcohol) Blockiness on the Kinetics and Mechanism of Grafting*”.
- **American Chemical Society 217<sup>th</sup> National Meeting**, Anaheim, California: March 21-25, 1999, “*Characterization of Partially Hydrolyzed Poly(vinyl alcohol) I : Sequence distribution of Poly(vinyl alcohol) via <sup>13</sup>C and <sup>1</sup>H-NMR and a reversed-phased gradient elution HPLC technique*”.
- **Annual Review Meeting**, Emulsion Polymers Institute Liaison Program, Lehigh University; March ‘96, ‘97, ‘98 & 1999, “*Grafting Reactions in the Emulsion Polymerization of Vinyl Acetate using Poly(Vinyl Alcohol) as Emulsifier.*”
- **Ticona Award Meeting of the Society of Plastic Engineers**, Bethlehem, Pennsylvania: October 1998, “*Characterization of Poly(vinyl alcohol) via <sup>13</sup>C and <sup>1</sup>H-NMR.*”
- **American Chemical Society 3<sup>rd</sup> National Graduate Polymer Conference**, University of Akron, Akron OH; June 1998, “*Characterization of Poly(vinyl alcohol) via <sup>13</sup>C and <sup>1</sup>H-NMR.*”

## Professional Affiliations (to present)

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1995	American Chemical Society (ACS), Division Memberships: Colloid and Surface Chemistry Polymer Chemistry (POLY) Polymeric Materials: Science and Engineering (PMSE)
1995	American Institute of Chemical Engineers (AIChE)
1995	Society of Plastic Engineers (SPE)
2000	International Society of Optical Engineering (SPIE).
2004	American Association for the Advancement of Science (AAAS).

## Research Interests

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- **Micro/Nanofluidics**

Use a combination of “*top-down*” lithographic techniques and “*bottom-up*” assembly of hollow nanofibers to fabricate 2-D and 3-D nanofluidic devices. The aim will be to achieve 2-D patterning of the nanochannels (e.g., introducing gradients along the channel/nanofiber widths). By adding additional switching capabilities I will design more complex nanofluidic arrangements and multi-channel networks to conduct chemical and biochemical reactions.

- **Nanotemplating or Nanopatterning self-assembled monolayers using surfactant-polymer interactions**

The ideas I would like to study include:

- 1) nanostructured particle templating technology.
- 2) synthesize nanostructured materials templated by colloidal crystals (emulsion particles or surfactants)
- 3) continue to build expertise in surfactant phase behavior.

Surfactants and/or emulsion nanoparticles that organize into honeycomb-like structures, can be utilized as templates for the formation of more permanent structures made out of ceramic, metallic or polymeric materials for the preparation of such devices as displays, catalysts, microfiltration for gases, photon bandgap crystals, optical filters, and nanoelectronic devices.

- **Smart or Responsive Polymers / Vesicles**

Polymers have revolutionized our lives. Now interest is turning to “*smart*” polymers that respond to external changes. The use of reversible, non-covalent interactions is a recurring design principle for responsive materials. Incorporation of block copolymers into vesicles which can combine mechanical stability with the ability to respond to external stimuli eg. changes in temperature and pH, could be potentially exploited in drug-delivery applications.

- **Nano/Micoencapsulation**

Preparation of nanocapsules for a variety of applications. Anisotropic polymeric particles, monodisperse double emulsions and polymerosomes were recently prepared *in-situ* in microfluidic flow devices [S. Utada, E. Lorenceau, D. Link, P. Kaplan, H. Stone, D. Weitz, *Science*, 306, 537, (2005)]. However, while specific control of the morphologies (e.g. spheres, disks and rods) of the *liquid-in-liquid* or *droplet-in-droplet* were achieved on the micrometer scale, each technique reported above has yet to demonstrate *encapsulation at the nanometer scale*.

- **Biosensors/Biochips**

Making capsules or colloids/vesicles with nanopores which home in on specific cells in the body, allowing some molecules in and out but not others, based on size exclusion or osmotic pressure. A potential application would be, for example, the delivery of insulin to diabetic patients, the use of encapsulated pancreatic insulin producing cells, allowing glucose in (detection) and letting insulin out (response) of the capsule. The encapsulated material to could produce high temperatures under laser light, cauterizing tissue. I will explore templated fabrication, based on the techniques described above, of capsules that can address these requirements. This project could be combined with projects in developing of capsules for biosensing purposes.



## Teaching Interests

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- **Introduction to Polymer Science**

Introduction to concepts of polymer science. Kinetics and mechanism of polymerization, synthesis and processing of polymers, characterization. Relationship of molecular conformation, structure and morphology to physical and mechanical properties.

- **Physical Polymer Science**

Structural and physical aspects of polymers (organic, inorganic, natural). Molecular and atomic basis for polymer properties and behavior. Characteristics of glassy, crystalline, and paracrystal-line states (including viscoelastic and relaxation behavior) for single-and multi-component systems. Thermodynamics and kinetics of transition phenomena. Structure, morphology, and behavior.

- **Emulsion Polymerization: Theory and Applications**

Fundamental concepts important in manufacture, characterization and application of emulsion polymer latexes. Topics include colloidal stability, polymerization kinetics and mechanisms, reactor design, characterization of particle surfaces, latex rheology, morphology considerations, polymerization with functional groups, film formation and various applications problems.

- **Polymer Synthesis and Characterization (course and laboratory)**

Techniques include: free radical and condensation polymerization synthesis; analysis of synthetic polymers: molecular weight distribution by gel permeation chromatography, crystallinity and order by differential scanning calorimetry; pyrolysis and gas chromatography; dynamic mechanical and dielectric behavior, morphology and microscopy, surface properties, knowledge of liquid chromatography theory, practical liquid chromatographic problem solving skills and the ability to operate and trouble-shoot liquid chromatographic instrumentation.

- **Colloid and Surface Science**

Physical chemistry of everyday phenomena. Intermolecular forces and electrostatic phenomena at interfaces, boundary tensions and films at interfaces, mass and charge transport in colloidal suspensions, electrostatic and London forces in disperse systems, gas adsorption and heterogeneous catalysis.