

Steven Raymond Lustig, PhD

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MULTI-DISCIPLINARY RESEARCH & DEVELOPMENT

Solves innovation problems faster and better with theory, computation, and experiments

- Accomplished innovator and entrepreneur
- Commercialized technologies, including polymerization catalyst, ultra-performance fiber composition, inkjet ink, molecular property modeling software.
- Established record and recognition for solving complex problems in science and technology.
- Demonstrated skills in leadership and multi-disciplinary collaboration.
- Won project funding-from industry and government
- Published 34 journal articles, 24 issued U.S. patents, 20 pending patents.

Materials design, synthesis and characterization:

soft matter, polymers, fluoropolymers, qLCPs, DNA, proteins, ionic liquids, ultra-performance fibers, membranes, colloids, SWNTs, dielectrics, piezoelectric effect, electrocaloric effect

Science and Engineering:

biochemical physics, chemical engineering, materials science, statistical mechanics, protein engineering, electrochemistry, catalysis, advanced mathematics, software development, computational chemistry, molecular simulation, high performance computing, microbiology

Business:

R&D pipeline optimization, business probability of success, technology and market analyses, options analysis, management strategy testing

SPECIALIZED SKILLS

Laboratory and Analytical Techniques:

FTIR, Raman Spectroscopy, UV-Vis Spectroscopy, AFM, Rheology, NMR, HPLC, MDSC, X-Ray Scattering, Electron Microscopy, SIMS, FIB, Potentiostat, Electrochemical Quartz Crystal Microbalance, Microbiology, Phage Display

Theoretical Methods:

Classical and Nonequilibrium Thermodynamics, Statistical Mechanics, Continuum Mechanics, Molecular Mechanics, Quantum Mechanics, Mesoscale Modeling, Inverse Problems

Programming Languages:

Java, C, C++, Perl, VB, Swift, PHP, Python, Enterprise Web services, OpenMP, MPI, LabView, Instrumentation Control and User Interfaces, Symbolic Mathematics

Innovation and New Business Development:

R&D pipeline modeling, rapid market assessment, rapid technology assessment, options analysis, new business opportunity and cash flow analyses, probability of success.

PROFESSIONAL EXPERIENCE

Adjunct Professor

2012-Present

*Department of Chemical & Biomolecular Engineering, Department of Materials Science & Engineering
University of Delaware, Newark, Delaware*

- Improved accuracy of COSMO-SAC statistical thermodynamics model that predicts pure liquid and mixture solution thermodynamic properties in high performance software
- Developed novel rheological characterization method with simultaneous polarized Raman scattering, particularly applied to industrially-relevant liquid crystalline polymer solutions
- Conducted largest contemporary massively-parallel nonequilibrium Brownian dynamics simulations of monodisperse and polydisperse colloids in shear, discovering why discontinuous shear-induced ordering transition is inhibited at a critical polydispersity.
- Taught courses (graduate) Advanced Polymer Science, Polymer Physics, Classical and Statistical Thermodynamics, Green Engineering, (undergraduate) Chemical Process Analysis.
- Served as doctoral thesis advisor and dissertation defense committee member for 4 graduate students.

Principal Investigator, Research Associate, Sr. Research Engineer, Research Engineer

1990–2016

Central Research & Development, E.I. du Pont de Nemours & Co., Inc., Wilmington, Delaware

- COSMOdesign Conceived and developed theory and software that directly solve molecular design, inverse-thermodynamic problems in which a required thermodynamic property objective in a chemical process or reaction is specified and new molecular structures or material components are derived from the statistical thermodynamics of molecular solvation surfaces. Results generated several proprietary technologies.
- Enzyme Catalysis Designed laccase-catalyzed air cathode for microbial fuel cell to generate clean water and electricity from industrial waste streams. Performed competitive market and technology analysis that won project funding.
- Next Generation Kevlar® Designed ultra-high strength copolymer fiber composition for 2016 commercial manufacturing scale-up by inventing fundamental improvements in pre-spinning, solution process technology, resulting 8 patent applications covering low-sulfur process technology inventorship. Invented fundamental improvements in pre-spinning, solution process technology.
- Artistri™ P5910W™ Invented the commercialized white inkjet ink producing multiple million dollar profits. Invented trade secret: thermally-cleavable dispersants and surfactants; microwave curing hardware for aqueous, high print speed textile inks; and nanoparticle Nucrel® fusants for ultra-durable aqueous inks.
- Polytransesterification Catalysis Invented Ti/Zr catalysts that provide high polymerization rates, environmental and biological compatibility, and colorless polymers, contributing to successful manufacture of DuPont Sorona® as well as newer condensation polymers based on biologically-sourced trimethylene glycol. Co-catalyst annihilates chemical chromophores from thermal degradation.
- Nanotube Technologies Invented 1st process to cut SWNTs to narrow length distribution while chemically functionalizing only the tube ends. Discovered polypeptides that selectively bind and disperse SWNTs and SWNT/DNA hybrids in water. Developed theoretical model for structural and electrostatic characterization of SWNT/DNA hybrids to separate SWNTs by chirality. Developed self-assembly chemistries to place SWNTs on silicon wafers.
- Ionic Liquids Invented compositions for aqueous absorption cooling refrigeration that greatly increased thermodynamic efficiency and decreased lifetime cost. Invented proprietary compositions for energy-efficient carbon dioxide capture from coal-burning power plant flue gas by decreasing parasitic energy and lifetime process cost.

E.I. du Pont de Nemours & Co. (Cont.)

- Lithium Ion Electrolytes Developed: new correlation between electrolyte solvent's electronic structure and redox stability; new speciation method for COSMO theory to predict temperature-dependent solubility of LiPF₆ and ionic conductivity; combined spectroscopic and quantum chemical method that infers the structure and composition of the solid-electrolyte interface.
- M5 High Performance Fiber Performed molecular modeling of poly(hydroquinone-diimidazopyridine), resulting in a mechanistic prediction for the tensile modulus loss in the presence of trace water that agreed quantitatively with experimental measurements. The understanding led to cancelling M5 development.
- Hydrogen Storage Patented nano-porous, ultra-high surface area carbon which met the U.S. D.o.E. Stage I gravimetric and volumetric capacity metrics, using capillary at high pressure but ambient temperatures.
- Polyester Technologies Created new patent estates of new manufacturing technologies: high yield syntheses and ring-opening polymerizations of cyclic oligomers, suspension condensation polymerization, and clay-based coatings for high barrier applications.
- Polyester Regeneration Technology Investigated PETRETEC plant performance and enabled doubling the capacity of recycled products with comparable physical and chemical properties to virgin materials.
- Next Generation Refrigerants Developed and applied methods to discover refrigerant molecules and azeotropes with low global warming potential, low ozone depletion, low toxicity, and low fire hazard potential.
- Polymer-Polymer Interdiffusion Invented the ATR-FTIR diffusion method and established analysis to infer the diffusion coefficient. Made the first measurements in semi-crystalline polymers and discovered non-Fickian kinetics. Developed novel model of diffusion in random, disordered media that reproduces the kinetics. Developed practical and quantitative diagnostic to optimize polymer welding and fusion-bonding resins.
- Math Modeling of Research Modeled product development pipeline to test management strategies, examine common modes of failure/success, balance R&D portfolio, predict portfolio, benchmark and test improving the overall rate of business growth against management processes and strategies, and set appropriate expectations for growth with R&D budgetary resources. Compared the merits of funding in-house discovery versus purchasing external intellectual property, which enabled senior management to formulate and justify long term budgets and portfolio strategy decisions.

SYNERGISTIC ACTIVITIES

- Anti-Ballistic Fiber Research, Army Research Laboratory Developed novel *iso-locus* AFM method for monitoring changes in mesoscale structure of fibers during dynamic extension to increase fiber strength with improved manufacturing.
- LAMMPS CRADA Principal investigator in multi-disciplinary, multi-institutional Cooperative Research And Development Agreement (CRADA) program to develop the high-performance, parallel-scalable software Large-scale Atomic/Molecular Massively Parallel Simulator (LAMMPS). Project summarized and freely distributed at <http://lammeps.sandia>
- MCCCS TOWHEE CRADA Principal investigator in multi-disciplinary, multi-institutional CRADA develop the high-performance, parallel-scalable software, Monte Carlo for Complex Chemical Systems (MCCCS). Project summarized and freely distributed at <http://towhee.sourceforge.net>

- NSF Nanoscale Grant Principal investigator in National Science Foundation Nanoscale Interdisciplinary Research Team grant “Solution-Based Dispersion, Sorting and Placement of Carbon Nanotubes” provided theoretical understanding and experimental techniques resolving ss-DNA/SWNT hybrid structure, manipulation, and chiral separations.

ADDITIONAL EXPERIENCE

- Visiting Scientist, Faculté de Pharmacie, Université de Paris-Súd XI, France
- Physical Scientist Aide, Chemistry Department, Naval Research Laboratory, Washington, D.C.
- Undergraduate Research, Chemistry Department, University of Virginia, Charlottesville, VA
- Visiting Scientist, Biochemistry Department, National Bureau of Standards, Gaithersburg, MD

COMMUNITY ACTIVITIES

- President, Director, Somerset Lake Civic Association
- President, Board Member, New Garden Elementary School Parent Teacher Organization
- Conference Chair, Core Organizer DuPont TechCon
- Medical First Responder

AWARDS

- AIChE Industrial Research & Development Institute Award
- DuPont Central Research Accomplishment Award (9 Awards)
- DuPont TechCon Award
- DuPont Information Security Organization Accomplishment Award
- Pittsburgh Coal Conference Top Three Conference Innovations
- DuPont Crop Protection DevStars Award (2 Awards)
- DuPont Polyester Leapfrog Technology Award
- DuPont Materials Science and Engineering Accomplishment Award (3 Awards)
- Phi Lambda Upsilon
- Award in the Sigma Xi University-wide Student Research Competition
- Sigma Xi
- Plastics Institute of America National Fellowship
- Purdue University Fellowship
- Dean's List, University of Virginia (4 years), Purdue University (6 years)
- Special Achievement Award, Naval Research Laboratory (2 times)
- Certificate of Honors, University of Virginia
- Westinghouse Science Talent Search

EDUCATION

Ph.D. Chemical Engineering, Purdue University, West Lafayette, IN, Thesis: *A Continuum Thermodynamics Theory for Transport in Polymer/Fluid Systems*. Advisors: N.A. Peppas and J.C. Caruthers

M.S. Chemical Engineering, Purdue University, West Lafayette, IN, Thesis: *Scaling Analysis and Mathematical Modeling of Solute and Penetrant Transport in Equilibrium and Dynamically Swelling Polymers*. Advisor: N.A. Peppas.

B.S.Ch.E. with Distinction, University of Virginia, Charlottesville, VA, Thesis: *Gas Mixing during Fire Suppression in Enclosed Spaces by Nitrogen Pressurization*. Advisors: F.W. Williams and L.U. Lilleht.

PUBLICATIONS AND PATENTS

See LinkedIn and Website (<http://www.stevelustig.com/CV/SteveLustig-PublicationsPatents.pdf>) for patents and publications in *Nature Materials*, *Reviews in Modern Physics*, *Physical Review Letters*, *Journal of Physical Chemistry*, *Chemical Physics*, *NanoLetters*, *Macromolecules*, *Journal of Fluorine Chemistry*, *Journal of the American Chemical Society*, *Chemical Engineering Science*, *Annals of the New York Academy of Science*, *Journal of Polymer Science*, *Polymer*, *Hydrogels in Medicine and Pharmacy* and more.