

Exponent®
Engineering & Scientific Consulting

Ryan Fox, Ph.D.
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Professional Profile

Dr. Fox is a materials and polymer scientist specializing in the analysis of the physical and chemical properties of polymer materials and complex fluids, including engineering thermoplastics, thermoplastic elastomers, crosslinked thermosets, high-performance polymers, liquid crystal polymers, hydrogels, organogels, emulsions, polymer nanocomposites, carbon nanomaterials (i.e., graphene, carbon nanotubes, carbon black), surfactants, polyelectrolytes, polymer electrolyte membranes, solid-state battery membranes, shear thickening fluids, colloidal suspensions, self-assembled nanostructures, nanoparticle dispersions, bioadhesive membranes, foams, and antifoams.

Dr. Fox assists clients in understanding the structure-function-property relationships and failure modes of such materials in a wide variety of industries and applications, such as oil, gas, and water pipelines, electrical cables and wiring, construction materials (adhesives, sealants, coatings, membranes, etc.), medical devices, sporting equipment, automotive components, and consumer electronic devices, among others.

Dr. Fox led the establishment of and is the manager for Exponent's ISO/IEC 17025:2017 accredited thermal analysis laboratory in Bowie, MD. In this role, he develops and implements laboratory-specific technical procedures, documentation, and controls required for accreditation, including method validation, standard operating procedures, equipment calibration and maintenance programs, measurement traceability, training and competency records, data review processes, and records management. He manages accredited testing activities involving thermal analysis of polymeric and related materials, including differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA), and supports continued compliance with ISO/IEC 17025 requirements through internal audits, corrective actions, proficiency testing, uncertainty evaluations, and continual improvement of laboratory processes. Through this work, Dr. Fox supports the generation of accurate and traceable analytical data for materials characterization, product evaluations, failure investigations, and related matters.

Dr. Fox routinely investigates failures of piping systems manufactured from polyethylene (MDPE, HDPE), polypropylene (PP), polyvinyl chloride (PVC, CPVC), and other polymeric materials. He is an active member of the Plastics Pipe Institute (PPI) and has provided consulting services for clients including pipe and fitting manufacturers as well as pipeline operators and owners. He is a certified pipe fusion inspector and large diameter pipe butt fusion operator with a deep working knowledge of material property testing and industry standards for pipe and pipe joining methods. Moreover, he is able to employ his extensive experience applying physical and chemical analytical techniques to solve materials-related questions and to perform root-cause investigations, including oscillatory and steady-shear rheology, dynamic mechanical thermal analysis (DMTA), tensile testing, thermogravimetric analysis (TGA), differential scanning calorimetry (DSC), capillary viscometry, small- and wide-angle x-ray scattering (SAXS/WAXS), small-angle neutron scattering (SANS), dynamic and static light scattering (DLS/SLS), Fourier-transform infrared (FTIR) spectroscopy, UV/Vis spectrophotometry, scanning electron microscopy (SEM) and

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energy-dispersive X-ray spectroscopy (EDS), polarized optical microscopy (POM), and atomic force microscopy (AFM).

Prior to joining Exponent, Dr. Fox was a graduate research assistant at the University of North Carolina at Chapel Hill in the Department of Applied Physical Sciences. His research focused on the structure, rheology, and nanocomposites of liquid crystal polymers. As part of his doctoral research, Dr. Fox was funded by the Department of Energy as a visiting researcher at Oak Ridge National Laboratory employing rheo-SANS to investigate the structure and alignment of liquid crystal polymers under shear.

Academic Credentials & Professional Honors

Ph.D., Materials Science, University of North Carolina, Chapel Hill, 2020

B.S., Chemical Engineering, North Carolina State University, 2016

Department of Energy Office of Science Graduate Student Research (DOE SCGSR) Fellowship, 2019

Prior Experience

Graduate Research Assistant, University of North Carolina at Chapel Hill, 2016—2020

DOE Office of Science Graduate Student Research (SCGSR) Fellow, Oak Ridge National Laboratory, 2019—2020

Undergraduate Research Assistant, North Carolina State University, 2014—2016

Fermentation Optimization Intern, Novozymes, 2015

Formulation and Process Engineering Co-op, Stiefel, a GlaxoSmithKline company, 2014

Professional Affiliations

American Chemical Society (ACS) Member

The Plastic Pipe Institute (PPI) Task Group Member

Publications

Fox RJ, et al. High-Strength Liquid Crystal Polymer-Graphene Oxide Nanocomposites from Water. ACS Appl. Mater. Interfaces 2022; 14(14):16592-16600. DOI: 10.1021/acsami.2c00186 (Featured as a Supplementary Cover).

Dahl DK, Whitesell AN, Sharma-Huynh P, Maturavongsadit P, Janusziewicz R, Fox RJ, et al. A mucoadhesive biodissolvable thin film for localized and rapid delivery of lidocaine for the treatment of vestibulodynia. Int. J. Pharm. 2022; 612:121288. DOI: 10.1016/j.ijpharm.2021.121288.

Yu D, Zanelotti CJ, Fox RJ, et al. Solvent-Cast Solid Electrolyte Membranes Based on a Charged Rigid-Rod Polymer and Ionic Liquids. ACS Appl. Energy Mater. 2021; 4(7):6599-6605. DOI: 10.1021/acsaem.0c03133.

Fox RJ, et al. Fingerprinting the Nonlinear Rheology of a Liquid Crystalline Polyelectrolyte. Rheo. Acta 2020; 59:727-743. DOI: 10.1007/s00397-020-01234-4.

Fox RJ, et al. Irreversible Shear-Activated Gelation of a Liquid Crystalline Polyelectrolyte. ACS Macro Lett. 2020; 9:957-963. DOI: 10.1021/acsmacrolett.0c00168 (Featured as a Supplementary Cover).

Fox RJ, et al. Observation of Transition Cascades in Sheared Liquid Crystalline Polymers. Soft Matter 2020; 16:3891-3901. DOI: 10.1039/D0SM00275E (Featured as an Inside Cover).

Hegde M, Yang L, Vita F, Fox RJ, et al. Strong Graphene Oxide Nanocomposites from Aqueous Hybrid Liquid Crystals. Nat. Commun. 2020; 11(830):1-7. DOI: 10.1038/s41467-020-14618-0.

Fox RJ, et al. Nanofibrillar Ionic Polymer Composites Enable High-Modulus Ion-Conducting Membranes. ACS Appl. Mater. Interfaces 2019; 11(43):40551-40563. DOI: 10.1021/acsami.9b10921 (Featured as a Supplementary Cover).

Chang D, Fox RJ, et al. Investigation of interfacial properties of pure and mixed poloxamers for surfactant-mediated shear protection of mammalian cells. Colloids Surf B Biointerfaces 2017; 156:358-365. DOI: 10.1016/j.colsurfb.2017.05.040.

Presentations

Budiansky A, MacLean S, Jing B, Fox R, Kreder M, Moll J. Microtomy of Extra-Large Polymer Samples. International Applications & Technologies Conference and Exposition – IMAT, October 2023.

Fox RJ, et al. Observation of Transition Cascades in Liquid Crystalline Rods under Shear. Poster presentation, Gordon Research Conference, Ventura, CA, 2020.

Fox RJ, et al. Shear-Induced Gelation of Charged Liquid Crystalline Rods. Oral presentation, Society of Rheology 91st Annual Meeting, Raleigh, NC, 2019.

Fox RJ, et al. Shear-Induced Gelation of Charged Liquid Crystalline Rods. Oral presentation, Southeast Polymer Forum, Oak Ridge, TN, 2019.

Fox RJ, et al. Shear-Induced Gelation of a Liquid Crystalline Polyelectrolyte. Poster presentation, Soft Matter Workshop, Durham, NC, 2019.

Fox RJ, et al. Nanocarbon Dimensionality Controls Molecular Aggregation of an All-Aromatic Polyetherimide. Poster presentation, ORNL User Group Meeting, Oak Ridge, TN, 2019.

Fox RJ, et al. Supramolecular Nanofibrillar Networks Enable High Modulus Polymer Electrolyte Membranes. Oral presentation, The Future of Materials III Workshop, Raleigh, NC, 2019 (2nd place speaker award).

Fox RJ, et al. Mechanical Reinforcement of Liquid Crystal Polymers with Liquid Crystal Graphene Oxide. Poster presentation, ACS Polycondensation, Alexandria, VA, 2018.

Fox RJ, et al. Mechanical Reinforcement of Liquid Crystal Polymers with Liquid Crystal Graphene Oxide. Poster presentation, Soft Matter Workshop, Raleigh, NC, 2018.

Fox RJ, et al. Mechanical Reinforcement of Liquid Crystal Polymers with Liquid Crystal Graphene Oxide. Oral presentation, 13th National Graduate Research Polymer Conference, Minneapolis, MN, 2018 (Outstanding speaker award).

Fox RJ, et al. High Performance Polymer-Graphene Oxide Nanocomposites from Aqueous Liquid Crystals. Oral presentation, The Future of Materials II Workshop, Raleigh, NC, 2018 (1st place speaker award).

Fox RJ, et al. High Performance Polymer-Graphene Oxide Nanocomposites from Aqueous Liquid Crystals. Oral presentation, Carolina Science Symposium, Raleigh, NC, 2017 (1st place speaker award).

Fox RJ, et al. Rods Meet Plates: Nanocomposites from Water Soluble Rigid-Rod Polymers and Graphene Oxide Platelets. Poster presentation, Southeast Polymer Forum, Virginia Tech, VA, 2017.

Fox RJ, et al. Rods Meet Plates: Nanocomposites from Water Soluble Rigid-Rod Polymers and Graphene Oxide Platelets. Poster presentation, Soft Matter Workshop, Chapel Hill, NC, 2017.

Fox RJ, et al. Novel Deactivation Strategies for Norovirus Using Colloidal and Molecular Systems. Poster presentation, ACC Meeting of the Minds, Syracuse, NY, 2016.

Fox RJ, et al. Novel Deactivation Strategies for Norovirus Using Copper-Infused Lignin Nanoparticles. AIChE National Student Conference, Salt Lake City, UT, 2015 (1st place poster award).

Fox RJ, et al. Improved Foam Control of Industrial Enzyme Fermentations. Poster presentation, 14th Annual NC State University Undergraduate Research Symposium, Raleigh, NC, 2015.

Fox RJ, et al. Characterizing Scale Up and Shear Geometry of Batch Rotor-Stator Mixers. Poster presentation, AIChE Southern Regional Conference, Clearwater, FL, 2015 (1st place poster award).

Project Experience

Plastic Piping

- Investigated butt fusion failures in large diameter high density polyethylene (HDPE) pipelines due to insufficient mixing of carbon black.
- Performed industry standard testing to quantify and characterize carbon black distribution and dispersion.
- Conducted audits of manufacturing facilities for high density polyethylene (HDPE) pipe to verify conformance with industry standards and advise on quality control practices.
- Performed root cause analysis (RCA) of electrostatic pinhole leaks in large diameter high density polyethylene (HDPE) gas pipelines.
- Investigated a medium diameter high density polyethylene (HDPE) gas distribution pipe that failed in service.
- Performed fractographic analysis and review of fusion procedures for large diameter high density polyethylene (HDPE) pipe that fractured in service at a butt fusion joint.
- Processed and machined large and medium diameter high density polyethylene (HDPE) pipe and butt fusion joints using chainsaws, band saws, and planers for preparation of standardized tensile testing coupons for mechanical property evaluations.
- Performed thermal analysis and mechanical property testing to assist in evaluation of a HDPE pipe supplier.
- Inspected polyvinyl chloride (PVC) and chlorinated polyvinyl chloride (CPVC) pipe for the presence of voids, contamination, and other attributes.
- Performed fractographic examination of a chlorinated polyvinyl chloride (CPVC) pipe used for potable water service that cracked due to environmental stress cracking (ESC) while in service leading to a water loss event.
- Performed thermal analysis for a polyvinyl chloride (PVC) pipe manufacturer to evaluate compliance with UL standards.

Electrical Wire and Cable

- Analyzed effects of elevated temperature and quantified lifetime reduction of crosslinked polyethylene (XLPE) insulation and plasticized polyvinyl chloride (PVC) sheathing.
- Reviewed industry standards and technical literature for material property and performance requirements of electrical cable insulation and sheathing materials.
- Performed thermomechanical testing to determine the degree of residual stress present in crosslinked polyethylene (XLPE) insulation.
- Reviewed and analyzed industry standards and technical literature related to manufacturing, quality control, and performance testing of rubber insulating lineman gloves.

Building and Industrial Materials

- Led an investigation into the failure of a hot melt adhesive (HMA) used in the corner joints of composite windows.
- Analyzed the physical and chemical degradation of a waterproofing membrane utilized in a wastewater storage tank within a mixed-use development in a major metropolitan area.
- Performed an investigation into degradation of polyurethane gel sealants used in a clean room facility and determined the root cause of failure.
- Evaluated the effect of hydraulic oil exposure on various building components, including silicone sealants, EPDM gaskets, and engineered stone products.
- Experimentally determined the role of surface preparation on the failure of an adhesive utilized in an industrial device subjected to internal pressurization.
- Experimentally measured the transition temperature of a material used in a temperature limit switch using thermomechanical characterization techniques.
- Researched and analyzed the technical literature available on asphalt to determine the effect of polymer modification on its flow properties.
- Performed materials testing and chemical analysis of plasticized polyvinyl chloride (PVC) roofing membranes to investigate suspected formulation variations.
- Led failure analysis of a cracking polycarbonate skylight material with suspected environmental stress cracking (ESC) agent contamination.
- Analyzed thermal testing data on an injection molded semi-aromatic polyamide to determine the role of process conditions on final material properties.

Biomedical Devices and Biomaterials

- Investigated the role of pore structure and chemistry on the mechanical property of collagen foams.
- Performed thermal analysis and rheological characterization to characterize differences in linear low density polyethylene (LLDPE) packaging materials.
- Evaluated the degradation of hydrogels in a medical device through the use of Fourier transform infrared spectroscopy (FTIR), rheology, and differential scanning calorimetry (DSC).
- Performed factory audits of manufacturer for medical device utilizing hydrogel as part of a failure analysis investigation.

- Utilized differential scanning calorimetry (DSC) to identify excessive thermal exposure in polyvinyl chloride (PVC) resin used in a medical device.

Consumer Products

- Characterized the thermal and thermomechanical properties of plasticized polyvinyl chloride (PVC) materials used in consumer sports equipment.
- Utilized chemical and mechanical testing to identify that medical examination gloves marketed as nitrile gloves were instead plasticized polyvinyl chloride (PVC).
- Investigated uniformity of non-stick silicone coatings on paper products through the use of X-ray fluorescence (XRF) analysis.

Automotive Materials

- Performed thermal testing and fractographic analysis to determine root cause of fracture in constant velocity joint (CVJ) boots.
- Performed failure analysis of cracking in polycarbonate automotive components.

Additional Education & Training

Understanding ISO/IEC 17025:2017 for Testing & Calibration Laboratories, Certificate of Competence, A2LA Workplace Training (AWPT), 2026.

Polyethylene Pipe Large Diameter Fusion Operator Qualification (Butt Fusion per ASTM F2620), McElroy University™, 2022

Polyethylene Pipe Fusion Inspector Qualification (Socket Fusion, Saddle Fusion, Butt Fusion, Data Logging, Joint Integrity Testing per ASTM F2620 and ASTM F3124), McElroy University™, 2022

20th National School on Neutron and X-Ray Scattering, Argonne National Laboratory and Oak Ridge National Laboratory, 2018.

Peer Reviews

Journal of Failure Analysis & Prevention (JFAP)