TEXTILE CHEMISTRY—WHAT A WONDERFUL WORLD

By Karen K. Leonas

INTRODUCTION

Textiles surround us from the moment we are born until the last day of our lives. They clothe, protect, comfort, and inspire us. Beyond their tangible presence, textiles embody history, culture, and innovation. At the heart of textiles lies chemistry—an intricate and elegant science that gives fibers their unique properties, enables vibrant coloration, enhances performance, and advances sustainability. It is truly a wonderful world where chemistry and textiles intersect, shaping human experience while addressing global challenges. Receiving the Olney Medal is both a profound honor and an opportunity to reflect on the impact of textile chemistry, my contributions, and the exciting journey ahead.

SCOPE AND IMPACT OF TEXTILE CHEMISTRY

Textile chemistry bridges polymer science, material science, and consumer needs. Its influence extends far beyond the laboratory: from enhancing comfort and durability to creating protective clothing that saves lives, to advancing processes that minimize environmental impacts. Each innovation—whether in fiber modification, coloration, or finishing—represents chemistry at work in service of society. As the global textile complex is not also concerned with all areas of sustainability, understanding chemical foundations unlocks performance and aesthetics while ensuring responsibility for the future—a balance guiding much of my work.

PROTECTIVE APPAREL: HISTORICAL AND MODERN PERSPECTIVES

Protective apparel has also been a focus area of my research program, integrating fiber science, finishing chemistry, and human safety. In the 1980s and 1990s, I developed laboratory methods to quantify pesticide penetration through fabrics, guiding occupational clothing for agricultural and lawn care workers.[1,2,3] These studies evaluated the effects of temperature, humidity, and chemical finishes on fabric barrier performance, laying the groundwork for modern protective textiles.[4]

By the mid-1990s, systematic evaluations of surgical gowns and masks emphasized the importance of fabric structure, porosity, and finishing on liquid and bacterial transmission.[5,6,7] The innovative use of Laser Scanning Confocal Microscopy to see microorganism transmission through fabrics was a breakthrough, impacting the fabric design to improve barrier effectiveness.[5] Functional finishes, including antimicrobial and repellent treatments, were shown to enhance barrier performance while maintaining comfort.[8,9] Research also revealed that repeated laundering affects the barrier properties of reusable gowns, highlighting the interplay between chemistry, structure, and durability.[10]

In the 2000s, investigations into face masks and nonwoven materials expanded knowledge on layering order, repellency finishes, and fluid resistance.[11,12,13] These studies demonstrated how small changes in chemistry, such as finish application or fiber bonding, directly affected protection against biological and fluid hazards.

More recently, research has continued to integrate polymer chemistry, fabric structure, and functional finishes in the design of advanced protective apparel. Studies have addressed antimicrobial performance, microbial transfer, and the effects of laundering on reusable medical textiles.[14,15] Collectively, this body of work illustrates how protective apparel has evolved from simple barriers into engineered systems that balance safety, durability, comfort, and sustainability.

FIBER SCIENCE, POLYMER DEGRADATION, AND SUSTAINABILITY

As early as the 1980s, the textile community was grappling with wastewater treatment and environmental compatibility of fibers and finishes.[16,17] These concerns have only intensified, as we now face the realities of microfiber release, climate change, and circular economy imperatives. A research area that has continued throughout my academic career has focused on fibers and textile products—their properties, performance, and environmental behavior. Early studies examined degradation pathways of plastics in aquatic and terrestrial environments, providing systematic data on how polymer additives and structures affect breakdown rates.[18,19] Subsequent work extended into agricultural and specialty textiles, including biodegradable mulches.[20,21]

Microfiber pollution has emerged as a critical global issue. Research I co-led documented how fiber chemistry, textile structure, and laundering variables contribute to fiber shedding.[22] An editorial highlighting microfiber pollution as a sustainability concern further elevated awareness in the industry.[23]

Polymer degradation studies have informed recyclability and end-of-life considerations. Work on electrospun polycaprolactone demonstrated how morphological changes during in vitro degradation impact material behavior.[24] Collaborative studies on biodegradable mulches showed that visual assessments alone do not reliably predict mechanical integrity, emphasizing the need for quantitative evaluation.[21]

Life cycle assessment (LCA) has been an essential tool for quantifying impacts across the textile supply chain. From wastewater permitting strategies to recent studies on sustainability trends in apparel, and consumer recycling behaviors, my research emphasizes systems-level thinking.[16,25,26] Fiber-to-fiber recycling has emerged as a cornerstone of circularity, highlighting technological drivers and policy enablers necessary for scaling these solutions.[27] Studies on consumer participation in take-back programs reveal the importance of aligning behavioral insights with technological advances.[27,28] Grants focused on LCA databases and microfiber leakage reduction, underscore the central role of chemistry in enabling circularity and mitigating environmental impacts.[29,30]

INNOVATIONS IN DYEING AND FINISHING CHEMISTRY

Color remains central to textile expression, yet dyeing has historically been resource-intensive. My research has explored dyeing and finishing technologies that are effective and sustainable. For example, polypropylene dyeing with vat dyes expanded coloration options for this challenging fiber.[31] More recently, collaborations on foam dyeing with reactive dyes achieved colorfastness while reducing water and chemical inputs.[32]

Finishing chemistry has also been a sustained area of contribution. Studies on antimicrobial and repellent finishes for nonwoven surgical fabrics established effective one-bath processes that combined durability with barrier performance.[8,9] Investigations into layering order and repellent treatments in face masks showed that small changes in finishing chemistry could significantly impact filtration and protection.[11,12,13] These examples illustrate how targeted chemical interventions align consumer needs, safety requirements, and environmental responsibility.

LEADERSHIP, MENTORSHIP, AND BROADER INFLUENCE

Scientific progress thrives not only on research but also on people—students, colleagues, collaborators, and communities. I have been committed to mentoring the next generation of textile chemists, technologists, product designers and developers, supply chain managers, and others who have careers in the global textile complex, instilling both technical excellence and ethical responsibility. Graduate students under my supervision have contributed across academia, industry, and policy, extending the impact of our work far beyond the laboratory.

Industry collaborations and sustainability partnerships have also been central to my career. A collaborative study on water and energy conservation in textile production demonstrated the power of cross-sector approaches.[33] My involvement in national and international sustainability consortia has ensured research insights translate into practice. Supporting junior faculty and building inclusive academic environments remain core commitments, recognizing that textile chemistry is enriched when diverse voices shape its future.

LOOKING AHEAD: TEXTILE CHEMISTRY IN A WONDERFUL WORLD

Textile chemistry today stands at the nexus of transformative technologies: nanotechnology, biotechnology, digitalization, and artificial intelligence. These tools offer opportunities to reimagine fibers, finishes, and processes. From biosynthetic dyes to smart textiles capable of sensing and responding to the environment, the horizon is wide and promising.

Challenges remain: climate change, water scarcity, and microplastic pollution demand urgent and creative solutions. Textile science may be used to continue designing materials and processes aligned with planetary boundaries. Collaboration across disciplines will be essential—chemists, engineers, biologists, designers, and social scientists working together toward a sustainable textile future.

In this "wonderful world," textiles will not only clothe and protect us but also contribute to health, sustainability, and beauty. Chemistry remains the invisible architect shaping this vision, and its practitioners must balance innovation with responsibility.

CONCLUSION

Textile chemistry is, indeed, a wonderful world. It is a science that enhances quality of life, supports industries, and protects the planet. My career has advanced fiber science, improved dyeing and finishing, addressed microfiber pollution, embedded sustainability through LCA, and advanced protective apparel. Mentoring students and supporting colleagues has been among the most rewarding aspects of this journey.

As we look ahead, it is critical to blend curiosity with responsibility, ensuring that every new fiber, dye, and finish contributes to a sustainable and equitable future. It is with gratitude and optimism that I accept the Olney Medal and celebrate the extraordinary and wonderful world of textile chemistry.

Karen K. Leonas
2025 AATCC Olney Medal Recipient

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The Olney Medal Paper

Established in 1944 in honor of Louis Atwell Olney, the founder and first president of AATCC, the Olney Medal recognizes outstanding achievement in textile or polymer chemistry or other fields of chemistry of major importance to textile science. The award consists of a gold medal, a scroll, and an honorarium. The medal is presented at the AATCC annual conference where the recipient delivers their traditional Olney Medal Address. The technical paper of the Olney Medal address is published annually in *AATCC Review*.

Olney Medal Recipient

Karen K. Leonas is the 2025 recipient of the **AATCC Olney Medal**. Leonas, Professor in the Department of Textile and Apparel, Technology and Management at North Carolina State University, is recognized for her prolific contributions to textile sciences. Leonas has primarily worked in academia, with a focus on sustainable processes and practices throughout the supply chain including textile processing, recycling, examination of closed-looped manufacturing, circular economy processes, life-cycle analysis, and social justice; weathering and degradation of polymeric materials; protective apparel material design and development specifically for resistance to small particle and liquid penetration; and surface and chemical modifications of textiles and polymeric materials. She has spent many years instructing and influencing future textile professionals for the industry.

AATCC Involvement

Leonas has been a member of AATCC since 1978. As an active member, Leonas has been a part of several committees, such as RA100 Global Sustainability Test Methods, and the editorial board of *AATCC Journal of Research*. Leonas also served as the AATCC Student Chapter Advisor at Washington University from 2008 to 2013, and currently serves as the AATCC Student Chapter Advisor at North Carolina State University. She has presented at several AATCC conferences and workshops, and was a session moderator at the AATCC International Conference in 2004.

For information about the Olney Award, and a list of past Olney Medal recepients, visit **www.aatcc.org/olney**.