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Plastic Pollution and Its Many Forms: Lessons Learned from the M/V X-Press Pearl Ship Fire

Monday June 27th
Lecture 4:00-5:00 p.m. **|** Physics/Astronomy Auditorium (PAA) A118
Reception 5:00-6:00 p.m. **|** Benson Hall Lobby

Bio

Dr. Bryan D. James is a Weston Howland Jr. Postdoctoral Fellow jointly appointed in the Departments of Marine Chemistry and Geochemistry, and Biology at the Woods Hole Oceanographic Institution. His current research focuses on understanding the fate, persistence, and toxicity of plastic in the marine environment to inform the rational design of next-generation materials. Prior to diving into plastic pollution, Dr. James completed his Ph.D. in Materials Science and Engineering at the University of Florida and his B.A.Sc. in Materials Engineering from the University of Toronto. For his graduate work, Dr. James was a National Institutes of Health predoctoral fellow (F31) investigating sex-specific vascular cell–material interactions to inform precision biomaterial design and pioneering the use of nucleic acid–collagen complex-based biomaterials for hard and soft tissue engineering. Dr. James is also a dedicated educator, mentor, communicator, and leader. He is the former secretary/treasurer of the National Student Chapter of the Society For Biomaterials; he has organized three Biomaterials Day symposia and the first ACS Science Café in Florida, he placed first in the 2019 Biomaterials Education Challenge (Society For Biomaterials) and 2018 Hydrogen Student Design Contest (Hydrogen Education Foundation), and has received several awards and distinctions including the Gridley McKim-Smith Women's Health Fellowship (Foundation for Women's Wellness), the Attributes of a Gator Engineer for Leadership Award (Herbert Wertheim College of Engineering), is a member of the Early Career Editorial Advisory Board for ACS Biomaterials Science and Engineering, and was named a 2022 ACS PMSE Future Faculty Scholar.

Abstract

According to the United Nations Environment Programme, along with climate change and loss of biodiversity, **plastic and chemical pollution are considered an existential threat to humanity**. In 2016, it was estimated that 19 to 23 million metric tons (11%) of plastic waste generated globally entered aquatic ecosystems posing harm to wildlife and human health.[1] Of the estimated 2-3 billion metric tons of waste generated annually, nearly one third to one half is estimated to be openly burned (**Fig. 1A**) potentiating a significant source of unaccounted, mismanaged burnt plastic waste capable of entering aquatic ecosystems with unknown impact.[2-3]

For my talk, I will discuss my efforts championing an international and interdisciplinary team of scientists and engineers to characterize the fate, persistence, and toxicity of pyroplastics (burnt plastic) in the ocean– a form of plastic pollution that has yet to be fully explored.[4] I conclude by arguing that to address the challenges of plastic pollution and engineer next generation ecocompatible and biocompatible plastics requires interdisciplinary collaboration.[5]

In May 2021, the M/V *X-Press Pearl* container ship caught fire and spilled approximately 1680 tons (70 billion) of preproduction plastic pellets (also called nurdles) off the coast of Sri Lanka making it the **largest plastic spill to date** (**Fig. 1B**). Complicating the crisis, the ship fire created an unprecedented complex mixture of colored nurdles, burnt plastic pieces, and combustion remnant chunks that littered the west coast of Sri Lanka (**Fig. 1C**). Using a set of complementary techniques including densitometry, microscopy, elemental analysis, and comprehensive gas chromatography (GC×GC), our team rapidly provided much needed clarity on the nature of the plastic immediately washing onshore.

Despite the tragedy of the spill, it offered a real-world opportunity to resolve some of the uncertainty surrounding pyroplastics. Our subsequent analyses of the nurdles focused on the transformations and fate of the plastic and its additives after being subjected to heat and fire. Notably, heat and fire changed the color and hydrophilicity of the surface of the nurdles without altering their bulk physical properties, presenting new forms of burnt plastic with uncertain environmental fate and impact to wildlife.

Of concern, especially for Sri Lankans, has been the hazardousness and toxicity of pyroplastics. To begin addressing this, our team measured the concentration of polycyclic aromatic hydrocarbons (PAHs) associated with the plastic and we are currently testing for the toxicity of the plastic. PAHs were targeted because they are known carcinogenic byproducts of incomplete combustion. The concentration of PAHs associated with the burnt plastic and combustion remnants ranged from 20,000 to 150,000 ng/g making them **some of the most PAH-contaminated plastic found in the ocean**. These concentrations of PAHs likely classify pyroplastic as hazardous waste, posing both logistical and financial challenges for its disposal. Presently, in a zebrafish bioassay, I am testing the bioavailability of chemicals associated with the spilled plastic and their toxicity. Collectively, our results show that pyroplastics are complex, potent, and likely hazardous pollutants.

The M/V *X-Press Pearl* plastic spill elevated pyroplastic pollution to international concern. In part to solve the ever-growing threat of plastic pollution and its many forms requires an integrated and interdisciplinary approach and understanding of the physical, chemical, and biological processes that drive the fate, persistence, and toxicity of chemicals and materials in the environment and in the body. To do this, I work at the intersection of materials science, sustainability, and medicine in the new field of ecomaterials science and engineering.

Figure 1. Open burning of waste[2] (A). Plastic washing ashore onto Pamunugama Beach, Sri Lanka on May 25, 2021 during the *M/V X-Press Pearl* ship fire[4] (B). Burning and heat from the ship fire created at least five types of spilled plastic (C).

References

[1] Borrelle et al. *Science*. 2020, 369, 6510, 1515-1518.
[2] Wiedinmyer et al. *Environ. Sci. Technol.* 2014, 48, 16, 9523–9530.
[3] Velis and Cook. *Environ. Sci. Technol.* 2021, 55, 11, 7186–7207.
[4] de Vos et al. *ACS Environ. Au.* 2022, 2, 2, 128–135
[5] James et al. *Environ. Sci. Technol.* 2022, 56, 3, 1475–1477