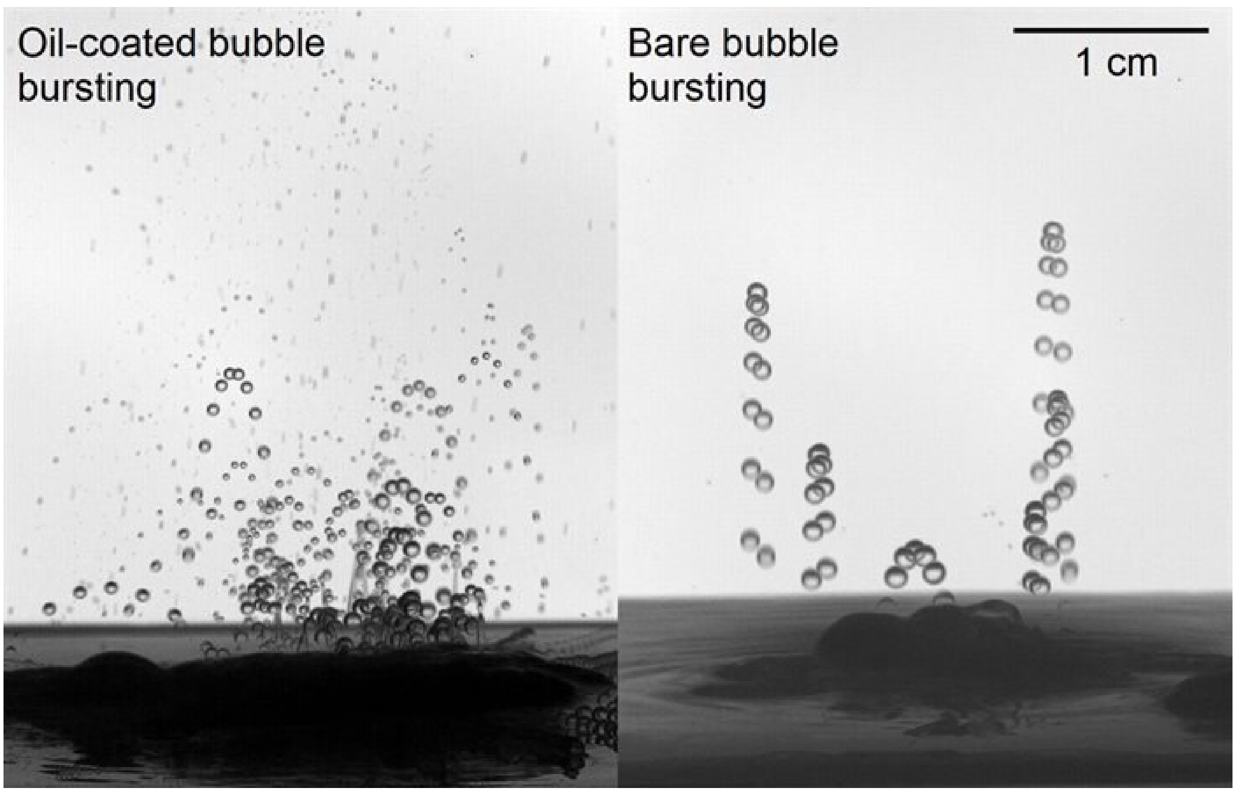
Tiny yet hazardous: New study shows aerosols produced by contaminated bubble bursting are far smaller than predicted

March 28 2023, by Amber Rose



Oil-coated bubble bursting (left) compared to bare bubble bursting (right.). Credit: The Grainger College of Engineering at University of Illinois Urbana-Champaign

A cold sparkling water. Waves crashing on the beach. The crackle of a bonfire. Steam from a kettle.

These are not only the makings of a relaxing weekend, but also sources of aerosols in our environment. Though some of these sources of aerosols aren't much of a concern, aerosols originating from industrial sources, such as wastewater treatment plants, and even natural sources, such as sea spray and dust, have the capacity to make more of an impact on the environment and even public health.

An aerosol is a suspension of liquid droplets or fine solid particles suspended in the air. Though aerosols are generated in numerous ways, one of the most significant sources is through the bursting of bubbles at the interface between a liquid and the air. Most previous research has focused on "clean" bubbles despite contaminated interfaces being more prevalent.

New research from University of Illinois Urbana-Champaign Mechanical Science and Engineering assistant professor Jie Feng and graduate student Zhengyu Yang has shown that bursting bubbles coated by a thin oil layer produce drops with smaller sizes, greater overall number of drops, and are ejected at a higher velocity than bubbles generated in clean water. This research was recently published in *Nature Physics*.

Aerosols are quite ubiquitous in our environment, and they can be natural or anthropogenic in nature. Bubble-bursting aerosols play a key role in the transfer of mass across liquid interfaces. Sea spray aerosols, for example, are primarily generated by bubble bursting at the ocean surface. The drops that are produced from bubble bursting can impact air pollution, global climate and even the transmission of infectious diseases. One important parameter of these droplets is their size since that is indicative of residence time and transport in the atmosphere—small drops are more easily lifted by winds and can travel much further.

Feng says, "We have contaminated water everywhere. When the bubble rises from deeper water to the surface, it will collect contaminants and form an organic layer around it. We call this a contaminated bubble. When it reaches the surface and bursts, it can actually aerosolize these contaminants into small droplets."

Feng and Yang investigated the impact a thin layer of oil has on bursting bubbles, as a model system for contaminated bubbles. The bursting of a millimeter-sized bare bubble at an aqueous surface produces drops with a typical size of around 100 micrometers (μm) (a typical human hair is around 100-200 μm). In this work, they found that drops can be as small as a few μm when the bursting bubble is coated by a thin layer of oil. Additionally, bare bubble bursting produces drops with a typical ejection velocity of 1 meter per second (m/s), whereas oil-coated bubble bursting produces drops with an ejection velocity as large as 10 m/s.

Feng summarizes, "The main conclusion of our work is that we found, for these contaminated bubbles, they can quite effectively aerosolize the contaminants into micron size droplets."

In an industrial setting like a wastewater treatment plant, smaller contaminated drops can pose a significant risk to those that work in the plant. Bubble bursting in these settings may generate acidic mists and bioaerosols. Understanding the effect of contaminated bubbles on size distribution and ejection speeds is crucial to designing effective personal protective equipment and implementing additional guidelines on air and water quality near such facilities.

On a broader scale, aerosols have an effect on weather, climate, and even human health.

"These droplets can transport pathogens, bacteria, and viruses," Yang said. "When you have these small aerosols, and they can be ejected higher, the small size and higher ejection speed can help them stay in the atmosphere for a longer time." Understanding size and composition of aerosols is important to improve global modeling efforts. Furthermore, these contaminated drops can pose a greater risk of pollutant spread as well as infection since smaller aerosols are able to penetrate further in the respiratory tract than larger aerosols.

Other contributors to this work include Bingqiang Ji (co-author, postdoc, MechSE, UIUC) and Jesse T. Ault (assistant professor, School of Engineering, Brown University).

More information: Zhengyu Yang et al, Enhanced singular jet formation in oil-coated bubble bursting, *Nature Physics* (2023). DOI: 10.1038/s41567-023-01958-z

Provided by University of Illinois Grainger College of Engineering