WATER ONLINE

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Are Nanobubbles Really A Big Deal?

Source: Mazzei Injector Company, LLC

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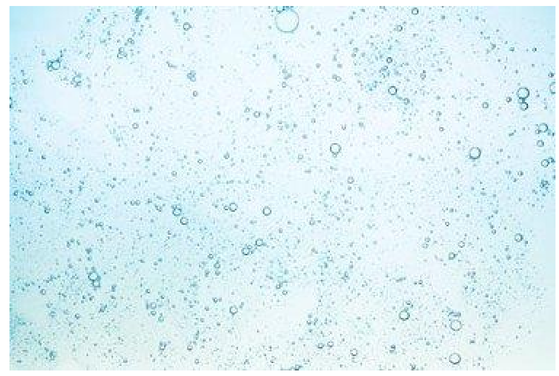

Tiny bubbles — less than 200 nanometers apiece, small enough to fit 5,000 or more side by side in a millimeter — are making a big splash in the venture capital markets, and in the media, too. Nanobubbles can destroy harmful algal blooms, purify contaminated water, rid irrigation systems of biofilm, and perform cleaning feats that are nothing short of miraculous.

The principles behind nanobubbles are intriguing. Generated by introducing gas into a water vortex that is broken into the tiny bubbles (the gas-water circulation method) or by dissolving a percentage of highly pressurized gas in water to form a supersaturated solution (the pressurized dissolution approach), countless nanobubbles are blasted into the target water system. They're tiny and carry a strong negative electrical charge, so instead of floating to the surface like larger bubbles do, they have a long lifetime in liquid, bouncing around randomly like molecules, a phenomenon called Brownian motion.

As a result, nanobubbles can remain in suspension for days, months — some proponents say it can even be as long as a year. While they are in the water, nanobubbles can attract positively charged bacteria and other contaminants, help float particulate matter, blast open to create free radicals, and oxygenate the water.

The long hang time in water is not only interesting, but necessary. Nanobubbles require long residence time to transfer gas because there is no shearing of the gas/liquid film. That is fine for aeration — for instance, to fuel waste-consuming microbes — though for ozonation, which is a race against the short life of the ozone molecule, the role of nanobubbles bears further exploration.

Big Excitement

The properties of nanobubbles have inspired a lot of enthusiasm in the water industry, and the possibilities are indeed exciting. Where conditions favor their activity and the scale is appropriate for their distribution, nanobubbles can indeed be a game-changer. And when conditions are less-than-perfect or the scale starts to extend beyond where nanobubbles can reach, mixing technologies like venturi injectors, pipeline flash reactors and basin nozzle manifolds can help a wider range of users take advantage of nanobubble technology.

The tiny size of nanobubbles is part of the appeal, but also part of the problem with scale. Because nanobubbles don't act like bubbles but instead move randomly, they can't be directed effectively for thorough mixing in a sizeable volume of water. And one of the principles of Brownian motion is that random motion speeds up as temperature increases, which means the temperature of the water can become a dramatically limiting variable when using nanobubbles.

Turbidity can be another limiting factor, strongly reducing the movement of nanobubbles. So can salinity. In short, plenty of variables interfere with the random movement that characterizes nanobubbles, so mixing and mass transfer are extremely localized. And even within those locally treated areas, gas transfer occurs through a passive process that is poorly understood. The industry is eager to see more research — not just in the lab, but in real-life conditions.

The bottom line is that a small, localized volume of water may be treated successfully with nanobubbles, but a large, cold, turbid or saline tank or water body would require a tremendous amount of nanobubble generating infrastructure to ensure thorough treatment.

Effort And Efficiency

One challenge for nanobubble systems is energy. Some systems promise greater efficiency than others, but all require significant pump energy to create the force that forms the nanobubbles and injects gas into the water. Pressures of 60 to 100 psi or more are not uncommon.

To maximize the mixing they can achieve and make the most of the energy they expend, some nanobubble systems integrate the mixing power of venturi injectors to mix nanobubble-treated water into the mainstream. They are taking advantage of the remarkable efficiency of venturis as they use the pressure change in the flow to draw in gas or treated water, inject it into the stream, and provide the shearing and mixing effect that aids in even distribution and mass transfer.

Venturi injectors also provide a powerful shearing effect, which dramatically improves gas transfer from the bubbles. Active shearing in a venturi continually renews the liquid/gas barrier, presenting a constantly refreshing interface for gas to go into solution. Nanobubbles alone must wait — often a long time — for passive transfer to occur through their negatively charged barriers.

As a result, the mass transfer efficiency of a well-engineered and -manufactured venturi — which can exceed 90 percent with air, oxygen or ozone — is already renowned among aeration and oxidation experts. It may also be a boost to nanobubbles. Other high-efficiency mixing technologies, like pipeline flash reactors and basin nozzle manifolds, can also contribute to better mixing in larger volumes.

Scale And Ability

The challenges around scalability are evident in the popularity of nanobubbles in systems that treat smaller volumes of water — for instance, greenhouse irrigation systems or algae-choked corners of ponds that can be shielded from ordinary flow through the water body.

At this stage, it appears that nanobubbles may have a big future treating small volumes of water, but where scale or the need for movement are larger, integration with high-efficiency injection and mixing systems may be necessary.

One industry expert points out that you can clean a stain on your shirt with a detergent pen, but to wash your whole shirt, you'll need a washing machine that can disperse the detergent.

That's nothing against today's detergents, which are head and shoulders above older chemistries. They just need to be delivered properly. I suspect we will see something similar as nanobubbles make their mark on our industry — either alone or integrated with other technologies to deliver the biggest impact.