Quantum of sonics: Bonded, not stirred

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Researchers at McGill University have discovered a new way to join materials together using ultrasound. Ultrasound – sound so high it cannot be heard – is normally used to smash particles apart in water. In a recent study, the team of researchers, led by McGill professor Jake Barralet, from the faculties of Dentistry and Medicine, found that if particles were coated with phosphate, they could instead bond together into strong agglomerates, about the size of grains of sand. Their results are published in the journal *Advanced Materials*.

Nanoparticles are extremely useful but are difficult to contain because they are invisible and are easily carried in the air. They can also enter the body easily, creating a concern for the safety of industrial workers and the public. A new method to stick nanoparticles to one another into something you can handle safely with your fingers, without changing their useful properties, could have implications for a range of everyday applications.

"Using ultrasound is a very gentle low-energy process compared to traditional furnaces and welding, so even active drugs and enzymes can easily be built into carriers to make new hybrid materials," says Prof. Barralet, lead investigator of the study and Director of Research in the Department of Surgery at the Research Institute of the McGill University Health Centre (RI-MUHC).

Ultrasound induces short-lived bubbles (known as cavitation) that create, for a fraction of a microsecond, when they collapse, 'hotspots' of thousands of degrees. Because this bubble formation is a random and

infrequent process, scientists have struggled with ways to harness this incredibly powerful phenomenon for assembling materials rather than for destroying them. The key to the McGill team's finding was developing a way to localize cavitation at the nanoparticles' surface. This led to the discovery that their phosphate coating interacts with unstable radicals created at these hotpots and makes the nanoparticles 'weld' together irreversibly.

Just as a mixologist (cocktail waiter) shakes drinks together to create your favourite martini, materials scientists can now simply mix preformed nanoparticles together and zap them in the ultrasonic bath to create new weird and wonderful hybrid and fully functional microparticle materials, such as conductive ceramic catalysts, magnetic polymers, and drug-loaded metals.

"Our discovery may help alleviate the loss of platinum from catalytic converters in car exhausts, for example. Half of the platinum mined annually worldwide is used to make catalytic converters and up to half of this platinum is lost into the atmosphere during the lifetime of the car. This results from a lack of a better method – up to now – for bonding nanoparticles in a robust and durable manner while still maintaining their activity."

The study's co-author and former McGill doctoral student, David Bassett, helped make the discovery when he spotted something unusual in the bottom of his ultrasonic bath.

"Instead of getting smaller, these things grew and kept on growing. We went up many blind alleys and it took me three years to unravel what was going on. It was painstaking but now it's really satisfying to finally have a grip on it."