Science at the Edge
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Inside a Collapsing Bubble: Sonochemistry and Sonoluminescence

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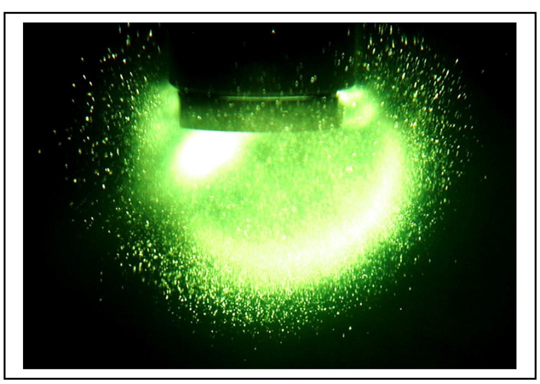
ABSTRACT

Fundamentally, chemistry is the interaction of energy and matter. Surprisingly, there are relatively few ways of putting energy into molecules. High intensity ultrasound has found numerous applications in driving chemical reactions and in the preparation of unusual materials. The chemical effects of ultrasound originate from acoustic cavitation: the formation, growth, and implosive collapse of bubbles in a liquid. Extreme temperatures and pressures are produced during that collapse through acoustic cavitation: the formation, growth and collapse of bubbles in a liquid irradiated with high intensity ultrasound. From sonoluminescence spectroscopy, we have established that cavitation produces local conditions inside clouds of bubbles of ~5000 K, ~1000 atm, with heating and cooling rates that exceed 10^{10} K/s. In isolated single bubbles, which can collapse more symmetrically and effectively, temperatures exceeding 18,000 K.

In otherwise cold liquids, ultrasound is able to drive reactions that normally occur only under extreme conditions. The sonochemical syntheses of nanostructured metals, alloys, metal carbides, supported heterogeneous catalysts, and nano-colloids derives from the sonochemical decomposition of volatile precursors during cavitation, which produces clusters a few nm in diameter. Such nanostructured solids are active heterogeneous catalysts for various reactions. Another remarkable phenomenon occurs during ultrasonic irradiation of liquid-solid slurries: extremely high speed inter-particle collisions caused by shockwaves produced by acoustic cavitation. These can induce induce melting of metal particles upon collision and easily cause fragmentation of molecular crystals. As a consequence, both stoichiometric and catalytic liquid-solid reactions can be tremendously enhanced.

http://www.scs.illinois.edu/suslick/index.html



To meet with the speaker on please contact R. Ghosh (ghosh@pa.msu.edu)