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Mechanoluminescence event yields novel emissions, reactions

Researchers at the University of Illinois report that a new study of mechanoluminescence revealed extensive atomic and molecular spectral emission not previously seen in a mechanoluminescence event. The findings, which appear online this month in the *Journal of the American Chemical Society*, also include the first report of gas phase chemical reactions resulting from a mechanoluminescence event.
Mechanoluminescence is light generated when a crystal, such as sugar or quartz, is fractured by grinding, cleaving or via other mechanical means. Sir Francis Bacon wrote about this phenomenon as early as 1605. Others have used the effect to impress, if not enlighten, others.

"You may, when in the dark frighten simple people only by chewing lumps of sugar, and, in the meantime, keeping your mouth open, which will appear to them as if full of fire," Father Giambattista Beccaria wrote in "A Treatise Upon Artificial Electricity," in 1753.

Scientists believe mechanoluminescence occurs as a result of the generation of opposite charges along the fracture plane of an asymmetrical or impure crystal. When the charges recombine the surrounding gas is ionized and emits light.

Mechanoluminescence that results from simple grinding or cleavage of a crystal can be quite weak and difficult to study. Late last year, U. of I. chemistry professor Kenneth Suslick and graduate student Nathan Eddingsaas reported in the journal Nature that a new technique, the sonication of crystal slurries, produced a much more intense mechanoluminescence than grinding. Sonication, the use of sound energy to agitate particles or other substances, causes high intensity collisions of crystal particles in liquid slurries.

The resulting mechanoluminescence is an order of magnitude brighter than that produced by grinding.

Sonication of liquids causes acoustic cavitation: the formation, growth and implosion of bubbles. This generates tremendous heat, pressure and shockwaves within the liquid that can exceed the speed of sound. Crystal particles suspended in a sonicated liquid collide and fracture, causing intense mechanoluminescence.

The new study involved the sonication of a slurry of recorcinol (sugar) crystals in the liquid paraffin, dodecane. When nitrogen or oxygen was bubbled through the sonicated slurry, the resulting emission spectrum was more than a thousand time more intense than that produced by grinding. The researchers also saw emission lines not previously reported in a mechanoluminescence event. These peaks on the mechanoluminescence spectra are evidence of gas phase chemical reactions during the event.

"When oxygen is present, chemical reactions take place that are similar to those that occur in the production of diamond films using an electrical discharge," Suslick said. "The intense mechanoluminescence and chemical reactions produced by ultrasound give us a better understanding of mechanoluminescence, mechanochemistry and the effect of ultrasound on solids within a liquid."

Source: University of Illinois at Urbana-Champaign
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