Snap, crackle, pop

Army drill sergeants have long known that producing a lot of noise can make things happen fast; now chemists are learning the same trick. Researchers have found that very high-pitched sound, called ultrasound, can provide the energy needed to start a chemical reaction. Chemists now rely largely on heat and pressure (and sometimes on light) to start reactions; equipment to handle the high pressure and temperatures that are required is often costly. Ultrasound could make chemical processes cheaper.

A chemical reaction starts when there is enough energy to make molecules react with each other when they collide, instead of just bouncing off. Heat does this by making the molecules move faster and with more force; pressure by packing the molecules closer together. Ultrasound can start chemical reactions by creating short-lived pockets of high heat and pressure.

This process is known as cavitation. Sending a burst of ultrasound (inaudible to humans) through a liquid produces tiny bubbles, which last only a few hundred-millionths of a second. Inside the bubbles, the temperature can briefly reach 2,700°C and the pressure 300 atmospheres. That is enough to start some kinds of chemical reaction.

Ultrasound can create more efficient reactions than those produced by heat and pressure. For example, Professor Ajay Bose of the Stevens Institute of Technology in New Jersey has used ultrasound to help synthesise one of the building blocks of antibiotics. They are normally produced by boiling the chemical ingredients in the solvent toluene for hours; even then, yields are as low as 25%. With ultrasound, Professor Bose achieved a 60% yield at room temperature.

Another use for ultrasound may be in the production of catalysts (substances that speed up chemical reactions). Dr Kenneth Suslick of the University of Illinois, for instance, has used ultrasound to produce homogeneous catalysts. The homogeneous kind are more efficient than normal catalysts because they dissolve into the solution containing the chemicals they are meant to catalyse.

One drawback to homogeneous catalysts, however, is that they are hard to make. Many consist of metal complexes: metal atoms surrounded by other chemical groups. And the metals on which they are based—including molybdenum, tungsten and chromium—are unco-operative in reactions. Ultrasound, Dr Suslick has found, can overcome the reluctance of metals to react.

Professor Philip Boudjouk of North Dakota State University is using ultrasound to help improve conventional catalysts. The surfaces of these solid catalysts get clogged with chemical by-products. These stop the catalyst from coming into contact with the chemicals it is supposed to catalyse. Bombarding the catalyst with ultrasound while it is in a solution creates "microjets" of solvent that clean away the congestion.

The use of ultrasound to promote chemical reactions has yet to find its way out of the laboratory and into industry. The techniques are simply too new; researchers need more time to understand how ultrasound-driven reactions differ from ones powered by heat and pressure. There is also the practical problem of scaling ultrasound up from laboratory to industrial uses. But industrial backers are already looking into ultrasound. Several big companies, including America's Celanese, Amoco, Exxon, Du Pont and Dow Chemical, are experimenting with the technique.