March 21, 2007

Make a Wish: Chemists Snap Molecule like Wishbone

New way to kick-start reactions may lead to materials that resist breaking

It may sound like a headline from *the Onion,* but researchers have broken a molecule apart by, well, tugging on it. The team speculates that the technique may lead to materials that respond to mechanical stress by repairing themselves.

Technically, the researchers let ultrasound do the pulling for them. Looking for new ways to trigger chemical reactions, they decided to crack open a molecule called benzocyclobutene, which consists of carbon atoms arranged in a hexagon fused to a square. So they attached two long molecules on either side of the square region and ultrasonically vibrated a solution of the compound. They reasoned that the motion of the water would stretch the flanking molecules like a pair of stiff springs, pulling apart the two free corners of the square and leaving two dangling ends capable of forming new chemical bonds.

The researchers used two forms of benzocyclobutene with slightly different shapes. Typically the two structures, called isomers, would prefer to form different products, but a magnetic resonance imaging–like technique revealed that both isomers broke into the same molecule. The pulling action guides the atoms along a path they would not normally take, says team member Jeffrey Moore, a materials researcher at the University of Illinois at Urbana-Champaign. "It means we can start to move atoms in particular directions … that the intrinsic chemistry is really not favorable for," he says.

Researchers have ripped apart chains of repeating molecules before, but the bonds broke at random. To cleave specific bonds, chemists typically boil their compounds or use special catalysts.

Moore says he is now working on a molecule that changes color when tugged, which might be useful as a way to monitor safety cords or other materials for damage.

In the long run, he says he would like to see materials that reinforce themselves when stretched too close to the breaking point. "If we can trigger chemical reactions mechanically," he says, "that would be a way that we could make chemical bonds in regions where they're needed most: … where the material is experiencing a very large stress."

"Many frustrated chemists wish that they could simply reach into their flasks and pull apart any uncooperative chemical bonds," University of Pennsylvania chemists Brad Rosen and Virgil Percec write in an editorial published with the findings in this week's *Nature*. "Although chemists might not immediately rush to adopt this technique," they note, "the work is a remarkable first step."