Researchers build single molecule 'microphone' that can detect proton size displacements

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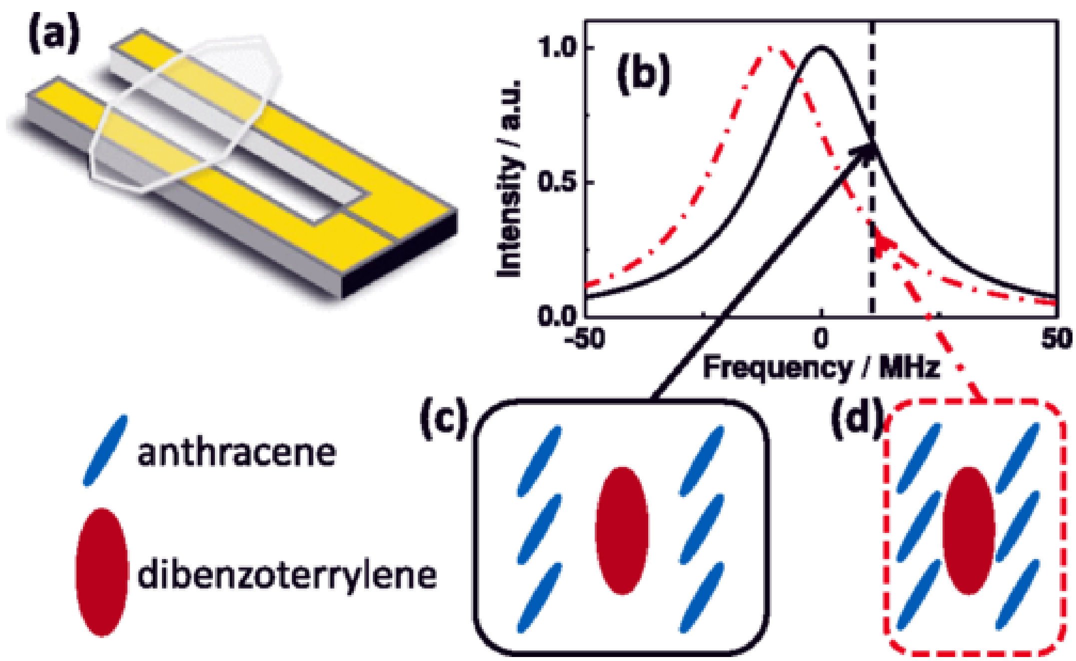

(a) Sample mounting: an anthracene crystal doped with DBT was attached to the quartz crystal tuning fork. (b) The ZPL of a single DBT molecule is shifted upon deformation of its surrounding host crystal, as shown in (c) and (d). The real deformations are three-dimensional and much more complicated, as molecules can also rotate and be distorted. Credit: *Phys. Rev. Lett*. 113, 135505 – Published 26 September 2014

(Phys.org) —A trio of researchers in the Netherlands has built a "microphone" out of just a single molecule that is capable of detecting displacements as small as a single proton. In their paper published in *Physical Review Letters*, Yuxi Tian, Pedro Navarro, and Michel Orrit describe how they embedded a single molecule in a crystal lattice along with a vibrating mechanism to create a new type of device capable of detecting vibrations at the nanoscale.

The researchers describe their device as a nanomicrophone, though it might best be shortened to just nanophone, as it picks up, or detects vibrations at the nanoscale. In either case, the effort was based on work conducted by a team in France recently who found that the electronic state of a molecule designated as a guest in a host matrix of another type of molecule, could be influenced by the matrix in such a way as to reveal vibrational properties of the matrix—finely enough to allow its use as a type of extremely miniature microphone.

To build their micronanaphone, the researchers embedded individual dibenzoterrylene (DBT) molecules in a anthracene crystal lattice (with a low enough concentration to prevent the DBT molecules from touching). The crystal was then glued to a bit of quartz to act as a tuning fork. When the quartz was made to vibrate via an electric current it caused vibrations in the lattice which impacted the DBT molecule. In response the molecule changed how much it fluoresced (when excited by a laser), offering a way to measure how much vibration was occurring by degree of fluorescence. The team found they could focus on just one of the DBT molecules at a time because of imperfections in the crystal, which meant the final microphone was actually just one molecule in size.

To test their device, the researchers stimulated the quartz in such a way as to fine tune the vibrations, measuring what they observed with just one molecule, photon by photon, over a full second and found that the device was able to accurately describe the amount of distortion occurring in the lattice.

The researchers believe their micronanophone could be used for measuring either chemical or nano sized systems and because it's so sensitive it could even be used to measure quantum effects in various structures such as extremely tiny cantilevers. One limitation is that the device only works at very low temperatures.

More information: Single Molecule as a Local Acoustic Detector for Mechanical Oscillators, *Phys. Rev. Lett.* 113, 135505 – Published 26 September 2014. journals.aps.org/prl/abstract/ … ysRevLett.113.135505

ABSTRACT
A single molecule can serve as a nanometer-sized detector of acoustic strain. Such a nanomicrophone has the great advantage that it can be placed very close to acoustic signal sources and high sensitivities can be achieved. We demonstrate this scheme by monitoring the fluorescence intensity of a single dibenzoterrylene molecule in an anthracene crystal attached to an oscillating tuning fork. The characterization of the vibration amplitude and of the detection sensitivity is a first step towards detection and control of nanomechanical oscillators through optical detection and feedback.