In a bid to corroborate potentially suspect results that were provided by the dispersants industry, the EPA tested eight dispersants, including COREXIT 9500, the one most widely used by BP. The agency's results showed broad similarities with industry's analyses—some effects on silverside fish and mysid shrimp, but no significant disruption of hormonal systems of animals, at least at the cellular level. "All the dispersants are roughly equal in toxicity and generally less toxic than oil," said EPA assistant administrator and chemist Paul Anastas in a press briefing on June 30. "The dispersant constituents are expected to biodegrade in weeks to months, rather than remaining in the ecosystem for years as oil might."

But at least one outside toxicologist has found reason to criticize the EPA and the methods it has used. "There is not any information on what is the environmentally relevant level of dispersants," says toxicologist Carys L. Mitchelmore of the University of Maryland, who helped to write a 2005 National Research Council report on dispersants. Nor is there any evidence that the agency had any requirements for defining acceptable toxicity levels in the industry-provided data. From that information alone, "I could not compare and contrast which one was more toxic than the other," Mitchelmore recounts.

In fact, it remains unclear whether anyone at the EPA ever checked the industry-provided numbers as required by law. When Scientific American asked Anastas about that, he did not directly answer the question, and the EPA did not respond to follow-up questions. Such clarification would be useful because the industry data appear to be full of potential faults, including, in the analysis of one dispersant, the use of the wrong reference toxicant. Nor did the EPA show the best understanding of toxicology in urging BP in a directive to use dispersants with a "toxicity value less than" a certain cutoff: in toxicology, a chemical that produces harm at low concentrations, say, five parts per million, is *more* deadly than those that kill at 10 parts per million.

OIL CHECK: A Coast Guard ensign logs water samples from the Gulf of Mexico to help determine the effectiveness of oil dispersants used by BP.

COURTESY OF PETTY OFFICER 2ND CLASS LUKE PINNEO *U.S. Coast Guard*

The problems are not entirely the fault of the EPA; policies for safety testing under current chemical regulations are flawed [see "Chemical Controls"; Perspectives, Scientific American, April]. "The magnitude of this event has raised important questions about how these previous, existing regulations [for dispersants] may need to be reexamined and revisited in ways that ask different questions and even better prepare us in the future," Anastas admitted.

Although Congress has suggested reforms, it is uncertain if the EPA will address these methodology issues as it explores the contamination in the Gulf of Mexico. In July the EPA began conducting toxicity tests for the specific light sweet crude from the Gulf, both alone and in conjunction with the various dispersants.

"Once it's mixed with oil, that's where you get the most impact, that's where you see most of the toxicity," says toxicologist Sergio Alex Villalobos of Nalco, the maker of COREXIT 9500. Anastas suggested that testing was expected to be completed before the end of August.

TECHNOLOGY

Quantum Light Switch

A single atom acts as a transistor for photons BY DAVIDE CASTELVECCHI

POINT TWO LASER BEAMS so that they cross each other, and each goes through as if the other one did not exist. Light rays cannot interact with other light rays—or can they? With the help of a single atom, physicists have devised a system in which one light beam can turn another on or off. Such a light switch could serve as the basic component of futuristic optical quantum computers and may help open the way to a quantum version of the Internet, which would offer unbreakable data security.

The device makes use of a phenomenon called electromagnetically induced transparency, in which a laser beam can render opaque clouds of atoms temporarily transparent to a narrow wavelength of light. The cloud can then act as a switch for a second beam, either letting it through or blocking it. The result is similar to what happens with transistors in electronic circuits, where a voltage applied at one electrode controls whether current can flow between two other electrodes.

Applications such as quantum computing demand the control of beams down to single photons, the elementary particles of light. For that purpose, single atoms are better than clouds of them, says physicist Martin Mücke of the Max Planck Institute for Quantum Optics in Garching, Germany. He and his collaborators trapped a rubidium atom and aimed two different laser beams at it: one for probing, or transmitting, and the other one for switching. Ordinarily the atom acts as a barrier to photons from the probe beam because it would first absorb them—going from its "ground" state to an "excited" state—and then shoot them back, that is, reflect them. This condition would constitute the "off" state of the device.

But turning on the switching beam changed the atom's possible states, so that it now had two different ground states. The probe beam then had two different ways of exciting the electron, each starting from a different ground state, but in the mathematics describing the atom's quantum-mechanical nature, the two possibilities cancel out, so that no excitation was possible. Thus, the probe beam photons, rather than being absorbed, could get through, marking the "on" state.

Making single photons interact can be useful because a photon can carry the units of quantum information, called qubits. They can exist in two states simultaneously and thereby represent both the 0 and 1 of binary code at the same time. Thanks to this feature, quantum computers could perform certain operations in parallel. In principle, they could quickly perform calculations that a typical computer could not do, at least not before the sun swells up and bakes the earth five billion years from now.

Max Planck's Gerhard Rempe, the senior researcher on the team, points out that a single-atom device could do more than mere switching. For example, it could store photons and release them at will without damaging their delicate quantum states—an application known as quantum random-access memory, which could be crucial for data routers of a quantum Internet. In such a network, privacy is guaranteed by the law of quantum physics [see "Privacy and the Quantum Internet," by Seth Lloyd; Scientific American, October 2009].

The new device still needs improvement: in the off position, the atom still lets through 80 percent of photons from the second beam. But the researchers say that straightforward improvements, such as keeping the atom colder, could bring that number down to 10 percent, if not to 0. (A more substantial limitation is that handling single atoms requires a fairly sophisticated physics laboratory.) The team published its results in the June 10 *Nature*. (*Scientific American* is part of Nature Publishing Group.)

Right now the device's low efficiency limits its usefulness, comments Paul G. Kwiat, a quantum optics expert at the University of Illinois at Urbana-Champaign. But if the team can improve efficiency, he notes, it "could open a new, potentially efficient approach to quantum computing."

Origami Sheets That Fold Themselves

Researchers have invented a real-life Transformer, a device that can fold itself into two shapes on command. The system is hardly ready to do battle with the Decepticons—the tiny contraption forms only relatively crude boat and airplane shapes—but the concept could one day produce chameleonlike objects that shift between any number of practical shapes at will.

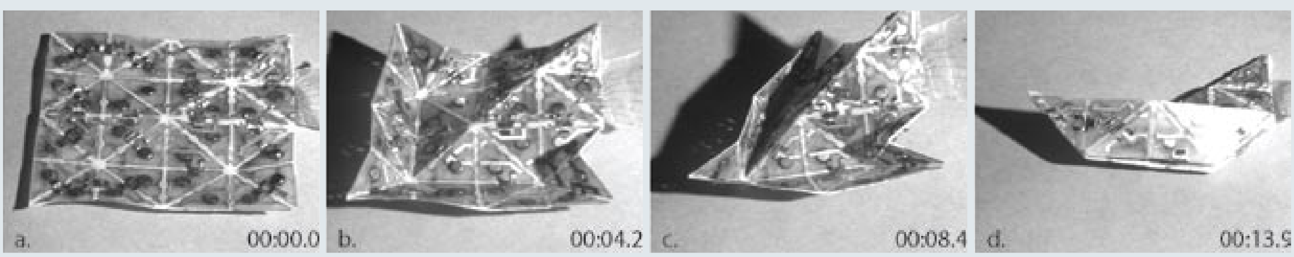
Self-folding sheets are just one facet of programmable matter. "Instead of programming bits and bytes, you program mechanical properties of the object," says Daniela Rus, a roboticist at the Massachusetts Institute of Technology.

The system, described online June 28 in the *Proceedings of the National Academy of Sciences USA,* consists of a thin sheet of resin–fiberglass composite, just a few centimeters across, segmented into 32 triangular panels separated by flexible silicone joints. Some of the joints have heat-sensitive actuators that bend 180 degrees when warmed by an electric current, folding the sheet over at that joint. Depending on the program used, the sheet will conduct a series of folds to yield the boat or airplane shape in about 15 seconds.

The researchers say that in principle the system could produce many more shapes than two. "We were looking for ways to embed a bunch of different functionalities into one low-profile sheet," says co-author Robert J. Wood, an electrical engineer at Harvard University.

In the near term, Rus envisions the computational origami technology forming the basis of three-dimensional displays—for instance, maps that can reproduce the topography of a given region on demand. In the more distant future, applications might move beyond shape mimicry to involve programmable optical, electric or acoustic properties.

—John Matson



AUTOBOTS, TRANSFORM! **Well, not really, but researchers have made "programmable matter" that folds itself into shapes, such as a boat.**

COURTESY OF HARVARD MICROROBOTICS LAB

Watch a video of the shape-shifting matter at **ScientificAmerican.com/sep2010/shape**