'Look Mom No Electricity': Transmitting Information with Chemistry

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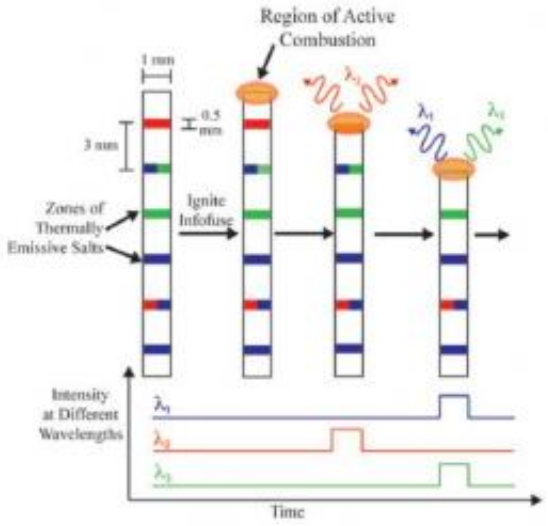

Burning an infofuse transmits a sequence of pulses of light, in which information is encoded using different wavelengths (determined by various metallic salts) and the order of the pattern. Image credit: Samuel W. Thomas III, et al. ©2009 PNAS.

(PhysOrg.com) -- While information technology is generally thought to require electrons or photons for transmitting information, scientists have recently demonstrated a third method of transmission: chemical reactions. Based on a flammable “infofuse,” the new system combines information technology and chemistry into a new area the researchers call "infochemistry."

In the study, led by George Whitesides of Harvard University, with other coauthors from Harvard, Tufts University, and DARPA, the scientists explain that their system transmits information in the form of coded pulses of light generated entirely by chemical reactions, without electricity. The system is self-powered, with power being generated by combustion. The power density of the system is higher than that of electrochemical batteries, and has the advantage of not discharging over time.

As Whitesides explained to *PhysOrg.com*, the significance of the study is that it "demonstrates direct chemical to binary encoding, and transmission of information at a useful bit rate, without batteries." The researchers hope that their prototype will one day make it possible to make systems that transmit useful information in circumstances in which electronics and batteries do not work, such as harsh environments and under water.

As the scientists explain, the system consists of a strip or fuse of combustible material (nitrocellulose) about 1 mm long. When ignited, a yellow-orange flame moves along the infofuse. To encode information, the scientists patterned the fuse with various metallic salts, which could be done using a desktop inkjet printer or a micropipettor. With their different emission wavelengths, the salts created distinct emission lines in different regions of the electromagnetic spectrum, similar to how the colors of fireworks are made: blue (copper), green (barium), yellow (sodium), red (lithium, strontium, calcium), or near-infrared (potassium, rubidium, cesium).

The infofuse, which burns at about 3-4 cm/sec depending on thickness and pattern spacing, is then read by a detector, such as a color CCD camera or fiber optic cable coupled to a spectrometer. The distance between the detector and burning infofuse was typically 2 m, but the detector could still detect a signal up to 30 m away in daylight.

By coding letters of the alphabet using patterns of metallic salts, the scientists transmitted the phrase, “LOOK MOM NO ELECTRICITY” on a single infofuse using the new technique. As the scientists explain, light pulses have several controllable variables that can be used to represent different letters and symbols. In addition to emission wavelength, other variables include pulse duration, time between pulses, and emission intensity. Using combinations of three alkali metals, the researchers demonstrated how to encode 40 different characters by varying some of these parameters.

“It needs a flame, but it does not need additional batteries or power, or auxiliary devices, to convert a chemical signal to a digital one,” Whitesides said. “The power needed to generate the light is produced by chemistry directly, not by drawing power from a battery.”

Although the current infofuses convert energy into light with only 1% of the efficiency of a battery-operated LED, the infofuses generate 10 times more energy per weight than an alkaline battery generates. In general, integrating information technology and chemistry could have certain advantages, possibly leading to systems that operate beyond binary schemes by using a variety of parameters that allow each information unit to carry more information than a bit. Also, since infochemistry is not bound by the principles of electronics (such as fixed circuitry), but rather the principles of chemistry, new systems could lead to novel architectures.

The scientists hope that further improvements to their system could lead to lightweight, portable, self-powered systems that can transmit information and integrate with modern information technologies. Applications could include environmental sensing and transmitting the data optically over a distance. The system could also be used for message transmission in search-and-rescue type applications.

More information: “Infochemistry and infofuses for the chemical storage and transmission of coded information.” Samuel W. Thomas III, et al. *Proceedings of the National Academy of Sciences*. vol. 106, no. 23, 9147-9150.