



With Self-Erasing Ink, Paper Does Not Have to be Disposable

Paper waste contributes to climate change more than most people realize. The carbon footprint of producing, transporting, and disposing 12 sheets of paper is equivalent to driving one mile in a gasoline-powered car — despite generous assumptions of 30% recycled content in the paper and an unrealistic 100% recycling rate (1).

More than 45 years ago, pundits predicted that the arrival of the paperless office was just around the corner. However, offices use more paper now than they did then. Lawyers reading cases, analysts reviewing financial reports, and even students wanting to read online course material without distractions feel the need to print.

Laser printing and inkjet technology deliver near archival document life spans, but for the past 20 years, most printed documents have been needed only temporarily. Many printed documents go into the recycling bin the same day they are printed. In fact, a study by Xerox estimated that 21% of paper in an office is discarded the same day it is printed (2).

A company aptly named Blue Planet Ink, based in San Diego, CA,

A large amount of paper is consumed printing permanent hardcopies in situations where a temporary hardcopy would suffice. Frequently a temporary hardcopy would be adequate for a meeting agenda, a draft of an article, memorandum, or report to be proofread, or recurring information such as daily schedules or news. It is often helpful to have hardcopy in hand to read but a permanent hardcopy copy of the information is not required. For this reason many paper documents are discarded the same day they are printed.

▲ The figure above is a scanned image of a sheet of paper where the printed text had been previously printed and erased 10 times. The bottom half of the figure, where no text is visible, shows what the same paper looks like after the printed ink has disappeared.

recognized that printing on paper for short-term use is not good for the environment, but the problem is not going away on its own because paper printouts are useful. With support from the National Science Foundation (NSF), Blue Planet Ink has created a novel, self-erasing ink — called Paper Saver ink — for temporary printing and copying.

Paper Saver ink can be used on regular paper in standard inkjet printers. The type of inkjet printing used most frequently for printing documents is called drop-on-demand. Drops of ink are individually ejected through tiny nozzles on the print head onto the paper to form an image. Blue Planet Ink's process follows the same paradigm; a standard inkjet printer or copier deposits droplets of the novel self-erasing ink on paper to create an image. However, the ink on the paper gradually undergoes a chemical reaction and loses its color over time, leaving behind blank paper ready to be used again.

The self-erasing ink is water-based. Instead of a conventional pigment or dye, the ink uses a pH indicator such as o-cresolphthalein as a colorant. The pH indicator is colored at a high pH and colorless at a low pH. The ink is printed at a high pH for maximum readability. Subsequently, the printed image absorbs carbon dioxide and water vapor from the air, which form carbonic acid. This lowers the pH of the ink and causes the printed image to become colorless. The ink is still on the paper, but invisible.

Documents printed with the ink are typically readable for a day or two, but the readability time can be tuned from six hours to several days. After that, the ink fades to the point that the previously printed paper is indistinguish-

able from brand new paper. The paper can be reprinted over and over again with self-erasing ink. Or, it can be used for conventional printing and copying, handwriting, or virtually anything else. At the end of its many lives, the paper can be recycled.

There have been many other efforts to make paper reusable. Some organizations have created reusable substrates to replace paper, while others have created new inks and toners with corresponding equipment to erase them on demand. Paper Saver self-erasing ink is unique in that it uses ordinary paper and does not require erasing equipment; the paper erases itself with air exposure, even when stacked.

Formulating the self-erasing ink has several challenges. The ink must render printed text with the right droplet placement accuracy (print sharpness), optical density (print darkness), and minimal paper curling (wrinkling). It must be optimized for reliability, the ability to self-erase, and long shelf life in the ink cartridge. If the pH is too high, the ink can corrode the printhead. In addition, many standard additives are not compatible with the ink's unusual chemistry.

Blue Planet Ink has met these challenges and is now selling its self-erasing ink in bottles and cartridges for select printer models. One bottle provides enough ink to print eight reams of paper (4,000 sheets), similar to conventional inks. Inks for additional printer models are under development. **CEP**

1. U.S. Environmental Protection Agency, "Greenhouse Gas Equivalencies Calculator," <https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator> (Mar. 2020).

2. Markoff, J., "Xerox Seeks Erasable Form of Paper for Copiers," *The New York Times*, p. C8 (Nov. 27, 2006).

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