# Green Chemistry Makes Computing Safer for the Environment

*Apple's "elemental" approach is a milestone achievement in environmental protection.*

The popularity of "green" electronics is on the rise. Consumers are increasingly interested in investing in features that have a lower environmental impact, according to a recent study by the Consumer Electronics Association.[1] Up until now, energy efficiency has been the basis for most green product claims, but some of the chemicals used in electronic products also have a significant impact on the environment. Because thousands of chemicals are required to produce a typical cell phone, PDA, notebook, or television, identifying and avoiding those chemicals that pose the greatest environmental risks is key to providing consumers with products that are greener throughout their life cycle.

Apple Inc.'s commitment to re-engineer all of its products worldwide to remove elemental forms of bromine and chlorine marks an extraordinary step forward for the electronics industry.[2] When the approach is fully implemented, Apple will have gone further than any other electronics company toward designing a wide range of products that greatly reduce the risk of exposure to chemicals known or suspected to impact the environment and human health.

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## Creating New Standards

Apple's "elemental approach" far exceeds even the world's strictest governmental regulations, which go no further than targeting a limited number of bromine and chlorine based chemicals. By executing a strategy that goes beyond the chemical-by-chemical focus conventionally used by electronics manufacturers, Apple is blazing a trail for the industry. Moreover, Apple's policy is consistent with the intent of green chemistry, a systematic approach to avoiding substances hazardous to human health and the environment in favor of safer chemicals.

A key way for electronics manufacturers to green the chemistry of their products is by eliminating compounds that could cause problems in the environment and or workplace. When computers contain halogenated elements like chlorine and bromine, they can act as precursors to dioxin and furan formation during manufacturing and recycling of brominated and chlorinated compounds.[3]

Dioxins and furans are among the 12 "dirty dozen" chemicals banned by the United Nation's Persistent Organic Pollutants (POPs) treaty because they can cause "serious health effects including certain cancers, birth defects, dysfunctional immune and reproductive systems, greater susceptibility to disease and even diminished intelligence."[4] Because POPs can travel thousands of miles in the atmosphere, scientists believe that the increasing concentrations of dioxins and furans endanger people in other countries, far from the initial sources of dioxins, in addition to harming the workers directly exposed to them.[5] People throughout the world now have dioxins, furans, and other POPs in their blood.[6]

## The Burden of Proof

The rationale for eliminating the use of bromine and chlorine containing chemicals is based on their tendency as a group to bioaccumulate, be persistent and/or toxic—or to degrade in the environment into new halogenated organic molecules that have one or more of these problematic tendencies.[7] Not all brominated and chlorinated compounds are problematic, but there are many "bad actors" in this family of chemicals. The burden of proof therefore should be on manufacturers of these chemicals to demonstrate that a particular compound is **not** hazardous, persistent, or bioaccumulative in humans or the environment. However, to prove a compound's safety requires comprehensive test data for human health and environmental endpoints which are rarely available. Knowing that the synthesis of halogenated organic chemicals can produce many unwanted and toxic by-products, it can be more pragmatic for manufacturers to simply avoid this class of chemicals altogether.

This is the approach taken by Apple across the millions of products it has already shipped worldwide. Apple is the first to

apply elemental restrictions globally on bromine and chlorine to its new desktops, notebooks, iPods and iPhones. It has also successfully restricted uses of mercury and arsenic by using mercury-free light emitting diode (LED) and arsenic-free display glass in new MacBooks. This groundbreaking policy required the company to make a substantial engineering investment in new materials and technologies that reduce toxicity, while increasing recyclability and energy efficiency. The company's successful transition to this new elemental policy demonstrates that Apple knows its product chemistry and is able to assess and avoid the most hazardous chemicals.

In contrast to Apple's elemental approach, most major electronics manufacturers have made commitments to discontinue using some brominated flame

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retardants (BFRs) in their products and to avoid the use of only some chlorinated materials such as polyvinyl chloride (PVC) plastic in certain parts. The timetable and definitions for implementation vary from company to company. The IPC association representing computer manufacturers and suppliers is currently developing an industry standard to officially define what materials manufacturers must avoid in order to make such claims.[8] This standard will provide an important step forward once it is finalized, but it seems likely to allow the continued use of many brominated and chlorinated compounds.

Apple's approach reflects the reality that brominated and chlorinated compounds are also used in electronic applications besides flame retardants and PVC plastic formulations—including solvents,

inks, dyes, optical films, and flux. The company had to reformulate hundreds of components in order to eliminate bromine and chlorine from its products. To find replacements for PVC plastic in some external power cords, Apple went as far as conducting its own tests for flammability because most of the world's fire safety standard organizations only had protocols for power cords made of PVC. Apple's success in devising and discovering these new formulations and testing protocols demonstrates that the rest of the industry can go a lot further.

Apple's standard limits the amount of bromine and chlorine allowable in its products to 900 parts per million (ppm), or 0.09%, by weight, per homogeneous material.[9] This represents a huge reduction from the 50,000 ppm of brominated flame retardants, on average, that are generally added to protect plastic electronics components such as printed circuit boards from accidental ignition. The elemental restriction on bromine essentially closes the door on all BFR compounds, because BFRs are simply not effective at such low concentrations in homogenous materials, thereby precluding its use by electronic suppliers. The elemental approach also addresses the concern that suppliers would seek to avoid detection by re-engineering rather than by replacing commonly used flame retardants such as tetrabromobisphenol A (TBBPA).

At the same time, Apple's 900 ppm limit reflects the reality of the manufacturing processes used by its thousands of suppliers. Brominated compounds can be present in environments where electronic components are manufactured and fabricated for a variety of reasons, including their use in some fabrication steps. For this reason, suppliers would be unwilling to contractually bind themselves to a 0 ppm limit.

### Additional Steps

Apple also made the decision to avoid certain alternative flame retardants that appear to be problematic, including red phosphorus and antimony trioxide in favor of less hazardous flame retardants

like magnesium hydroxide and ammonium polyphosphate. In addition, since 2001 Apple has led the industry in using inherently fire-resistant materials, such as titanium, steel, aluminium and more flame resistant plastics.

To ensure compliance with Apple's material standard, the company took another unusual verification step. Rather than relying solely on supplier declarations—which past experience has shown can be unreliable—Apple conducts its own testing to make sure that the parts it buys conform to its requirements.[10] The company also informs its suppliers of relatively inexpensive analytical tests they need to certify that their parts meet the requirements.

Apple's elemental approach enables organizations and regulators to easily verify that the company's products live up to its promises. Checking for the presence of TBBPA is far more costly and complicated than analyzing a material for the presence of elemental bromine. This helps guarantee that the specification is being met in a supply chain that is dependent on thousands of suppliers.

The European Union's Restriction on Hazardous Substances Directive (RoHS) set new environmental protection standards worldwide in 2006 by restricting substances like lead at the elemental level. Apple's elemental restrictions on bromine and chlorine are setting the next major environmental health standard in the elec-

tronics sector. If Apple's approach is established in public policy and industry standards, more environmentally benign alternative chemicals and materials will become more affordable for all electronic manufacturers. By redefining what is possible and implementing green engineering throughout its supply chain, Apple's move has the potential to improve the environmental footprint of all electronic products.

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## ENDNOTES

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