Harmful Chemicals in Electronic Cigarettes

While a limited number of studies have been conducted on electronic cigarettes to date and more studies are necessary, scientific studies have identified hundreds of chemicals in the vapor of mainstream smoke (inhaled by the person smoking) or in the secondhand side stream. Some of these are known to cause health effects, are toxic, or may cause cancer. A Greek study found cotinine — a byproduct of nicotine — samples in the blood of people exposed to electronic cigarette vapors had "similar nicotinergic impact to tobacco cigarettes." Like tobacco, the only way for cotinine appears in the blood of nonusers is through secondhand exposure. Based on the research to date, GASP of Colorado believes there is enough evidence to recommend that the public avoid exposure to secondhand electronic cigarette smoke.

Forty-Two Chemicals Identified in Electronic Cigarettes

✔= exposure can be especially harmful to the health. Chemicals in red are emitted in secondhand smoke.

2-butanone (MEK)
2-furaldehyde
Acetaldehyde ✔
Acetic acid
Acetone ✔
Acrolein ✔
Aluminum
Barium
Benzene ✔
Boron
Butanal
Butyl hydroxyl toluene
Cadmium ✔
Chromium ✔
Copper
Crotonaldehyde
Diethylene Glycol ✔
Formaldehyde ✔
Glyoxal
Iron
Isoprene ✔
Lead ✔
Limonene
m,p-Xyelen
Magnesium
Manganese
Nickel ✔
Nicotine ✔
N-Nitrosonornicotine ✔
o-Methylbenzaldehyde ✔
p,m-Xylene
Phenol ✔
Polycyclic Aromatic Hydrocarbons ✔
Potassium
Propanal ✔
Propylene Glycol ✔
Sulfur
Tin ✔
Toluene ✔
Valeraldehyde
Zinc
Zirconium

Specific Dangers of Some Electronic Cigarette Chemicals

Side Stream Smoke

*** Benzene** *Found in pesticides and gasoline.*	Found in the air from emissions from burning coal and oil, gasoline service stations, and motor vehicle exhaust. Acute (short-term) inhalation exposure of humans to benzene may cause drowsiness, dizziness, headaches, as well as eye, skin, and respiratory tract irritation, and, at high levels, unconsciousness. Chronic (long-term) inhalation exposure has caused various disorders in the blood, including reduced numbers of red blood cells and aplastic anemia, in occupational settings. Reproductive effects have been reported for women exposed by inhalation to high levels, and adverse effects on the developing fetus have been observed in animal tests. Increased incidence of leukemia (cancer of the tissues that form white blood cells) has been observed in humans occupationally exposed to benzene. EPA has classified benzene as known human carcinogen for all routes of exposure.
Diethylene Glycol	A chemical used in antifreeze and capable of causing eye irritation and respiratory tract irritation and with chronic exposure can cause reproductive and fetal effects.
*** Isoprene**	One of the major components that makes up natural rubber and is used to make synthetic rubbers. It is also emitted from plants and trees, has been detected in tobacco smoke and automobile exhaust. Isoprene is a possible cancer-causing agent. The US government in 2000 classified it as "reasonably anticipated to be a human carcinogen." In laboratory animal studies of isoprene, cancer was observed in multiple organ sites following long-term inhalation exposures.

Mainstream & Side Stream Smoke

*** Formaldehyde** *Used for preserving dead bodies.*	A colorless, flammable, strong-smelling chemical that is used in building materials and to produce many household products. Formaldehyde sources in the home include pressed-wood products, cigarette smoke, and fuel-burning appliances. When exposed to formaldehyde, some individuals may experience various short-term effects. Formaldehyde has been classified as a known human carcinogen (cancer-causing substance) by the International Agency for Research on Cancer and as a probable human carcinogen by the U.S. Environmental Protection Agency. Research studies of workers exposed to formaldehyde have suggested an association between formaldehyde exposure and several cancers, including nasopharyngeal cancer and leukemia.
*** Nicotine**	Is a naturally occurring toxic chemical found in tobacco plants. It has a fishy odor when warm. Cigarettes, cigars, other tobacco products, and tobacco smoke contain nicotine. Worker exposure may occur during processing and extraction of tobacco. At one time, nicotine was used in the United States as an insecticide and fumigant; however, it is no longer produced or used in this country for this purpose. Nicotine affects the nervous system and the heart. Exposure to relatively small amounts can rapidly be fatal.
*** N-Nitrosonornicotine**	Chemical substance that is known to cause cancer.

Propylene Glycol *The main ingredient of e-liquids and is used in many e-cigarettes for producing vapor.*	Is a synthetic liquid substance that absorbs water. It is also used to make polyester compounds, and as abase for deicing solutions and by the chemical, food, and pharmaceutical industries as antifreeze when leakage might lead to contact with food. The Food and Drug Administration (FDA) has classified propylene glycol as an additive that is "generally recognized as safe" for use in food. It is used to absorb extra water and maintain moisture in certain medicines, cosmetics, or food products. It is a solvent for food colors and flavors, and in the paint and plastics industries. Propylene glycol is also used to create artificial smoke or fog used in fire-fighting training and in theatrical productions. Inhaling propylene glycol may affect airways. Short-term exposure in indoor air (for one minute) causes irritations in the eyes, throat and airways. Long-term exposure in indoor air may raise children's risk of developing asthma. People who have frequently been exposed to theatrical fogs containing propylene glycol are more likely to suffer from respiratory, throat and nose irritations than do unexposed people.
* **Toluene** A poisonous industrial solvent.	Is added to gasoline, used to produce benzene, and used as a solvent. Exposure to toluene may occur from breathing ambient or indoor air affected by such sources. The central nervous system (CNS) is the primary target organ for toluene toxicity in both humans and animals for acute (short-term) and chronic (long-term) exposures. CNS dysfunction and narcosis have been frequently observed in humans acutely exposed to elevated airborne levels of toluene; symptoms include fatigue, sleepiness, headaches, and nausea. CNS depression has been reported to occur in chronic abusers exposed to high levels of toluene. Chronic inhalation exposure of humans to toluene also causes irritation of the upper respiratory tract and eyes, sore throat, dizziness, and headache. Human studies have reported developmental effects, such as CNS dysfunction, attention deficits, and minor craniofacial and limb anomalies, in the children of pregnant women exposed to high levels of toluene or mixed solvents by inhalation. EPA has concluded that that there is inadequate information to assess the carcinogenic potential of toluene.

Mainstream Smoke

* **Acetaldehyde** *A poisonous solvent and paint stripper.*	Is mainly used as an intermediate in the synthesis of other chemicals. It is ubiquitous in the environment and may be formed in the body from the breakdown of ethanol. Acute (short-term) exposure to acetaldehyde results in effects including irritation of the eyes, skin, and respiratory tract. Symptoms of chronic (long-term) intoxication of acetaldehyde resemble those of alcoholism. It is considered a probable human carcinogen (Group B2) based on inadequate human cancer studies and animal studies that have shown nasal tumors in rats and laryngeal tumors in hamsters.
* **Cadmium** Toxic heavy metal used in car batteries.	The main sources of cadmium in the air are the burning of fossil fuels such as coal or oil and the incineration of municipal waste. The acute (short-term) effects of cadmium in humans through inhalation exposure consist mainly of effects on the lung, such as pulmonary irritation. Chronic (long-term) inhalation or oral exposure leads to a build-up of cadmium in the kidneys that can cause kidney disease. It has been shown to be a developmental toxicant in animals, resulting in fetal malformations and other effects, but no conclusive evidence exists in humans. An association between cadmium exposure and an increased risk of lung cancer has been reported from human studies, but these studies are inconclusive due to confounding factors. Animal studies have demonstrated an increase in lung cancer from long-term inhalation exposure to cadmium. EPA has classified cadmium as a Group B1, probable human carcinogen.
* **Lead**	Lead is a naturally occurring element found in small amounts in the earth's crust. While it has some beneficial uses, it can be toxic to humans and animals causing of health effects.
* **Nickel**	Occurs naturally in the environment at low levels and is an essential element in some animal species, and it has been suggested it may be essential for human nutrition. Nickel dermatitis, consisting of itching of the fingers, hands, and forearms, is the most common effect in humans from chronic (long-term) skin contact with nickel. Respiratory effects have also been reported in humans from inhalation exposure to nickel. Animal studies of soluble nickel compounds (i.e., nickel carbonyl) have reported lung tumors. EPA has classified nickel refinery dust and nickel subsulfide as Group A, human carcinogens, and nickel carbonyl as a Group B2, probable human carcinogen.

- These compounds Proposition 65 are listed in California's Proposition 65, the Safe Drinking Water and Toxic Enforcement Act of 1986. The Proposition is designed to protect California citizens and the State's drinking water sources from chemicals known to cause cancer, birth defects or other reproductive harm, and to inform citizens about exposures to such chemicals. Products containing chemicals on the Proposition 65 list are required to carry the following warning in California: "WARNING: This product contains chemicals known to the State of California to cause cancer and birth defects or other reproductive harm."

Some sources:
Electronic Cigarettes – An Overview, German Cancer Research Center, 2013
Acute impact of active and passive electronic cigarette smoking on serum cotinine and lung function, Inhalation Toxology, 2013
Indoor Air from the Fraunhofer Wilhelm-Klauditz-Institut 2012
Web sites of the EPA and FDA; and others.
"Peering through the mist: What does the chemistry of contaminants in electronic cigarettes tell us about health risks?" (Lists many of the chemicals in this paper. It is funded by the e-cig advocacy group CASAA and uses the wrong standard of exposure (see http://www.tobacco.ucsf.edu/new-e-cig-risk-assessment-uses-wrong-standard).