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(FORM UPDATED: 08/11/2010)

WISCONSIN STATE LEGISLATURE ...
PUBLIC HEARING - COMMITTEE RECORDS

2013-14
(session year)

Assembly
(Assembly, Senate or Joint)

Committee on...
State Affairs and Government Operations
(AC-SAGO)

INFORMATION COLLECTED BY COMMITTEE FOR AND AGAINST PROPOSAL

- Appointments ... **Appt** (w/Record of Comm. Proceedings)
- Clearinghouse Rules ... **CRule** (w/Record of Comm. Proceedings)
- Hearing Records ... bills and resolutions (w/Record of Comm. Proceedings)
  (**ab** = Assembly Bill) (**ar** = Assembly Resolution) (**ajr** = Assembly Joint Resolution)
  (**sb** = Senate Bill) (**sr** = Senate Resolution) (**sjr** = Senate Joint Resolution)
- Miscellaneous ... **Misc**

* Contents organized for archiving by: Stefanie Rose (LRB) (December 2014)

To: Members of the Wisconsin State Assembly, Committee on State Affairs and Government Operations,
From: Allison Miller, Wisconsin government relation director, American Cancer Society Cancer Action Network
RE: Testimony in opposition to Assembly Bill 762
Date: March 4, 2014

Dear Chairman Weininger and members of the committee:

The American Cancer Society Cancer Action Network (ACS CAN), the nonprofit, nonpartisan, advocacy affiliate of the American Cancer Society, is opposed to Assembly Bill 762, which will allow the use of electronic cigarettes in public places and workplaces where smoking is otherwise prohibited.

Wisconsin is on the cusp of celebrating the fourth anniversary of the state's smoke-free air law in July. The law is incredibly popular. Allowing the use of electronic cigarettes or e-cigarettes in public spaces undermines this popular and effective law and creates confusion for business owners, the public and in enforcement efforts.

More research is needed on electronic cigarettes.
ACS CAN has significant concerns about the potential public health effects of electronic cigarettes. Over the last several years, there has been a dramatic growth in the marketing and sale of e-cigarettes and in the claims being made by e-cigarette manufacturers, as well as a proliferation in the various types of e-cigarettes being sold. Despite the dramatic rise in the use of e-cigarettes, very little is known about their ingredients, their health risks to users and bystanders, their impact on youth tobacco use or whether they are effective in helping smokers quit.

There are more than 250 types of e-cigarettes on the market today and the products vary considerably by ingredients and quality control. E-cigarette makers claim their ingredients are "safe" but without any standards there is no sure way for e-cigarette users to know what they are consuming and the extent of potential risk.

Only a limited number of studies have so far examined the contents of e-cigarette vapor. Some of the studies have found them to contain heavy metals, volatile organic compounds and tobacco-specific nitrosamines, among other ingredients. A 2009 study done by the Food and Drug Administration (FDA) found cancer-causing substances in several of the e-cigarette samples tested.

The health effects of e-cigarettes are scientifically uncertain, especially their long-term effects. Additionally, the effects of secondhand vapor from e-cigarettes require further study, especially to determine differences among the many brands and types of e-cigarettes.

Until more research is conducted and the FDA determines if they're safe, we strongly recommend that states treat e-cigarettes like all other tobacco products.

Electronic cigarettes should not be exempt from Wisconsin's smoke-free air law.

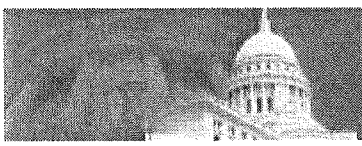
Because electronic cigarette use simulates the behavior of smoking, use of these products complicates enforcement of the smoke-free air law and weakens its effectiveness. Use of an e-cigarette in public places normalizes the action of smoking which can result in higher youth smoking rates and a slower decline in cessation rates.

Additionally, the use of these products, which often resemble traditional cigarettes, and produce a visible cloud when exhaled, are causing confusion for the public and enforcement officials alike. Explicitly exempting e-cigarettes from the restrictions imposed by smoke-free would add to this confusion and could lead to false reports of violations of the smoke-free law.

Moreover, business operators, striving to follow existing law shouldn't have to become experts at differentiating between cigarettes and e-cigarettes. If it looks like someone is smoking in a public space where it is prohibited, it should be treated as such.

Growing evidence shows electronic cigarettes are an increasing problem among youth.
The use of e-cigarettes is increasing, including among youth. A recent Centers for Disease Control and Prevention (CDC) report shows that in the United States from 2011 to 2012—just one year—the percentage of youth (middle and high school students) using e-cigarettes more than doubled. Furthermore, more than 75% of the youth surveyed who used e-cigarettes also smoked conventional cigarettes. As well, 1 in 5 who used e-cigarettes had never tried traditional cigarettes. This could indicate that e-cigarettes are a gateway to traditional tobacco products.

Overall, the need for more research is absolutely essential to guard against possible public health risks and prevent e-cigarettes from creating a new generation of youth tobacco users, increasing the overall number of people addicted to nicotine, convincing current tobacco users not to quit or re-glamorizing the act of smoking. The committee can ensure that history does not repeat itself with a new generation of products by opposing AB 762 and maintaining the integrity of Wisconsin's smoke-free air law.



WISCONSIN STATE LEGISLATURE

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Improving Life,
One Breath at a Time

AMERICAN LUNG ASSOCIATION®
of Wisconsin

March 5, 2014

To: Members of the Assembly State Affairs and Government Operations

Re: Assembly Bill 762

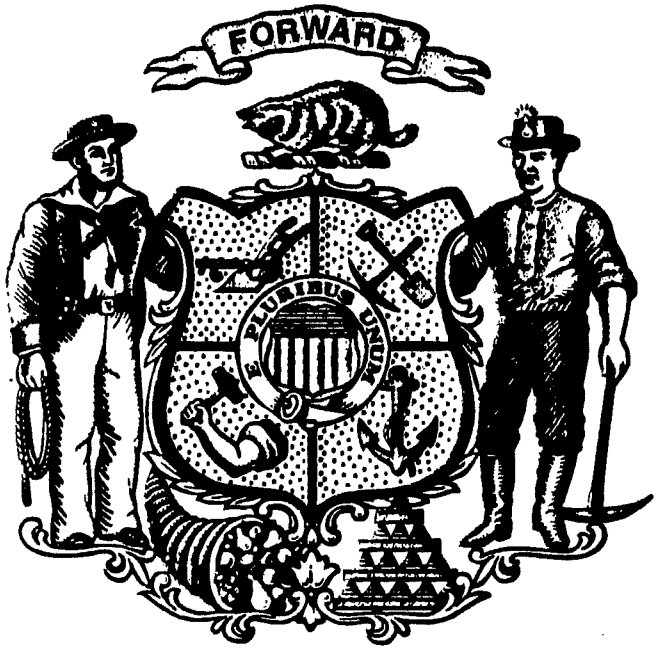
Dear members of the committee,

The American Lung Association in Wisconsin respectfully urges you to vote no on the recommendation for passage of AB 762, which would exempt e-cigarettes from the state's smoke-free law.

First, the long-term impact of e-cigarettes on the health of our state's residents remains unknown. Some of the studies that have been conducted, like a 2009 study by the U.S. Food and Drug Administration found that some of these devices contained toxic carcinogenic chemicals in addition to nicotine. Yet even those limited studies don't even begin to scratch the surface of investigating the 250 plus brands currently offered. Without federal oversight, each of these brands is free to include any combination and assortment of ingredients – including toxins – in their products.

Secondly, there's no reason to change Wisconsin's very successful and strongly supported smoke-free air law that protects owners, workers and customers from the dangers of second hand smoke. Granting e-cigarette smokers an exemption will also cause enforcement problems throughout the state by creating confusion and inconsistency in the application of the law.

That is why we oppose AB762 and its companion bill Senate Bill 440. If you have any questions regarding our position, please call us at 1-800-586-4872. Thank you for your time and consideration.


FORWARD
E PLURIBUS UNUM

My name is Kristin Noll-Marsh. I am 46 years old, a Wisconsin resident and a former smoker. I have also served as the volunteer vice president of CASAA, the Consumer Advocates for Smoke-free Alternatives Association, for the past 4 ½ years.

CASAA is a non-profit 501(c)(4), all-volunteer organization with a grassroots membership of thousands of individuals from all walks of life. We are a consumer-focused organization, not a trade association.

I strongly urge this committee to vote "yes" on AB 762. This is a landmark bill that will set Wisconsin apart from the knee-jerk legislation currently occurring across the country. I truly believe that the day will come when those attempting to restrict access to and use of e-cigarettes will be forced to explain why they treated a powerful tool, made to reduce the health risks of smoking, as though it was a public health risk - without any science to back it up. You have the opportunity to make Wisconsin the leader in supporting tobacco harm reduction policies, by protecting an important incentive for smokers to switch to products that can reduce their health risks by 99%. Banning public use of these products only reduces their appeal to adult smokers.

This is a photo of my family. Four of the six people pictured were smokers, who now no longer smoke because of e-cigarettes. My youngest daughter, born when I was 39 years old, is the reason why I didn't want to die early from smoking-related diseases. Unfortunately, that still didn't get me to actually quit. Although I had quit while pregnant and nursing, I still started smoking again. I thought I would smoke until I died, but then I saw an e-cigarette. I bought it on a whim - and that is very important for you to hear – I wasn't trying to quit smoking. Gums and patches only work if you are trying to quit and if you want to quit. I bought that e-cigarette because it was less expensive than smoking, I could still use it when the smoking ban took effect and I could eliminate my exposure to harmful cigarette smoke. The effectiveness and safety of FDA-approved gums and patches was meaningless to me, because I wasn't planning to quit smoking. Yet here I am today, smoke-free for nearly five years.

in-law even quit using the e-cigarette. Ironically, my adult sons didn't start using an e-cigarette until their smoking friends started using them. Sadly, it seems smoking is still considered to be more "cool" than e-cigarettes in this 18 to 25 year old group.

My story may be anecdotal and not scientific, but I can tell you that surveys of thousands of CASAA members tell the same story. Thousands of people who didn't intend to quit smoking, yet did when they tried an e-cigarette. It may not be the results of a controlled study in a lab, but it is happening in the real world, every day. This is not something that should be easily dismissed.

I was never a political person. I didn't get involved in activism until I started using an e-cigarette and saw all of the misinformation being presented to lawmakers by organizations such as the American Lung Association and American Cancer Society. Frankly, I was shocked that these organizations were coming out against e-cigarettes rather than encouraging their use. That is how I came to be involved with CASAA. I wanted people to know the truth.

Today you may hear a lot of statistical and scientific claims being made, but I can guarantee that you will not hear the whole truth from many of those public health organizations. I've told you of my personal experience, but as a CASAA representative, I ask for just a few more minutes of your time to tell you important facts that you won't hear from public health organizations today. Otherwise, please refer to my written testimony provided.

Since CASAA's founding in 2009, we have educated the public and increased awareness about the benefits of reduced harm alternatives to smoking, including e-cigarettes. We also encourage responsible legislative policy designed to improve public health by recognizing that smoke-free nicotine-containing products are inherently far less dangerous than smoking. That is why we support this bill.

You may have heard that we don't know what is in e-cigarettes or conversely, that harmful chemicals and carcinogens have been found in e-cigarettes, including a chemical found in anti freeze. However, the carcinogens detected were at the same harmless levels as found in FDA-approved nicotine gums and patches. The so-called anti freeze chemical had been detected in only one of the samples tested by the FDA and that it was at a level so low that an adult would have to drink over half a gallon of the liquid for it to be toxic.

Over 60 chemical studies have been done and those studies were reviewed by Dr. Igor Burstyn, of Drexel University's School of Public Health, who concluded in a peer-reviewed and published study that *"there is no evidence that [e-cigarette use] produces inhalable exposures to contaminants of the aerosol that would warrant health concerns by the standards that are used to ensure safety of workplaces....Exposures of bystanders are likely to be orders of magnitude less, and thus pose no apparent concern."*

There are unsubstantiated and vague concerns that e-cigarettes used in public may cause confusion and complicate enforcement of smoking bans, but there is no evidence of this happening. I have been using my device in public since 2009 and have never had anyone confuse it with smoking. No one has ever been bothered by the vapor either. Any time I've been approached, I'm asked "Is that one of those e-

cigarettes?" and "Where can I get one?" At a 2013 hearing in New York City, regarding an ordinance to include e-cigarette use in the Smoke-free Air Act, the New York City Hospitality Alliance testified that e-cigarettes have not become an issue of concern among association members. Using e-cigarettes inside has also reduced noise and cluttering on sidewalks caused by traditional cigarette smokers in front of some bars and clubs.

It sometimes seems that what e-cigarettes look like, rather than their actual health effects, are more of a concern to some. That e-cigarettes will send the wrong message to youth and somehow "renormalize" or even glamorize smoking. But that is the exact opposite of what we think will happen. Seeing e-cigarettes in use in public is not sending a message that smoking is OK, but instead sends the message that someone is choosing to not smoke. My 12 year old step-daughter's mother smokes and my daughter tells her all of the time that she should get an e-cigarette instead. If my 12 year old child can make that distinction, so can any child. The more our youth see e-cigarettes in use, the less they will see people actually smoking.

Although youth e-cigarette use (which includes even trying an e-cigarette only once) doubled from 1.1% to 2.1% nationally between 2011 and 2012, youth smoking and tobacco use actually declined during that same period. Youth tobacco use is at a historical low.

There is no evidence that e-cigarettes are leading youth to smoke conventional cigarettes, because the youth surveys reported by the CDC didn't ask smoking youth which they used first. However, we do know that the survey showed that less than 1% (0.63%) of the students surveyed had tried e-cigarettes without having smoked previously.

Then there are the flavors. Obviously, e-cigarette companies are targeting youth with sweet flavors, because adult smokers wouldn't want them. Of course, FDA-approved nicotine gums and lozenges, which are clearly marketed to adult smokers, don't come in sweet flavors such as cherry, orange, fruit chill, cinnamon and mint.

As a 46 year old former smoker, I am here to tell you that if there weren't e-cigarette flavors like peach and chocolate available, I'd still be smoking today. Incidentally, tobacco companies only started selling e-cigarettes in 2012 and none of the tobacco company e-cigarettes are available in bubblegum or other candy flavors.

There may be things you hear today that I haven't mentioned and I welcome you to call on me if you would like to know all of the facts. For the health of the nearly 900,000 adult smokers in Wisconsin, most of who will not try to quit smoking anytime soon, I urge you to vote yes on AB 762.

Thank you.

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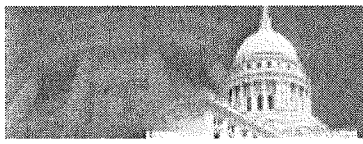

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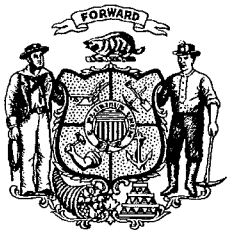

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Testimony for WI Assembly Bill 762

Thank you for allowing me to speak to you today. My name is Joe Dralle and I am the Director of Product Development for Johnson Creek Enterprises, the largest manufacturer of smoke juice, or e-Liquid, in the United States. We also sell our own electronic cigarette, Vea. I am here today to voice my support for Assembly Bill 762.

My background as an engineer is integral to improving the manufacturing processes we use, as well as improving the products themselves. My job has a direct impact on the experience of our customers AND my fellow employees. While working for Johnson Creek over the last 18 months I've gravitated toward the company's belief that valuing one's employees creates a better value for one's customers. This priority has allowed our company to nearly double in size year after year, and it will help to create even more jobs and more positive experiences for our customers. Personally, I look forward to advancing the technology of our industry to create more valuable solutions for customers and coworkers alike.

As someone who works with electronic cigarette technology on a daily basis I am obliged to discuss the fundamental differences between traditional cigarettes and electronic cigarettes. The traditional cigarette functions on the principle of burning tobacco to produce smoke, while the electronic cigarette functions by heating a liquid solution to evaporate it into a vapor or aerosol. The combustion of a traditional cigarette undergoes a chemical reaction that releases even more chemicals than are already present. On the other hand an electronic cigarette merely vaporizes the ingredients from the liquid to the aerosol form without the existence of a combustion reaction.

Moreover, the physical differences between the two are hard to miss. Electronic cigarettes are composed of a battery (used as an energy source), which is connected to a cartridge that contains a heating element (known as an atomizer) and a liquid solution that may or may not contain nicotine. Many consumers call these cartridges "cartomizers," which is a portmanteau of cartridge and atomizer. Cartomizers are available in countless form factors and styles, but they almost all function on the same principle. This principle uses the power of electricity to vaporize liquid without combustion or its byproducts.

With that said I would like to offer an invitation to all of you to visit our facility where we can provide you with more information about our company and our technology. Thank you for your time.

Regards,
Joe Dralle

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QA-Testimony for WI Assembly Bill 762

Hello, my name is Julianne Endres. I am the Quality Assurance Manager at Johnson Creek Enterprises and I am in support of Assembly Bill 762.

I have been a member of the Johnson Creek Enterprises family since August 2013 and was introduced into the world of electronic cigarettes and vaping about the same time. In this relatively short period of time, I have witnessed and will give testimony to the benefits of vaping and JCE.

We are the largest manufacturer of smoke juice in the United States and because of this, it is our responsibility to set the standard in regulating our industry. Our most important core value is "Be Aware, Accurate and Honest". As the Quality Assurance Manager this value is rudimentary to the manufacturing of smoke juice, and we have excelled in this by:

- Being ISO 9001:2008 certified since 2012
- Following strict cGMP's
- Being OSHA Certified yearly
- Having 15 employees certified in First Aid, CPR & AED
- Implementing and maintaining our Hazard Analysis and Critical Control Point Program and our Quality Management System
- Having a Vendor Certification program
- Routinely auditing our vendors
- Batch testing by Gas Chromatography Mass Spectrometer Flame Ionization
- Random 3rd party verification testing of our batch testing

What these programs & initiatives bring to our company and our smoke juice is, in short, quality. Each of our vendors is certified by Johnson Creek Enterprises before we order from them through our vendor surveys, which goes to the extent of auditing our vendors at their manufacturing site. Our shipping and receiving program demands that each good received is not only in optimal quality, but each shipping truck, out going product, and internal inventory is maintained to the highest degree possible. Being ISO 9001:2008 certified brings extreme validation to the quality practices we perform, this standard validates that what we do at Johnson Creek Enterprises adheres to the International Standards Organization.

Not only does our company provide validated quality in smoke juice, it is an outstanding company to have in the State of Wisconsin. I am honored to be one of the few people who can say, without a doubt, I love my job. As my colleague, Susan, has described the amazing story of Christian Berkey and Johnson Creek Enterprises, I am a testimony to the dedication our

company brings out in their employees. I have chosen to express my support of the Assembly Bill 762 today and by doing so have pushed back my honeymoon by a day, to be able to do this.

It isn't just the respect and support I have for Johnson Creek Enterprises but also the respect and support I have for the e-cigarette industry that has caused me to speak today. A family friend of mine is a true American in every sense of the word. He is an amazing man who served his country for 8 year, 2 tours in Iraq, as a Marine Corporal, and continues to serve his country today by being a career firefighter in the State of New York. He used to smoke two packs a day for 10 years. For a Christmas gift, I gave him our e-cigarette and smoke juice to try. He is so delighted with an alternative to cigarette that he has switched to vaping and smoking just 3 cigarettes a day. I am proud to be able to provide him an alternative to the cigarette with the quality smoke juice that Johnson Creek Enterprises creates.

Thank you very much for your time today. Please let me express, that if anyone has questions regarding quality in e-cigarettes or Johnson Creek Enterprises, that I would be happy to answer them.

Julianne Endres
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Testimony for WI Assembly Bill 762

Good Afternoon and thank you for allowing all of us to present our opinions to you in regards to Assembly Bill 762

My name is Susan Geiger and I am the Director of Communications at Johnson Creek Enterprises, makers of America's Smoke Juice and electronic cigarettes. I, along with my two colleagues, Julianne Endres and Joe Dralle, are here to lend support for the passing of this important bill.

As a leader in this industry, we have a vested interest in its success. But it is bigger than just our interest. It's about one of America's most coveted values, the freedom to choose. We see using e-cigarettes as a choice for smokers of legal age and this bill helps ensure the freedom to use these devices in public places.

In 2008, our founder and CEO, Christian Berkey, was a heavy smoker, and working as a manager in an Apple store near Milwaukee. An avid fan of technology and by trade and personal choice, he was an early adopter of electronic devices. He found an ad on the Internet for something called an electronic cigarette. Intrigued, he ordered one. When it arrived from China, he marveled at the mechanics of it – but choked on the horrible, chemical tasting e-liquid inside. Mr. Berkey set out to build a better mousetrap. Many months and many recipes later, he came up with an e-liquid he liked. To test his theory, he asked people on an online e-cigarette forum if they'd like to try it and give him feedback. When the dozen or so volunteers he'd hoped for turned into 400 people, he quit his job, cashed in his 401K plan, created a website, and founded Johnson Creek Enterprises (named after the small town in which he lived). That was July 25, 2008. It was the beginning of the Great Recession.

Fast forward to 2013, a mere five years after its formation. Inc. Magazine named us as one of the fastest growing privately held companies in America. Specifically, # 9 in Wisconsin, #56 in consumer goods and #873 in America. Johnson Creek has joined the ranks of Intuit, Zappos, Under Armour, and Microsoft who all earned similar awards in past years. In 2013, we shared that honor with LivingSocial and Otterbox, among others.

In this same 5 year period, we went from the original 3 employees to the 60 we have today. In 2011, we moved our headquarters to a 42,500 square foot campus in Hartland and have expanded within that space three times. We hire the best candidates and offer 75% employer paid medical, dental, & vision insurance as well as 100% employer paid STD, LTD and term life insurance. All of these benefits (including spouse and dependent benefits at the same rates) are available after just 30 days + first of the month after hire.

What this means is that we are as passionate about our employees and about creating a new option for smokers of legal age. We work hard to provide this option and do so in a thoughtful and responsible manner. Johnson Creek cares about its customers, its employees and its community. Offering a new product like electronic cigarettes and e-liquid brings with it a responsibility to protect public health by providing smokers with the best product possible. We have been ISO 9001:2008 certified since 2012 and follow current Good Manufacturing Practices. Julianne will speak further about this in her testimony.

As pioneers in the industry, we were the first company to introduce shrink banding of our bottles, child-resistant caps, and the listing of all ingredients on our labels as well as nicotine warnings. These things are adopted by many companies now and it's thanks, in part, to the innovation and commitment to quality that we foster at Johnson Creek. We enjoy and respect the trust our customers give us and look forward to FDA regulation to help standardize benchmarks and best practices for the entire industry.

Johnson Creek is a strong and willing partner. By enacting this legislation into law, you are not only choosing to protect the livelihood of many people in our state, but more importantly, you are also choosing to protect the rights of adults to make new choices.

I would like to close by personally inviting you out to our offices in Hartland for a tour of our facility. Recently we produced and shot a video on what it means to be Made in America. You can find that video on our home page, smokejuice.com. Thank you in advance for your consideration.

Susan Geiger
Director of Communications
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Quick facts about Johnson Creek

Our facility:

- we occupy 42,500 SF and 51% of the building we rent
- we are ISO 9001:2008 certified
- we adhere to strict good manufacturing processes (GMP's)
- our lab is 4,200 SF

Our products:

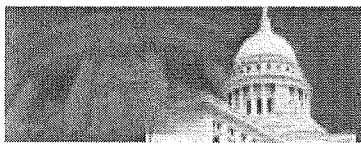
- we manufacture 27 unique flavors, in 4 different nicotine strengths, across 3 different product lines
- we manufacture 7 unique flavors, in 3 different nicotine strengths for bluCigs, the market leader in the e-cig industry. blu is owned by Lorillard Tobacco
- our bottled product comes packaged with a shrink band, child resistant cap, nicotine warning, ingredient listing

Our team:

- we've been in business for 5+ years
- we currently employ 55 full time employees, 1 part time employee and 3 temp-to-hire full time employees
- we offer 75% employer paid medical, dental & vision insurance to all employees after 30 days of hire + 1st of the month
- not only do we cover the employee at 75%, but we also cover their spouse and child(ren) at 75%
- we offer 100% employer paid STD, LTD and term life insurance to all employees after 30 days of hire + 1st of the month
- we hired 26 employees in 2013, almost doubling our head count
- we were named to Inc. Magazine's 5000/500 fastest growing, privately held companies in the US. #873 overall, #56 for consumer products and #9 in the state of WI
- we've already hired 4 full time employees and 3 temp-to-hire full time employees in 2014

Our revenue:

- 2010 $1.6M
- 2011 $2.7M
- 2012 $7.6M
- 2013 $8.5M



WISCONSIN STATE LEGISLATURE

Indoor Air 2013; 23: 25–31
wileyonlinelibrary.com/journal/ina

INDOOR AIR
doi:10.1111/j.1600-0668.2012.00792.x

Does e-cigarette consumption cause passive vaping?

Abstract Electronic cigarette consumption ('vaping') is marketed as an alternative to conventional tobacco smoking. Technically, a mixture of chemicals containing carrier liquids, flavors, and optionally nicotine is vaporized and inhaled. The present study aims at the determination of the release of volatile organic compounds (VOC) and (ultra)fine particles (FP/UFP) from an e-cigarette under near-to-real-use conditions in an 8-m^3 emission test chamber. Furthermore, the inhaled mixture is analyzed in small chambers. An increase in FP/UFP and VOC could be determined after the use of the e-cigarette. Prominent components in the gas-phase are 1,2-propanediol, 1,2,3-propanetriol, diacetin, flavorings, and traces of nicotine. As a consequence, 'passive vaping' must be expected from the consumption of e-cigarettes. Furthermore, the inhaled aerosol undergoes changes in the human lung that is assumed to be attributed to deposition and evaporation.

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Department Material Analysis and Indoor Chemistry, Fraunhofer Wilhelm-Klauditz-Institut (WKI), Braunschweig, Germany

Key words: Electronic cigarette; Indoor air quality; Formaldehyde; Ultrafine particles; Propylene glycol; Third-hand smoke.

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Practical Implications
The consumption of e-cigarettes marks a new source for chemical and aerosol exposure in the indoor environment. To evaluate the impact of e-cigarettes on indoor air quality and to estimate the possible effect of passive vaping, information about the chemical characteristics of the released vapor is needed.

Introduction

Electronic cigarettes show a rapidly growing market share and are advertised as a healthier alternative to conventional smoking. These 'e-cigarettes' contain a small battery-driven heating unit that vaporizes a mixture of chemicals, the so-called 'liquids'. They usually contain flavors and carrier substances and may be purchased with and without nicotine. The nicotine content roughly differs between 0 and 20 mg/ml depending on the brand (Trehy et al., 2011). A common carrier of the 'liquids' is 1,2-propanediol (propylene glycol, PG) that leads to a visible fume during exhalation. This compound is also frequently used as a solvent in dosage formulations of aerosolized drug delivery systems such as pressurized metered-dose inhalers and nebulizers for the clinical practice (Montharu et al., 2010). However, the frequency of use is expected to be higher in case of e-cigarette vaping, leading to a different exposure pattern. Propylene glycol is also a common humectant for tobacco cigarettes (Paschke et al., 2002). In contrast to conventional cigarettes, the released compounds are not generated from a combustion process (as a smoke) but by direct evaporation (as a vapor). For this reason, the term 'vaping' has been established among e-cigarette users as an analog to the conventional cigarette 'smoking' (Etter, 2010).

A recent study reports adverse physiological effects after the short-term use of e-cigarettes (Vardavas et al., 2011). This effect may be attributed to propylene glycol that is known to cause upper airway irritations (Wieslander et al., 2001). However, a comprehensive exposure assessment that compares the nicotine intake from e-cigarettes and conventional cigarettes – which also considers the impact of the carrier substances – is not available at the present state. Furthermore, the release of the organic compounds from the 'liquids' and

the release of particles into the indoor environment are still mostly unknown. In contrast, the impact of environmental tobacco smoke from conventional smoking on the indoor air quality has been intensively researched in the past decade. Numerous studies report the release of particulate matter (Nazaroff and Klepeis, 2003) and organic compounds such as formaldehyde, from the combustion of tobacco products (Baek and Jenkins, 2004; Baker, 2006; Paschke et al., 2002). These scientific findings led to a ban on smoking in public buildings and restaurants in many countries. This ban had a positive influence on the indoor air quality in these buildings (Bohac et al., 2010; Gleich et al., 2011).

Beyond indoor climate, airflow conditions, room size, and number of e-cigarette users, many other parameters have the potential to affect 'passive vaping'. The concentrations of the exhaled compounds during e-cigarette consumption can be expected to differ with the composition of the applied 'liquids', the type of e-cigarette in use, the age of the e-cigarette (e.g., owing to remains of previous 'liquids'), length of the puff, and interval between the puffs. Moreover, the composition of the exhaled air will be affected by age, sex, activity, health status, and diet of the user (Riess et al., 2010).

Another important aspect in the future discussion about e-cigarettes will be the effect of 'third-hand smoke' that mainly describes human exposure against residues of smoking on clothes, furniture, and other indoor surfaces (Matt et al., 2011). In case of e-cigarettes, the solvent of the 'liquids' may remain on available surfaces and be a source for the contamination of residents. Even more important might be the accidental spilling of 'liquids' that can lead to unintended uptake of nicotine by skin permeation – an effect that is intentionally used for nicotine patches (Hammer et al., 2011). It can be assumed that the health impact of e-cigarette use is mainly influenced by the safety and quality of the applied 'liquids'.

The present study provides first indications about the entry of volatile organic compounds (VOCs) and ultrafine particles into the indoor environment connected with the use of electronic cigarettes. One measurement was performed in a full-scale emission test chamber with one e-cigarette and different 'liquids'. Additional small-scale chamber measurements were performed to identify the effect of aerosol aging and the impact of different e-cigarette types. The experiments aim at the identification of the released compounds under near-to-real-use conditions to estimate the effect of 'passive vaping'.

Material and methods

Large-scale vaping/smoking experiment

The experiment was performed in an 8-m^3 stainless-steel emission test chamber. This chamber was operated at 23°C and 50% relative humidity at an air exchange rate of 0.3/h. The formaldehyde concentration in the chamber was continuously recorded every 30 s by an AL4021 formaldehyde auto analyzer (AeroLaser). A fast mobility particle sizer (FMPS; TSI Inc., Shoreview, MN, USA) recorded the particle number concentration of fine and ultrafine particles (FP/UFP) in the size range between 5.6 and 560 nm at 1 Hz in 32 channels.

Before the experiment and after each smoking event, 3 l of chamber air was pumped (200 ml/min) through stainless-steel tubes filled with 300 mg Tenax TA. The tubes were analyzed via thermal desorption (Ultra/Unity 2; Markes Int., Llantrisant, UK) and gas chromatography (6890 Series GC System; Agilent, Santa Clara, CA, USA; HP5MS 60 m × 250 μm × 0.3 μm column) coupled with mass spectrometry (5973N MSD; Agilent) according to ISO 16000-6. In parallel, lower aldehydes (formaldehyde, acetaldehyde, etc.) were collected using silica gel cartridges containing 2,4-dinitrophenylhydrazine (DNPH). The cartridges were analyzed according to ISO 16000-3 using high-performance liquid chromatography coupled with a variable wavelength detector (HPLC 1200 Infinity; Agilent).

A volunteering smoker took a seat in the chamber, and the chamber blank was measured after 20 min of conditioning. The e-cigarette was then filled with an apple-flavored nicotine-free 'liquid' (Liquid 1) outside of the chamber and given to the test person through a sampling port. The person took six deep-lung puffs (puff length ~ 3 s) with a delay of 60 s between each puff. The air sampling on Tenax TA tubes started at puff 4 and lasted 15 min. This procedure was performed for another two 'liquids', Liquid 2 and Liquid 3 (see Table 1).

After the e-cigarette was removed from the chamber, a conventional tobacco cigarette was lit outside the chamber and given to the test person. The sampling procedure was identical to the e-cigarette measurement.

For the determination of the feasible puff length, the mouthpiece and the wick (see Figure 1) were removed from the e-cigarette and the temperature of the heating coil was measured via thermography (ThermaCAM B20; FLIR Systems, Wilsonville, OR, USA) during

Table 1 Characteristics of the 'liquids'

Sample	Flavor	Main aroma compound	Nicotine content[a]
Liquid 1	Apple	3-Methylbutyl-3-methylbutanoate	0 mg/ml
Liquid 2	Apple	3-Methylbutyl-3-methylbutanoate	18 mg/ml
Liquid 3	Tobacco	Ethyl maltol	18 mg/ml
Conventional cigarette	–	–	0.8 mg/cigarette

[a]As stated by the manufacturer. [Correction added on 6 August 2012, after first online publication: Nicotine content for Liquid 2 and Liquid 3 changed from 1.8 mg/ml to 18 mg/ml.]

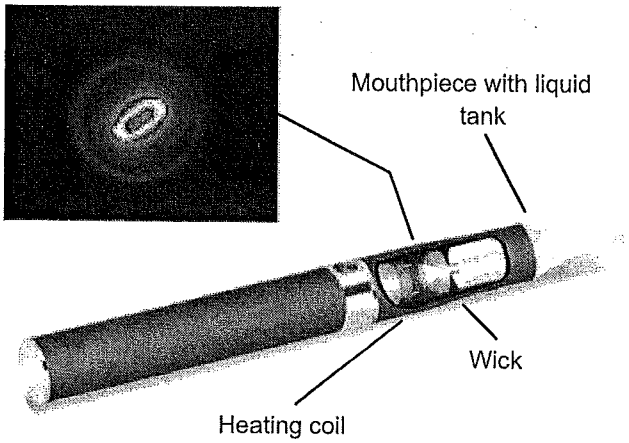

Fig. 1 Scheme of the tested e-cigarette A. The thermographic image shows the temperature distribution of the heating unit without 'liquid' (> 350°C in the center)

heat-up. The time-resolved analysis showed an interval of 3 s between start of the cigarette and reaching stable temperature conditions. The puff length was equally increased for e-cigarette and tobacco cigarette, even though the length of the puff was approximately 1 s longer than specified in ISO 3308 (2000). The puff interval (60 s) was selected according to ISO 3308. The number of puffs (10 in ISO 3308) had to be adapted to the new smoking conditions because the tobacco cigarette was depleted after six puffs.

Vapor analysis

An aerosol aging experiment was performed in a 10-l glass emission test chamber. The chamber is double walled and is temperature controlled by water. The air in the chamber is mixed by a small fan. The e-cigarette was connected to the inlet, and a pump was used to produce a slight underpressure that transfers the aerosol directly into the chamber. The e-cigarette was operated for 3 s. The aerosol was aged in the chamber for 1, 3, 5, 7, and 10 min at 37°C. Additionally, the aerosol was aged 5 min at 23, 37, and 50°C. Then, the FMPS (sample flow rate of 8 l/min) was connected to the chamber, and the chamber inlet was equipped with a HEPA filter.

Analysis of VOCs in exhaled breath

After measuring the VOC chamber blank, an e-cigarette consumer was asked to exhale one e-cigarette puff into the 10-l glass chamber. The VOCs within the chamber were then determined by GC/MS after sampling on Tenax TA tubes (6L, 150 ml/min).

Table 2 Characteristics of the tested e-cigarettes

Sample	Casing	Delivery system	Comparative price
e-Cigarette A	Stainless steel/rubber	Tank	High (>35 Euro)
e-Cigarette B	Stainless steel	Cotton	Medium
e-Cigarette C	Stainless steel	Tank	Low (<25 Euro)

Measurement with three different e-cigarettes

Three different types of e-cigarettes (see Table 2) were filled with 'liquid' from the same stock (Liquid 1). The cigarette was operated for 3 s. The vapor from the e-cigarettes was transferred into the 10-l glass chamber using a pump. The chamber was set to 37°C and an air exchange rate of 3/h. Directly after injection of the vapor, sampling on Tenax TA was performed for 60 min (100 ml/min) and sampling on DNPH was performed for 200 min (120 ml/min). Between each measurement, the chamber was heated to 60°C for 24 h at maximum air exchange rate (6/h). The measured concentration c_S ($\mu g/m^3$) is converted into the released mass per puff MPP (μg/puff) according to Equation 1 using the sample volume V_S (m^3), the number of puffs n (puff), and the ratio between sample flow $\dot{V}_S$ (m^3/h) and chamber exhaust flow $\dot{V}_C$ (m^3/h). Additionally, the value is corrected for the expected exponential decay of the concentration because of the air exchange rate k (/h).

$$\mathrm{MPP}=\frac{c_S}{n}\cdot V_S\cdot\frac{\dot{V}_C}{\dot{V}_S}\cdot\frac{\int_0^\infty e^{-k\cdot t}\,dt}{\int_0^t e^{-k\cdot t}\,dt}=\frac{c_S}{n}\cdot V_S\cdot\frac{\dot{V}_C}{\dot{V}_S}\cdot\frac{1}{1-e^{-k\cdot t}} \qquad (1)$$

Descriptions of the performed experiments as well as the measured climatic conditions during measurement are summarized in Table 3.

Results and discussion

Emission of volatile organic compounds

Electronic cigarettes use a completely different principle of operation compared to tobacco cigarettes. The 'liquid' is vaporized and because of the thermodynamic properties of 1,2-propanediol (K_p = 188°C, ΔH_v = 64.5 kJ/mol at 298.15 K) (Verevkin, 2004), the heat from the coil (see Figure 1) is led off, which avoids pyrolysis. In contrast, conventional cigarettes release numerous compounds into the indoor environment. Paschke et al. (2002) listed hundreds of ingredients in tobacco cigarettes that form volatile combustion products. In Table 4, the 20 compounds with the highest concentrations in the 8-m^3 chamber air are summarized. During operation of the e-cigarette, the carrier substance of the 'liquids', 1,2-propanediol, was detected in the chamber atmosphere but the concentration was below the limit of determination. In contrast, a high concentration of 1,2-propanediol was observed for smoking of the conventional cigarette. The compound is known to be pyro-

Table 3 Description of the performed experiments

Experiment	Chamber	T (°C)[a]	RH (%)[a]	e-Cig.	'Liquid'	Smoker	Analytics
Large-scale experiment	8-m³ stainless steel	24.1 ± 1.1	44.5 ± 8.2	A	1–3	Yes	Fast mobility particle sizer (FMPS), AeroLaser, Tenax, DNPH
Vapor analysis/aging	10-l glass	22.7 ± 0.1	36.9 ± 0.5	A	1	No	FMPS
		37.1 ± 0.2	18.9 ± 0.6				
		49.9 ± 0.1	11.0 ± 0.6				
Exhaled breath	10-l glass	37.0 ± 0.2	27.2 ± 4.3	A	1	Yes	Tenax
Three e-cigarettes	10-l glass	36.8 ± 0.2	20.2 ± 0.6	A	1	No	Tenax, DNPH
		37.1 ± 0.2	18.2 ± 0.6	B			
		37.1 ± 0.2	17.7 ± 0.6	C			

[a]These values provide the measured mean climatic conditions (measuring interval: 1 min) and the standard deviations during performing the experiments.

Table 4 Concentrations (μg/m³) of selected compounds during the 8-m³ emission test chamber measurement of e-cigarette A and conventional cigarette using Tenax TA and DNPH

			E-cigarette			Conventional cigarette
Compounds	CAS	Participant blank	Liquid 1	Liquid 2	Liquid 3	
1,2-Propanediol	57-55-6	<1	<1	<1	<1	112
1-Hydroxy-2-propanone	116-09-6	<1	<1	<1	<1	62
2,3-Butanedione	431-03-8	<1	<1	<1	<1	21
2,5-Dimethylfuran	625-86-5	<1	<1	<1	<1	5
2-Butanone (MEK)	78-93-3	<1	2	2	2	19
2-Furaldehyde	98-01-1	<1	<1	<1	<1	21
2-Methylfurane	534-22-5	<1	<1	<1	<1	19
3-Ethenyl-pyridine[a]	1121-55-7	<1	<1	<1	<1	24
Acetic acid	64-19-7	<1	11	13	14	68
Acetone	67-64-1	<1	17	18	25	64
Benzene	71-43-2	<1	<1	<1	<1	22
Isoprene	78-79-5	8	6	7	10	135
Limonene	5989-27-5	<1	<1	<1	<1	21
m,p-Xylene	1330-20-7	<1	<1	<1	<1	18
Phenol	108-95-2	<1	<1	<1	<1	15
Pyrrole	109-97-7	<1	<1	<1	<1	61
Toluene	108-88-3	<1	<1	<1	<1	44
Formaldehyde[b]	50-00-0	<1	8	11	16	86
Acetaldehyde[b]	75-07-0	<1	2	2	3	119
Propanal[b]	123-38-6	<0.2	<0.2	<0.2	<0.2	12

[a]Quantified on the basis of toluene response.
[b]DNPH method.

lyzed to acetaldehyde and acetone during smoking (Paschke, 2002).

Ohta et al. (2011) proposed the formation of formaldehyde, acetaldehyde, and methylglyoxal in the e-cigarette because of the oxidation of propylene glycol during contact with the active heating coil. However, continuous monitoring only showed a slight increase in the formaldehyde concentration in the 8-m³ emission test chamber before and during the consumption of the three 'liquids' (see Table 4 and Figure 2). This might be caused by the person in the chamber itself, because people are known to exhale formaldehyde in low amounts (Riess et al., 2010) and the increase was already observed during the conditioning phase (Figure 2). Furthermore, the release of formaldehyde was also below the limit of detection in the small-scale experiments. The expected rise of the formaldehyde concentration in the chamber from smoking a conventional cigarette with a peak value of 114 ppb is shown in Figure 2. Other indoor pollutants of special interest, such as benzene, were only detected during the tobacco smoking experiment. The rising concentrations of acetic acid and acetone during e-cigarette operation may also be attributed to the metabolism of the consumer.

Although 1,2-propanediol was detected in traces only in the 8-m³ chamber during the consumption of e-cigarettes, this compound must be released owing to the visible fume in the exhaled breath. To determine the VOC composition in the breath gas directly, an e-cigarette smoker exhaled into a 10-l glass chamber. The identified chemical species are shown in Figure 3. The experiment revealed a high amount of 1,2-propanediol in the exhaled air. Other main components were the

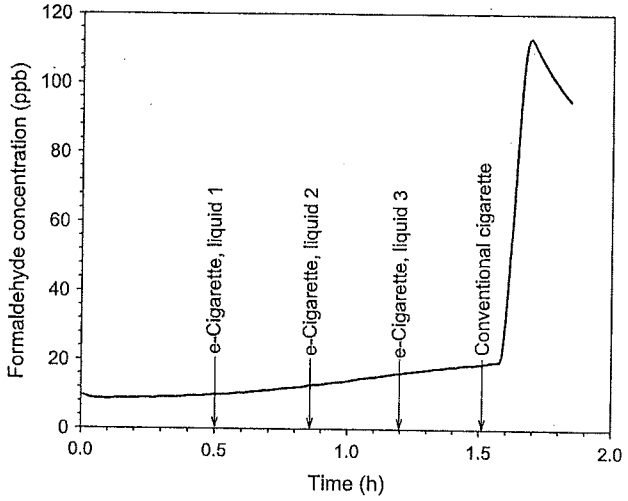

Fig. 2 Formaldehyde concentration in the 8-m^3 test chamber during consumption of e-cigarettes (Liquids 1–3) and one conventional cigarette

carrier substance 1,2,3-propanetriol, the flavoring source diacetin as well as traces of apple oil (3-methylbutyl-3-methylbutanoate) and nicotine. The fact that these compounds were not detectable during the 8-m^3 emission test chamber measurement is assumed to be caused by the short usage (6 min per 'liquid') and sink effects of the chamber for the very polar 1,2-propanediol.

Regarding the variability of e-cigarettes, the VOC emission strength seems to differ with different types of e-cigarettes (Table 5). While the e-cigarettes A and C have similar emission patterns, the emission from e-cigarette B is significantly higher. Formaldehyde was not detected during any measurement. With e-cigarette C, almost three times more propylene glycol is released per puff. This deviation is assumed to be caused by the 'liquid' supply technique. In case of e-cigarettes A and C, the 'liquid' is stored in a tank, while e-cigarette B features a cotton unit that is drenched with the 'liquid'. However, a general correlation between emission strength and 'liquid' supply technique (tank or cotton) is not possible from this limited data set. The effect of other systems, such as underpressure-activated e-cigarettes, was not determined in this study and is an important topic for further research.

Aerosol release from the e-cigarette

The airborne particles being related to the e-cigarette experiment are assumed to be formed from supersaturated 1,2-propanediol vapor. In contrast to the conventional cigarette, which continuously emits particles from the combustion process itself, the e-cigarette aerosol is solely released during exhalation. The e-cigarette aerosol measured in the 8-m^3 chamber is bimodal: one maximum is found in the range of 30 nm and one in the range of 100 nm (see Figure 4a). During the ongoing experiment, the ultrafine particle mode increased. The particles in the higher mode are assumed to be evaporated or deposited in the human lung. Because of the high vapor pressure of 1,2-propanediol (p_s = 17.36 Pa at 298.15 K) (Verevkin, 2004), the dynamics of the aerosol is expected to be fast. For comparison, the particle size distribution of the conventional cigarette provides a single mode with a maximum at 100 nm and a higher total number concentration (see Figure 4b).

For characterization of the e-cigarette aerosol, it was passed directly from the mouthpiece into a 10-l glass emission test chamber. Then, it was aged for 5 min at 23, 37, and 50°C, respectively. From Figure 5a, it is obvious

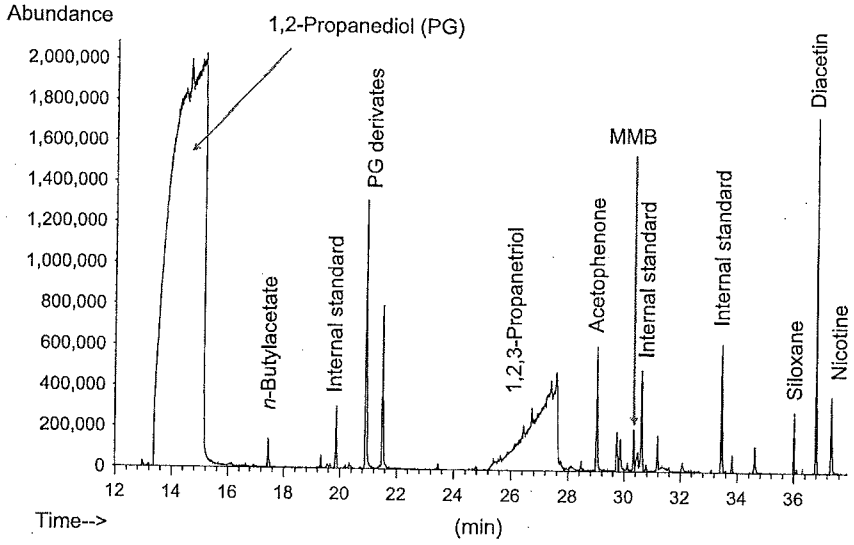

Fig. 3 Gas chromatogram of one exhaled e-cigarette puff (Liquid 2) in a 10-l glass chamber (sampled on Tenax TA, 3 l sampling volume) (MMB = 3-methylbutyl-3-methylbutanoate; PG = propylene glycol)

Table 5 Comparison of the release of volatile organic compound for a number of selected compounds from three types of e-cigarettes A-C (one puff, 3 s) in a 10-l glass chamber using Tenax TA and DNPH

Compound	Concentration ($\mu g/m^3$)			Estimated mass per puff (μg/puff)[a]		
	A	B	C	A	B	C
1,2-Propanediol	53 000	175 000	64 000	1673	5525	2021
1,2,3-Propanetriol	326	477	161	10	15	5
3-Methylbutyl-3-methylbutanoate	3	35	10	0.1	1.1	0.3
Diacetin	2	1	1	0.06	0.03	0.03
Triacetin	<1	<1	<1	<0.03	<0.03	<0.03
Nicotine	7	7	4	0.2	0.2	0.1
Formaldehyde[b]	<2	<2	<2	<0.25	<0.25	<0.25
Acetaldehyde[b]	<1	<1	<1	<0.13	<0.13	<0.13
Propanal[b]	<1	<1	<1	<0.13	<0.13	<0.13

[a]The conversion factors based on the sample volume, the sample flow, and the exponential decay of the concentration (see Equation 1).
[b]DNPH method.

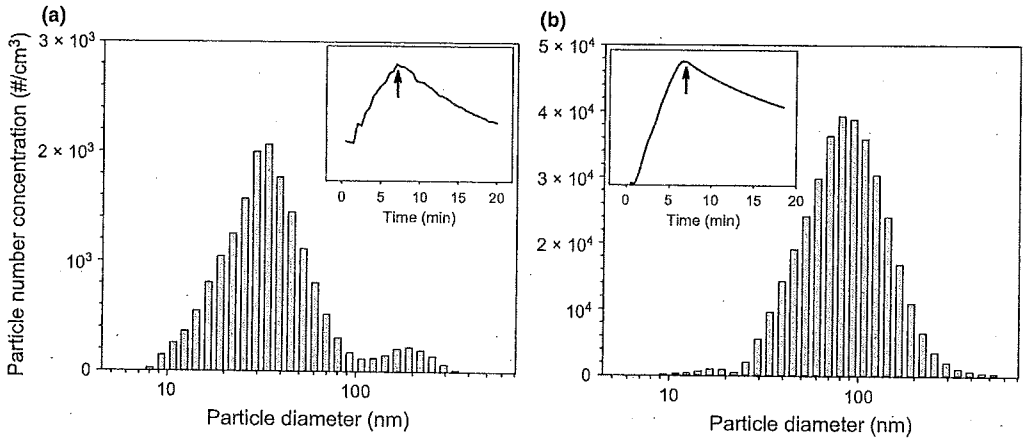

Fig. 4 (a) Aerosol size distribution during consumption of an e-cigarette in the 8-m^3 chamber. (b) Aerosol size distribution during consumption of a conventional cigarette in the 8-m^3 chamber. The arrows in the insets of (a) and (b) indicate the actual time in concentration development

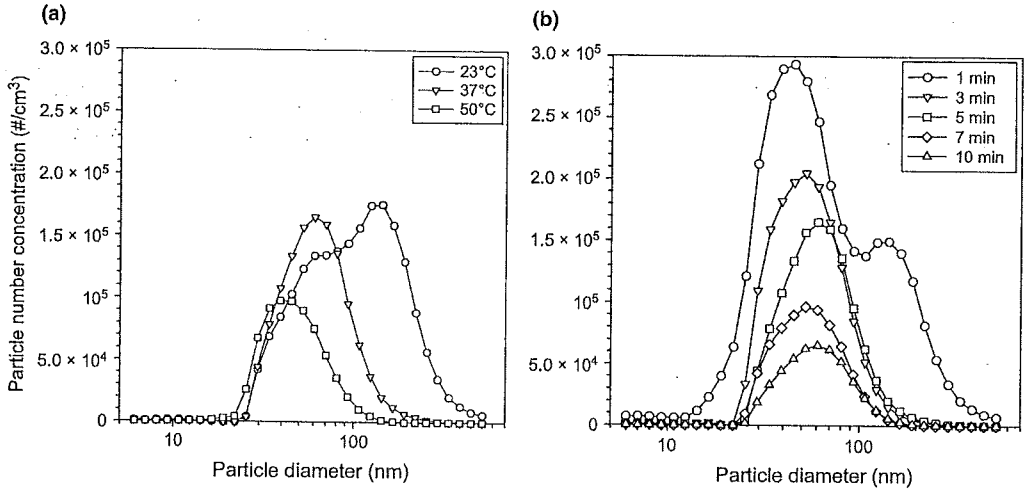

Fig. 5 Aerosol size distributions of aged e-cigarette aerosols in a 10-l glass chamber. The aerosol was aged for 5 min at different temperatures (a) and for different times at 37°C (b)

that because of increasing temperature, the aerosol shifts from a bimodal size distribution with maxima at 60 and 100 nm into a single-mode distribution with a maximum at 45 nm. Figure 5b demonstrates the effect of aging at 37°C. Between 1 and 3 min, the higher mode at 100 nm disappeared and a single-mode aerosol with a maximum

at 45 nm is left. This 'shrinking' of the particles can be attributed to the evaporation of the particles under ideal conditions. However, in the real indoor environment, the present airborne particles might affect aging, for example, owing to coagulation. The inlet air of the large-chamber experiment was free of particles, and thus, the experimental results in both chambers are conclusive. In total, these findings prove that the influence of the e-cigarette on the indoor air particle concentration cannot be determined solely from direct aerosol sampling at the source. The dynamics and changes of the aerosol size distribution resulting from the dwell time in the human lung must be considered.

Conclusions

The consumption of e-cigarettes causes emissions of aerosols and VOCs, such as 1,2-propanediol, flavoring substances, and nicotine, into indoor air. During inhalation of e-cigarette vapor, the aerosol size distribution alters in the human lung and leads to an exhalation of smaller particles. This effect is caused by the evaporation of the liquid particles in the lung and also in the environment after exhalation. The quantity of the inhaled vapor could be observed to depend on the 'liquid' delivery system of the e-cigarette in use.

Overall, the e-cigarette is a new source of VOCs and ultrafine/fine particles in the indoor environment. Therefore, the question of 'passive vaping' can be answered in the affirmative. However, with regard to a health-related evaluation of e-cigarette consumption, the impact of vapor inhalation into the human lung should be of primary concern.

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