The Surprising Science Behind Indoor Chemistry

With Dr. Charles Weschler

SPEAKERS
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DW
Dr Weschler
00:00
So many products have been introduced that did not exist when our parents were alive, or our grandparents or great grandparents, and those products emit a suite of chemicals, many of which hadn't even been synthesized in the 1930s or 1940s and they all contribute to this mix of chemicals in our indoor air.

KS
Kendra Seymour
00:28
Welcome to Your Indoor Air Podcast brought to you by Change the Air Foundation. My name is Kendra Seymour, and today we're diving into a surprising science of indoor chemistry. Now understanding indoor chemistry is a key part, if you ask me, to understanding the air in our homes and buildings. When you think about it really, we bring all sorts of things into our homes, people, pets, and furniture and paints and perfumes and cleaning products, and we have gas stoves. There's just so many things. And then we combine that with building related problems, like mold and water damage and radon and VOCs and things like that. And when all these elements mix together, it can create an interesting mix of chemicals, particulates, many of which can become airborne. So our indoor air can begin to feel, if you ask me, a little bit like an indoor giant chemistry experiment. And I think it's an experiment we need to be paying attention to, because, as you'll learn from my guest today, many of the chemicals presently found in our homes and buildings, as well as in the blood and urine of the people who live and work in them, weren't present 50 years ago. So the impact of what this has on our health and what it means for healthy indoor spaces is still not fully understood, although, as you'll learn, my guest today is digging into that and helping all of us breathe safer indoor air. So I want to welcome Dr. Charles Weschler today to the podcast. Not only is he incredibly knowledgeable, but I have heard him speak many times before. He has a real gift of explaining complex science in a way that is, I think, very relatable and is easy to understand. So thank you so much for being here, and welcome to the podcast.

DW

Dr Weschler
02:04
My pleasure to be here, Kendra.

KS

Kendra Seymour
02:06
Yeah, and for those who don't know Dr. Weschler, yet, after completing his PhD in chemistry at the University of Chicago, he did his postdoctoral studies with Professor Fred Basolo at Northwestern University. In 1975 he joined Bell Laboratories as a research scientist in physical chemistry division. He conducted research at Bell Labs and its successor institutions until 2001 being named a distinguished member of the technical staff. In 2001 he transitioned from Bell Comm to faculty positions at Environmental and Occupational Health Science at Rutgers University and the International Center for Indoor Environment and Energy Technical University of Denmark. He's continued in those positions through the present and in 2010 he joined the faculty at the Building Science Department of Tsinghua University as an ongoing visiting professor. He is also an adjunct professor at Rutgers School of Public Health. He has been a member of four committees of the National Academy of Sciences, and from 1999 through 2005 he served as the US EPA Science Advisory Board. More recently, he was an advisor for the Sloan Foundation's chemistry of indoor environments program. And he was elected to the International Academy of Indoor Air Sciences in 1999 and received the Pettenkofer Award, its highest honor in 2014. He has been conferred in the 2017 Haagen-Smith prize for atmospheric environment Distinguished Visiting Professor, and received an honorary doctorate from the Technical University of Denmark. He was elected a Fellow of the American Association of Advancement of Science, and he has an H index of 80 with over 20,000 citations on Web of Science, and 91 with over 20,000 citations on Google Scholar. So you are a very busy man. I'm so excited and so appreciative that you took the time out of your schedule. I know you've been traveling, but I think our listeners, homeowners and renters, who care a whole lot about indoor air quality are going to just love what you have to say. So before I jump in, I do have to take a moment and say thank you to two of our corporate sponsors, Home Safe Mold Inspectors of NWA, and to Dr. Jill Crista. We are a nonprofit. We are a 501(c)(3). That means we rely on the generosity of our donors, of our sponsors and people just like you, if you're listening to this podcast, and we couldn't do the work without them. Our free resources, our policy reform, and even the small scale research we fund. So huge thank you to those sponsors, and if you want to learn more, head on over to ChangeTheAirFoundation.org, and check out our corporate sponsors tab. All right, Dr. Weschler, let's jump in. So to start us off, you know, you have talked a lot about this term called indoor chemistry. So, I was wondering if you can kind of unpack that for listeners, so we're kind of all on the same page, because I think it's super fascinating. And then for those who may be unfamiliar, can you talk about what VOCs are, SVOCs, that sort of thing, just so that we're all on the same page.

DW

Dr Weschler
05:06
Okay, I'll attempt to cover that Kendra, and I'll try not to use up our time on that one question. When I speak of indoor chemistry, I'm speaking of the chemicals that are present in our indoor environment. And I've been interested in what those chemicals are and where they come from, and how they interact with one another, to give us other chemicals. Chemicals that were not necessarily there by design, and ultimately, how these chemicals can get into us. Whether that's inhalation of air or ingestion of dust or through our skin. So that's what I'm describing when I talk about indoor chemistry. You asked about VOCs and SVOCs. VOCs stands for volatile organic compounds. There's a number of different definitions of VOCs, but I think the simplest way to think of that term is these are chemicals that are present primarily in the air. Their tendency to sorb to dust or to sorb to surfaces, is relatively small. SVOCs, semi-volatile organic compounds, in contrast to VOCs, SVOCs tend to be present both in the air and on surfaces, sorb to indoor dust. So that's the, I think that's the simplest distinction to make. VOCs primarily in the air. SVOCs both in the air and on surfaces, including sorb to indoor dust.

KS
Kendra Seymour
06:53
Yeah, and that's really helpful, because there's so many things that we bring into our environment that we don't think about. Our paint, the flooring, the adhesives, or the cleaning chemicals. And we'll get into cleaning a little bit, because it always bugs me that people think, and I remember growing up that clean had a smell. It was that lemony, fresh scent of whatever came in the bottle that my mom picked up in the store and really, clean shouldn't have an odor, but I don't want to, we will jump the gun, and I don't want to do that. So it really is important for people to realize that there are lots of things in our air that we can't see or necessarily even smell that may be impacting our health. So we'll talk about some of those, maybe in the broader context in just a moment. But I think one of the things when I first reached out to you that I asked you about, it was based on a paper that you put out, and we're going to link to it in the show notes, because you talk about how there are things in our indoor air today that our grandparents did not have to worry about. So can you talk to us about through all your research and studies, what are some of the surprising sources of chemical exposures in our homes today, and what's happening in our indoor air when all those chemicals kind of interact with each other.

DW
Dr Weschler
08:02
Okay, I'll back up a moment on that. The era immediately after World War Two, really impacted the mix of chemicals in indoor environments. That was largely due to synthetic compounds, chemicals, polymers that became common in our everyday life after World War Two. Plastics are a good example, if you look at the explosion of plastics. That really began in that period from 1945

to 1950. The film The Graduate Dustin Hoffman. Now, when we talk about The Graduate that was around 1969, I forget the exact date, but there's a scene in there where someone advises Dustin Hoffman on the career he should pursue, and the advice is plastics, and plastics had just become such an important part of commercial life and our daily life at that point. Well, plastics have many advantages, but plastics, also, depending on the Polymer, have to be treated with chemicals. And we'll refer to these chemicals as additives. So let's talk about a really common plastic, PVC, polyvinyl chloride. If you do not plasticize PVC, if you don't add something to make it flexible, it's hard as a rock. So if you're talking about PVC pipe used for plumbing. You can pound a nail with PVC pipe, right? But you also have PVC shower curtains. Those PVC shower curtains are incredibly flexible. That's because chemicals have been added that help the polymer strain slide against one another to give you that flexibility. The most common plasticizer for PVC have been phthalate esters, and phthalate esters have just the right properties to give you flexibility in that particular polymer. Unfortunately, these plasticizers are not chemically hooked to the polymer. They're simply added, and they can easily migrate out of the polymer and become part of our indoor environment by themselves. If they're volatile enough, and some of them are, they'll be part of the air we breathe. If they're semi volatile, they'll also be attached to dust that we might ingest. I don't want to get ahead of myself, on the plasticizers, but that's just one example of an additive. Polymers also are treated with flame retardants sometimes, and that's another class of chemicals, again, not not chemically attached to the polymer. They can migrate out of the polymer and become part of the air we breathe. Chemicals that will protect the polymer from your UV degradation. Those are added. Scents are sometimes added, as you alluded to. So just going back to these changes that have occurred, let's say since the 1950s. You look at something like carpets or rugs, large surface area can be an important source of indoor chemicals. Prior to World War Two, most carpets were cotton or wool. After World War Two, we saw the introduction of nylon carpets, rayon carpets, other synthetic blends. Carpet industry has just changed so much in that period from before World War Two to after World War Two. So Speaking more broadly, that's just one example, but there so many products have been introduced that are that did not exist when our parents were alive, or our grandparents or great grandparents, and those products emit a suite of chemicals, many of which hadn't even been synthesized in the 1930s or 1940s and they all contribute to this mix of chemicals in our indoor air.

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Kendra Seymour

12:35

Yeah, so, I mean, I think it's really, it's kind of a wild thought when you realize that the materials in your home, what you bring into your home, that what's in them doesn't stay locked in, the material always. And I think that is something as I've gotten into this space over the last few years, thinking about my couch or my mattress or my carpet, especially once I had kids, I became a little bit more like, oh, maybe I should be paying a little closer attention to these things and understanding that it is going to potentially impact human health. And so I think about babies crawling on the floor, or young kids, they have those hand to mouth behaviors. Or if you're

someone who likes to, you know, eat dinner on the couch, or have a bowl of popcorn and you're sitting there watching TV, unwinding after a day. That you're you're contributing to some of that just not just inhalation, but ingestion. Are you comfortable, I know you're not like a medical practitioner, can you speak to a little bit about what we know about when some of those chemicals enter our bodies? Does it impact human health? Is there anything to suggest that this is harmful? Am I overreacting? Help us understand that just a little bit.

DW

Dr Weschler

13:50

There's just so many different chemicals in our indoor environment, and fortunately, most of them are not very harmful at the concentrations that they occur indoors. Of course, there's the classic expression, the dose makes the poison. And if the concentration gets high enough, many of the compounds present indoors are harmful, but at the concentrations they're typically present indoors, most are not. Unfortunately, a subset of them are harmful. A subset of them cause problems at the concentrations that occur indoors, or that can occur indoors. You're certainly familiar with indoor environments that have offensive odors, and there's indoor environments that are irritating, they might cause your eyes, irritation in your eyes or other mucous membrane areas if you're in them long enough, and that reflects specific chemicals that are responsible for that irritation, or specific chemicals that have exceeded their odor threshold, and we might find obnoxious. And then there's our, there are chemicals where the health effects are of even greater concern. I mentioned the phthalate esters. Several of those phthalate esters resemble human hormones, and they're referred to as endocrine disruptors. They are, they can mimic the action of a human hormone. And this scares me. You say correctly, I'm not health professional, I'm a chemist. But hormones are remarkable as a chemical. In terms of their ability just a very small amount of that hormone to signal something to our body that causes dramatic changes and so if you ingest or inhale or dermally sore with phthalate esters that mimics a particular hormone, there's the potential for the body to respond to that chemical as if it's a hormone made endogenously. Made within the body that has a specific purpose, and scary things can happen in that case. So, yes, there are chemicals present in our indoor environment whose potential adverse health effects do worry me.

KS

Kendra Seymour

16:30

Yeah, and for those listening, we have another interview with Lara Adler. We talk a lot in that one about flame retardants and formaldehyde, and we dig into some of the research on finding that in the blood and urine and tissue of people in crazy high amounts, in some cases. So it is something we want to be cognizant of. So we can take steps to maybe reduce our exposure until we fully understand some of the impacts that this is having on human health. Now, the first time I heard about you, Dr. Weschler, I didn't tell you this was, I think it was through Dr Joan Bennett. She had

talked about, she said, I have this friend, and he did this great research study in Denmark. And it was, he was looking into dermal absorption. So when we say dermal, we mean like absorption through the skin. Are some of these chemicals in the air, are we absorbing them just through our skin alone? So can you talk a little bit about dermal absorption and what that might look like?

DW
Dr Weschler
17:32
Happily, and we'll use phthalates again as an example. Those experiments we conducted at the Technical University of Denmark, they have a wonderful set of chambers there, and in these chambers we can simulate different indoor environments. So we took advantage of one of those chambers and set it up as if it were a typical indoor room. And we deliberately added two phthalates esters to the concentration of the air in that chamber, and the resulting concentrations in the air were high, but not higher than the existing health standards. And we were our own volunteers in these experiments.

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Kendra Seymour
18:22
So you were the guinea pig you're saying.

DW
Dr Weschler
18:24
We were, we were the guinea pigs, and you alluded to the fact that we can find out about chemicals in us by sampling our blood or collecting urine. Well, in the case of these two phthalate esters, if you take a urine sample, it lets you know whether you've been exposed to these two phthalates esters. Whether you've, somehow they've gotten into your body. Whether it's through inhalation or dermal absorption or ingestion. So these two phthalate esters, it's very easy to measure them in urine, and the amount you measure in urine can be from that you can back calculate how much you were exposed to, how much you inhaled or dermally absorbed. We had, we were in that chamber for five hours, and we were in that chamber under two sets of conditions, and we repeated these experiments, but in one set of conditions, we looked like, oh, an astronaut from a 1950s movie. We wore these helmets, and the helmets gave us clean air to breathe, and we were there in shorts, but, otherwise not, not fully clothed. And we collected our urine immediately afterwards, actually for the next five days, because it takes about five days to fully clear, and we had another condition where we were in the chamber without wearing the helmet. So in that first condition, when we're wearing the helmet. Almost the only source for these phthalate esters is air through skin to blood. In the second condition where we're not wearing the helmet, there's two ways the chemicals can get into us dermally, air through skin to blood, or inhalation. And when we looked at what was in our urine in those two different

situations, the amount of these, the metabolites of these phthalates in our urine, was roughly one half when we were dermally exposed, one half of what we were found, what we found when we both inhaled and were dermally exposed. I'll say that another way that's a little clearer. We were, those phthalate esters, were entering our body roughly in equal amounts, directly from air through skin versus via inhalation. So this really, well it confirms something that we suspected. I want to be clear to your listeners, only a subset of chemicals have the right chemical properties to go through our skin quickly. These two particular phthalate esters, diethyl phthalate and dibutyl phthalate have just the right kind of properties to go through the barrier that our skin presents and get into our blood relatively quickly. There's a lot of chemicals that can't do that, but those two can, and it's important to be aware of the fact that our body is, in effect, breathing these chemicals through its skin. So for certain chemicals, dermal absorption directly from air, occurs, and it's important to be aware of it.

KS

Kendra Seymour

20:23

Yeah, that's really fascinating. I mean, the takeaway here isn't to scare people, but to bring a level of awareness that it's not just what we inhale, it's not just what we ingest. It can also be what rubs against their skin or we touch. Because I am all about the actionable steps. So if you're listening and we're starting to, you know, make you a little nervous here we're going to talk about some ways that we can reduce some of these things, and if you're interested in more the specifics. For those listening, we've had several interviews with Andy Pace about building materials and VOCs and talking about those and making healthier swaps Lara Adler and more. We'll link to a bunch of those in the show notes, because we don't want to leave you hanging, But I appreciate you talking about this and just to really like, not with the desire to scare people, but just with the intent to understand and raise awareness so that we can take steps to remedy that. So let's talk about a little bit about cleaning our homes, because that is a really common intervention. I talk with people about. About reducing dust, you know, removing particulates and things that settle with effective cleaning practices. But sometimes, and I was definitely guilty about this once upon a time, and definitely growing up, sorry, mom, but we add products that might make the situation worse. I know you've written and talked before about, you know, things like people using chlorine bleach or vinegar or hypochlorous acid. So can you talk to us a little bit about a typical cleaning regimen, and if there are safer alternatives that still get the job done?

DW

Dr Weschler

23:40

Okay, something that we've learned over, really, the past decade, remarkably recently, is how valuable cleaning can be for reducing our exposure to chemicals indoors. We've learned that indoor surfaces are much larger reservoirs for chemicals than we thought they were historically. Let's go back to that term volatile organic compounds. The term implies these chemicals are

present primarily in air, but what we've learned over the past decade is that chemicals that are certainly volatile outdoors, indoors with a very large amount of surface area, a very large surface to volume ratio, and given the nature of some of these surfaces, like paint films or gypsum board, these indoor surfaces can hold a huge amount of a particular chemical, even these so called volatile chemicals. We've learned that in these test houses, you can open the windows and you can ventilate the test house and bring the concentration of some of these VOCs down to just about zero, and then you close the windows and you watch the concentrations of these VOCs go back to where they were. And you can do that repeatedly. And that's happening because these indoor reservoirs are so very large. Now, one of the things you can do to reduce the chemicals in your indoor reservoir is to clean to get rid of that surface dust as much as possible. To wipe down the surfaces, to remove some of those chemicals that are sorbed to the surface. But then how do you do that in such a way that you don't introduce more chemicals to your environment. I think you want to keep the cleaning as simple as possible and still be able to clean. So you basically adjust your cleaning approach to what you're trying to remove. Vacuuming is relatively simple, but you want to make sure you use a vacuum that isn't going to put the stuff you're taking off of surfaces back into the air, all right. So you want to use a vacuum with a good filter.

KS

Kendra Seymour

26:13

Yeah, like a sealed system with a HEPA filter, because I've seen, we've talked about this before with some interviews with John Banta that we'll link to. Where they'll do like smoke tests, and you'll just see the vacuum leaking out air from all the crevices where it comes together. And it almost feels like you're defeating the purpose.

DW

Dr Weschler

26:31

Precisely, yeah.

KS

Kendra Seymour

26:32

So you want to make sure it's a sealed vacuum. Yeah.

DW

Dr Weschler

26:34

Sadly, some of the old vacuum cleaners were just redistributing the dust and putting it back into the air for a while.

KS

Kendra Seymour
26:41
And I will say, though, that there are some very expensive vacuums out there that are not really sealed symptoms or sealed systems, excuse me. So more expensive doesn't mean better, you know. So do your homework, do your research, you know and I always recommend to, I don't know if you agree with this, that you get the vacuum with the bag. I know that's not as cool anymore. The canister where you can see all the dust, you're like, oh, it looks so cool. I get it. But then you have to take that outside, and you're banging it against your trash bag, and you're, you know, risk reaerosolizing some of that stuff. So I always prefer a bag, even though it looks less cool than the bagless. But maybe that's

DW
Dr Weschler
27:18
And I'll just, just as you said, the more expensive vacuum isn't necessarily the best. You can buy a remarkably good vacuum cleaner, effective vacuum cleaner, without spending an arm and a leg. So, yeah, do your research and buy an effective vacuum cleaner.

KS
Kendra Seymour
27:39
What about the cleaning solution?

DW
Dr Weschler
27:41
So, back to cleaning. When some type of solvent is required, if you can get away with hot water, just hot water and a rag for a surface, then don't use more. If you don't, if it's something that soluble with hot water, you don't need to add something that cuts grease. If it's greasy, and you can attack it with soap and water. Use soap and water. This escalates, okay, and some cleaning jobs do require stronger solvents. And if it requires a stronger solvent, make sure you do that cleaning job when you can ventilate, when you can as much as possible remove the chemicals that have been emitted to the air via ventilation. So maybe you're using a window cleaner with 2-Butoxyethanol. 2-Butoxyethanol is fairly volatile. It's also irritating, as maybe you experienced, and you don't want to wind up with high concentrations of 2-Butoxyethanol in your indoor air. Use it when you can have, when the outdoor conditions allow for open windows and good ventilation, and you see what I'm driving at. During the pandemic, bleach use increased. Bleach, hypochlorous acid is an active ingredient in bleach. It's a powerful oxygen and it's also a chemical that exists in the gas phase as well as in that aqueous solution. So when you use bleach, hypochlorous acid goes into the air and it winds up bouncing into other indoor surfaces, if you will. You're oxidizing not just the surface where you've applied the bleach. You're oxidizing other

indoor surfaces when you use bleach indoors. One surface you don't want to oxidize is your respiratory tract, right? Really important to ventilate if you're using bleach indoors, and to the extent that you can protect your respiratory tract, you want to do that. There's a lot of downside chemistry to using bleach. And if you can avoid using bleach, I think it's a good idea.

KS

Kendra Seymour
30:23
Yeah, And when it comes to mold remediation, folks, you don't need it at all. We won't even get into that here. We talk about that a lot on all of our resources in our mini class. I know grandma probably said, just put a little bleach on that mold. We don't do that. We don't recommend that for a variety of reasons, but even for your standard cleaning, really, it sounds like simple is effective in most cases, a non toxic, maybe unscented dish soap and a quart of water. And

DW

Dr Weschler
30:59
Yes, and you just said a magic word there that I omitted, unscented. And sadly, it's become more difficult, I think, to buy unscented cleaning products, and we have to go out of our way sometimes to purchase an unscented cleaning product, but the scents are not helping you with the cleaning. Now, I should modify what I said right there. Something like some of these scents have solvent properties. Old fashioned pine oil is an example. Why does, I won't use a commercial name, but pine oil is relatively cheap. You can get it by distilling pine stumps. It's very good at cutting grease. It also has a pleasant scent. Smells like pine trees. Okay, so there's some there's a product that has a pleasant scent and has good cleaning products as well, but you probably don't want to add the chemicals that constitute pine oil to your indoor environment.

KS

Kendra Seymour
32:10
Yeah, I mean, and we're in those enclosed spaces for a long time, and even if you don't have, you know, chemical sensitivity, those odors can be, you know, maybe initially you're like, oh, it smells nice. I feel like I did something in my bathroom, but I think it's probably more psychological than it than anything. Some of these odors and scents, unless you live on the ocean, your home shouldn't smell like an ocean breeze. So there's something to think about. Now, one of the other things I've heard you talk a lot about is ozone. Now people may have heard about ozone. Maybe think about it outside. But we can talk about it in the context of our homes. So can you help us understand where it's coming from in our homes, why it might be a concern, and I know you've even said before that ozone can interact with the oils in our skin. So what does that mean for our health? Let's let's unpack ozone for a bit.

DW

Dr Weschler
32:56
Okay, so in most indoor settings, the ozone has come from outdoors. It enters with the ventilation air, or the air that infiltrates. In some cases, we have indoor sources of ozone. Anytime you make a spark, anytime you have a corona discharge, you're going to create some ozone. Something like a photocopier. That process involves a corona discharge, it makes ozone, but good photocopiers have filters that remove the ozone. So a photocopier, if it's a good photocopier, if the filter is working, it should not be a significant source of ozone. There are companies that sell ozone generators, and I'm sure you're familiar with ozone generators that have been used in remediation situations. Sometimes, when they are used for remediation, the advice is to do it in an unoccupied environment, the device isn't always followed. But regardless, to be present indoors with a device that's deliberately generating and emitting ozone to indoor air, not a good idea. We know that ozone per se has health effects. It's not good for the respiratory tract. Ozone also is an important indoor oxidant. It will take chemicals that are relatively benign and oxidize them to chemicals that are potentially harmful. A simple product of ozone chemistry is formaldehyde. You can start with a chemical that is, as I said, just, not a concern to health, and via oxidation, generate formaldehyde and if those formaldehyde concentrations get high enough, they will be a concern to health. Oxidation also produces what are called second organic aerosols, ozone initiated oxidation. Secondary organic aerosols is a mouthful for basically particles, and you can do a cute little experiment if you have a way to generate ozone. You can simply take something like an orange peel, and put that orange peel in a glass and hit it with a little ozone, and you'll actually watch this kind of smog develop in the glass. Those are particles that result from ozone oxidizing the terpenes in the orange peel, primarily limonene, giving you these secondary organic aerosols, giving you these particles. And these particles are quite small to begin with, over time, they grow into larger particles, but many of the particles produced by the ozone chemistry are in the right size range to be deeply inhaled to make it all the way to the alveoli in our lungs. And we become concerned when we have particles reaching the alveoli in our lungs. So when indoor ozone chemistry occurs, you can create a number of oxidized compounds, volatile and semi volatile, including particles that become part chemicals that become a part of particles, and it's just not a good idea. It's not a good outcome.

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Kendra Seymour
36:29
So I'm really glad you went there, because I was going to go there next. So this is a great segue. So often people in this community, homeowners and runners, and I remember being there. I remember being on the other end of the sales pitch. There's so many air purifiers, there's so many UV lights for your HVAC system. There's all these machines that when people find out that you care about indoor air quality, or maybe you had a mold situation, or you're currently in a mold, they're like, buy this unit, buy this machine, buy this device. It's going to, you know, sanitize. It's going to clean the air. And whether it's ozone or hydroxyl radicals or ions, you know, and they'll

say things like, oh, some of these things, they're like a waterfall. They come from nature. They're safe. But I really love that you're talking about some of these chemicals on their own. But then that like law of unintended consequences, right? I do this thing thinking I'm doing a good thing, and then I inadvertently create a situation where I make more of something else that's bad. So can without I know it could be like five episodes talking about some of these air purifiers and the technology, but because it's such an important, I don't want to say obstacle. It is something that many people encounter as part of their journey, and I tend to caution against it. Can you just give us your general thoughts on the use of those types of machines? What we know, the potential risk to human health, the is it worth it? I'll kind of just let you take that in whatever direction you want.

DW
Dr Weschler
38:04
Okay, the major indoor oxidants are ozone and to a lesser extent, the hydroxyl radical. And we also, if we use chlorine bleach, are talking about another indoor oxygen, chlorine, hypochlorous acid and chlorine. I've talked a little bit about ozone. Ozone is a discriminating oxidant. Ozone goes after organic compounds that have carbon, carbon double bonds. I won't go into the chemistry in any greater detail, but I'll make the general point that maybe 10% of the organic compounds that occur in indoor air react with ozone fast enough to compete with the air exchange rate. The hydroxyl radical is an indiscriminate oxidant. The hydroxyl radical reacts with almost everything present in indoor air. So if we're saying typically ozone react with 10% of the VOCs, the hydroxyl radical reacts with 95, 98% of the VOCs present indoors. And when oxidation occurs, typically, we're winding up with a product that is potentially of greater concern than the precursor. By oxidizing a chemical we're making it more water soluble. It potentially can penetrate deeper into our respiratory tract. Not all oxidation events produce chemicals that are harmful. But speaking generally, you're going from less harmful to more harmful. When you go from less oxidized to more oxidized indoor chemicals. The hydroxyl radicals. These device, I think there's devices out there that claim to produce hydroxyl radicals but don't, and there's other devices that really do produce hydroxyl radicals. I would not want to be in an indoor environment that used the device that actually produced hydroxyl radicals. The concentration of hydroxyl radicals indoors, on average, typically, is about a million times smaller than the concentration of ozone. So if we're talking about an indoor ozone concentration of 10 parts per million, divide that by a million, and that's your typical indoor concentration of the hydroxyl radical. If you're deliberately generating hydroxyl radicals indoors, you can wind up with hydroxyl radical concentrations much larger than you encounter in a typical indoor environment, and the amount of unintended chemistry can be quite large. So, I, yes, I'd be very nervous about devices that actually do generate hydroxyl radicals indoors. The, there are your expression unintended consequences when you deliberately introduce oxidants, whether it's ozone or hydroxyl radicals or hypochlorous acid or chlorine atoms, you can be surprised by the mix of chemicals you've made. I've been involved in this chemistry for over 40 years, and many, I've received many phone calls, many emails from

people who've used some type of cleaning device indoors, and they now find that they can't tolerate their indoor environment. Fortunately, that doesn't happen very often, but if it happens to you, if you've used an ozone generator or hydroxyl radical generator or something else indoors to deliberately oxidize that indoor environment, and then you find that you've created chemicals that have become part of your environment, they're difficult to get rid of, and you can no longer be comfortable in that environment. And that's a tragedy, and it happens sometimes. You just, I think you want to be very, very careful when you deliberately create chemistry indoors. Chemistry is complex. You can make chemicals that you just don't know you're making, and some of these chemicals can be very, very hard to get rid of once you've made them in your home.

KS

Kendra Seymour

43:10

Yeah, and so many of these, whether it's machines or even building products, they're all tested often in isolation, and we're not tracking long term how all those chemicals that interact with one another when they're in the real world situation? And that's one of the shortcomings you sometimes see with a lot of air purifiers, is they're not tested, you know, in real world situations. Sometimes it's a small little box and, you know, they're running their device and they, that's where they kind of make their claims and extrapolate from. So, one of the things that I tell people, if you are trying to reduce your exposure, so pay attention to the things you're bringing in, the things you're buying or not buying up your cleaning practices with those effective cleaning practices you talked about, but then focus on if you really insist on having something. I always say it's about removal. So some sort of HEPA filtration, something that is not going to add something to the environment and hopes that it fixes your problem. Focus on removal. Is that fair to say?

DW

Dr Weschler

44:13

That's fairly said, well stated.

KS

Kendra Seymour

44:17

So let's talk then, as we kind of wrap up with a little bit more focused on the solution side. You talked about ventilation and you talked about filtration. We touched on a little bit. Is there, what are your best strategies or recommendations for reducing and preventing some of these indoor chemistry things that we maybe don't want have happening? Do you have some tried and true recommendations for people listening?

DW

Dr Weschler

44:45
Well, I think you've already mentioned some. So minimizing indoor sources. Don't introduce indoor chemicals if you don't have to. And so to the extent that you can minimize the emission of chemicals indoors. Good idea.

KS
Kendra Seymour
45:05
Yeah

DW
Dr Weschler
45:07
Ventilation. You want to ventilate, you want to ventilate well. Now it can be tricky. It's July right now, July 14, and in many parts of the United States, it's warm and humid, and we're speaking eastern time about 10 minutes of four. And outside here in New Jersey, it's about 92 degrees and the relative humidity is high, and the dew points about 75 and I don't want to ventilate with outdoor air right now. So, and imagine you're living in Beijing, I'm going to change that. Beijing has really cleaned up their outdoor air. Imagine you're living in Hanoi, and there's serious outdoor air pollution in Hanoi, levels of pm are often very high. They don't have the luxury of being able to ventilate with outdoor air without bringing in high levels of PM. What do you do when the outdoor air is too warm, contains too much water, when the particle levels are too high. So ventilation isn't always simple. This time of year, we, myself and my wife, we tend to ventilate during the hours of the day when the temperatures are lower. If we get a period when the air is drier, we take advantage of that period, so ventilate, but ventilate with your thinking cap on, and don't ventilate at a time when you're going to cause problems with the air you're deliberately bringing into the home. If you know that wildfire smoke from Canada is going to be in your neighborhood, that's not the time to ventilate. And of course, you alluded to filtration, and filtration really can help us with particles, and I think you're familiar with some of the relatively inexpensive but effective HEPA filters that are available. The Corsi-Rosenthal box is a great example, and local high schools build them and then pass them out to their parents. In our neighborhood, at least. I, we know how to take particles out of indoor air, and we've learned how to do that relatively inexpensively. You can buy a good HEPA filter for, oh, on the order of two or $300 you can build one for less than $100 and if you do have wildfire smoke, and some of that smoke is getting into your home, use that filter. It'll actually help to clean your air. So for particles, we know how to filter, and you can do it, and it doesn't have to cost too much. There's filters for chemicals too. You can take charcoal. You can take ozone out of the air with charcoal, activated carbon filters, but that's more expensive. And I think the time might come where it becomes much less expensive to remove ozone from indoor air than it is today. We can do that today. Certain industries do that deliberately. If you synthesize drugs or if you make computer chips, often you remove ozone from the air where the drugs are being synthesized or the chips are being

fabricated. You're taking ozone out of the air because that chemistry interferes with the fine lines you need for lithography or oxidizes some of the chemicals involved in the drug synthesis, but we don't do it in our indoor environments as a rule. Another point, and this is a point you know very well. I recognize you, many of your shows address mold and issues of mold. Keep it dry. Keep your indoor environment dry. Keep your closets dry. Keep your drawers dry. It's not just mold. It influences chemistry as well. Acid base chemistry. We can have chemistry occurring on moist indoor surfaces that would not otherwise occur. So a damp building, a damp building is a problem, potentially in terms of mold, but a damp building also provides an opportunity for chemistry that might not occur in a dry building. So I would say those three things are very important, minimize emissions, ventilate to the extent that you can paying attention to the quality of outdoor air, and keep it dry. Keep that environment, indoor environment, dry.

KS
Kendra Seymour
50:22
Yeah, and I'm glad you brought that up, because we often talk about like relative humidity in the context of leading to microbial growth, but the fact that it can cause building materials to off gas and release those VOCs at higher amounts is also something that I think people don't think about so

DW
Dr Weschler
50:42
Another item I should mention there is corrosion.

KS
Kendra Seymour
50:44
Yeah, absolutely. And I'm glad you mentioned the Corsi-Rosenthal box. I'm going to try to leave put a link in the show notes, because I understand, I truly do this is very expensive if you're in the middle of maybe remediating your home and you have health challenges, and some of these units you buy are 1000s and 1000s of dollars, and they don't necessarily get to the root cause, which is where we always recommend. But a Corsi-Rosenthal box can be very affordable and very effective as a temporary management tool that is accessible, maybe more so than some of the expensive units that you can buy. So I'll try to link to that in the show notes. And then, because I always like to drop additional resources for people listening, we do have an episode on ventilation with Corbett Lunsford we'll link to. Dr Alison Bales, and then we do have an episode that talks a little bit more about HEPA filtration with Carl Grimes that I'll link to for people who want to do a deep dive. Dr, Weschler, thank you so much for joining us today. I can't wait to link to a bunch of your papers in the show notes. I forgot to mention I was going to link to the Why Indoor Chemistry Matters paper from the National Academies, because that talks about the reservoirs in great

detail. It was super fascinating read. So for people who want to dig a little deeper, is there anything that we didn't talk about, that you wanted to mention.

DW

Dr Weschler

52:05

I think what we've covered is for now sufficient, Kendra, I've enjoyed this opportunity, and I wish your listeners good luck with their indoor air quality.

KS

Kendra Seymour

52:17

Wonderful. Well, thank you so much. And for everyone listening, thank you for tuning in, and if you found this helpful, or if you want more resources like this, we've done a whole series lately on VOCs. We obviously have lots of resources on mold remediation, but also things like radon and carbon monoxide and other indoor air pollutants. So if you want to stay up to date on all of the great guests we have on the show, please head on over to ChangeTheAirFoundation.org, and sign up for our newsletter. That's the best way, really, to get this great information sent directly to your inbox. Thank you, everyone. We'll see you next time bye bye.