White Paper

Review of Airborne Particulates Detection, Collection and Elimination for the Improvement of Human Health and the Global Environment

Contents

Introduction

The purpose of this White Paper is to discuss in detail the attributes and methods used for effective elimination and removal of particulates in the air to the degree of efficiency that is effective in producing true results. The solution should be effective, but also efficient and easy to deploy and cost effective. Currently, there are multiple situations that attribute success to the removal of particulates in the air. However, they are largely inefficient toward smaller particulates, are expensive and usually have a large footprint for any kind of industrial purpose.

Additionally, this paper addresses solutions that are appropriate for today's modern. Environment. The output from this paper presents data and information to help people understand what the most effective way is to address this health and environmental problem. What is the most efficient way? And what is essentially the most effective technology and means that is not harmful to both humans and the environment.

Exposure to air pollution has been found to negatively affect people's health. When we breathe in air pollutants, they can enter our bloodstream and contribute to coughing or itchy eyes and cause or worsen many breathing and lung diseases, leading to medical crisis is which can lead to hospitalizations, cancer, and even possibly premature expiration of life. As per the California Air Resources Board a large number of adverse health impacts are associated with PM2.5 and PM10, which represent particulate matter sizes, which will be discussed later in this paper.[i] PM (Particulate Matter) 2.5 or 10 are reference numbers to those particulates which are inhalable. PM2.5 are those particulates that are 2.5 microns or less and PM10 are those particulates that are 10 microns or less. PM2.5 particulates make up a portion of the grouping of PM10 particulates.[ii]

The smaller the particle (larger than 1nm but called a Nuclide from 1 to 5 nm in size and they transport in nano clouds) or molecule (smaller than 1nm), the more common that it can be ingested into the lungs. This type of matter is harmful both to human and animal health but also to the environment. The World Health Organization states that PM2.5 is a major cause of the highest degree of adverse health effects relative to poor air quality, in the US but also worldwide.[iii]

It's very well known the harmful effects of air pollution as well as high ozone levels can cause sore throats, coughing, lung inflammation and possibly permanent lung damage. Ionization of the air catalyzes side effects where concentrations of ozone (O3) is developed causing some of these many problems described. Most of these problems make it difficult to breathe.

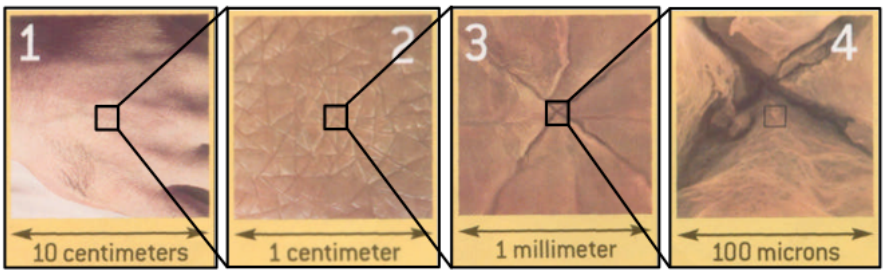
One of the more important facets of detecting and eliminating pollutants is to gain a strong understanding of what the pollutant physical attributes are, so they can be identified, detected, and eliminated if possible. There are five primary groups of particles, or dust as it is sometimes called.

- Big Dust – larger than 10 micrometers (mm)
- Fine Dust – smaller than 10 mm but larger than 2.5 mm
- MPPS (Most Penetrating Particle Size) – smaller than 2.5 mm but larger than .1 mm
- Ultrafine Dust – smaller than .1 mm or 100 Nanometer (nm) but larger than 1 nm)
- Pico Dust – anything smaller than 1 nm

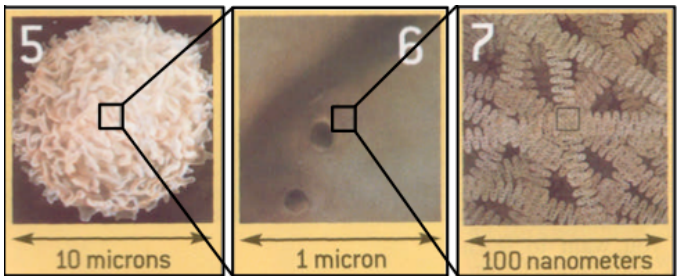
To illustrate the true size dimension comparisons, a matrix showing the different sizes is below:
Source: NanoSense, Lesion 2 Document. [iv]

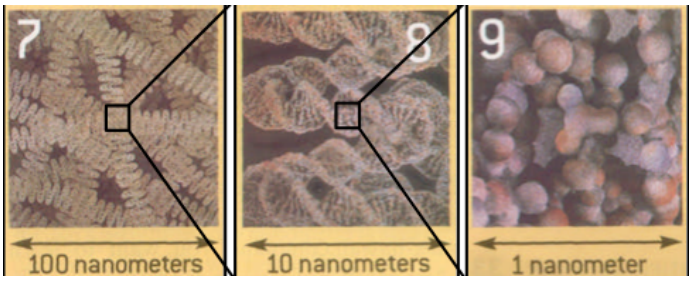
UNIT	MAGNITUDE AS A NUMBER (M)	ENGLISH EXPRESSION	COMPARABLE EXAMPLES
Meter	1	One	Slightly bigger than a yard stick
Centimeter (cm)	.01	One Hundredth	Width of a Fingernail
Millimeter (mil)	.001	One Thousandth	Thickness of a dime
Micrometer or Microns (mm)	.000001	One Millionth	A single medium molecule or cell
Nanometer (nm)	.0000001	One Billionth	10 hydrogen (H) atoms lined up
Picometer (pm) or Angstrom	.0000000001	One Trillionth	A large Atom

The different sizes in a pictorial image:



Skin on left most image above –





The above images are zooming in on your hand by powers of 10

The most constant particles (complex molecules) causing harm to the environment and to human health (some so deadly that they are fatal almost immediately if exposure is to 500ppm such as H2S) include VOCs, NOx, SO2, NH3, H2S etc. as well as the basic molecular structures, along with their kinetic diameter sizes in nanometers which make them up are listed below:

Molecule/Particle Name	Molecular Formula	Molecular Size in nm or microns
Ammonia[1]	NH3	.260 nm
Bacteria (variety)[2]	C6H6	3 – 8 microns
Benzene[1]	C6H6	.585 nm
Carbon[3]	C	.232 nm
Carbon Dioxide[1]	CO2	.330 nm
Carbon Monoxide[1]	CO	.376 nm
Chlorine[1]	Cl	.320 nm
Hydrogen[1]	H2	.289 nm
Hydrogen Sulfide[1]	H2S	.360 nm
Influenza (variety)[4]	Influenza	80-120 nm
Methane[1]	CH4	.380 nm
Nitrogen[1]	N2	.364 nm
Nitrous Oxide[1]	N2O (NOx)	.330 nm
Oxygen[1]	O2	.346 nm
Ozone (Ground)[5]	O3	.300 nm
SARS-CoV-2	SARS-CoV-2	50 nm
Sulfur Dioxide[1]	SO2	.360 nm
Sulfur[6]	S16	1 – 20 microns
Water[1]	H2O	265

[1] Wikipedia. Kinetic Diameter. Web: Kinetic diameter - Wikipedia. Retrieved: January 21, 2023.

[2] K W Tham, et al., PubMed. 2005. Size relationship between airborne viable bacteria and particles in a controlled indoor environment study. 15 Suppl 9:48-57.
doi: 10.1111/j.1600-0668.2005.00303.x.

[3] Carbon, C. Web: https://www.princeton.edu/~maelabs/mae324/glos324/carbon.htm. Retrieved: January 21, 2023.

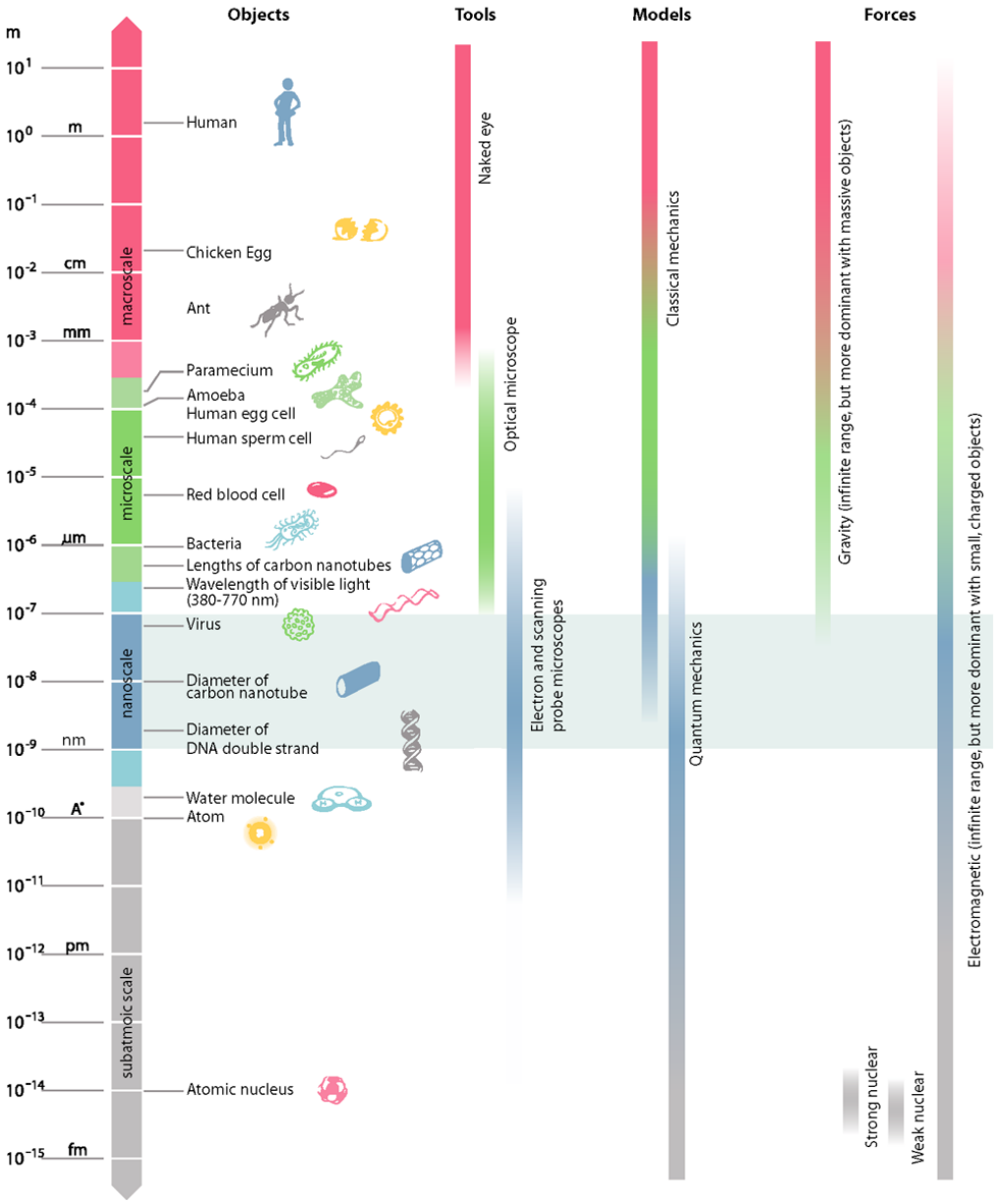
[4] Judith Vajda, et al., Journal of Chromatography A. 2016. Size distribution analysis of influenza virus particles using size exclusion chromatography. Size distribution analysis of influenza virus particles using size exclusion chromatography | Elsevier Enhanced Reader.

[5] PubChem-National Library of Medicine (reference from Wikipedia Ozone). Web: https://pubchem.ncbi.nlm.nih.gov/compound/Ozone. Retrieved: January 21, 2023.

[6] Annemerel R. Mol et al., MDPI. 2020. Properties of Sulfur Particles Formed in Bio-desulfurization of Biogas. Volume 10, Issue 5. *10*(5), 433; https://doi.org/10.3390/min10050433

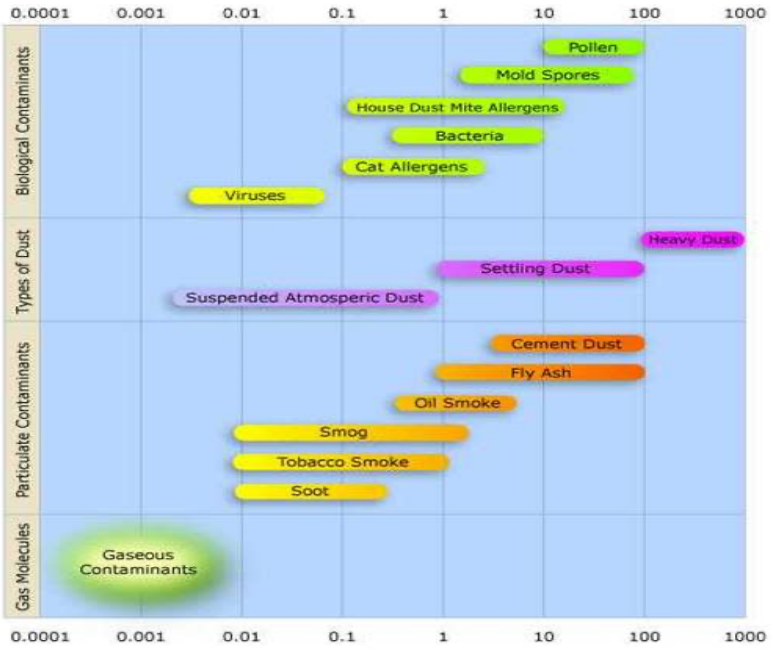
In the business of cleaning the air for healthier humans and cleaner and safer environments, size does matter, as the smaller the particulate, not only more difficult it is to catch and collect these harmful and potentially toxic contaminants but often it is more expensive. [iv]

Scale Diagram: Dominant Objects, Tools, Models, and Forces at Various Different Scales [iv]



A common term used is Most Penetrating Particle Size (Mpps). A particle of .3 microns (300 nm) is the Mpps for what is called the worst case of detection, collection, and treatment of particulates. The MPPS has been traditionally a target for development of technology to catch and collect particulates of that size, since it has presented a worst-case difficulty of catching in the past on average for technologies targeting catching particulates from .3 to .1 microns.[v]

Typical Sizes for Common Pollutants [vi]



Today's current situation regarding pollutants and toxins in the air with the increase in population, transportation methods and other means of generation of air particles has created serious harmful side effects to humans but also to the environment.

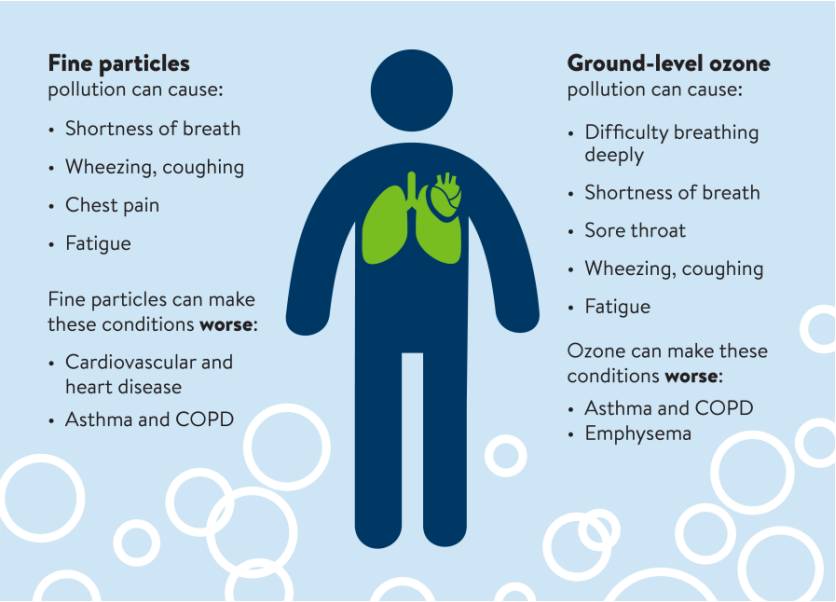
The World Health Organization (WHO) had a survey showing air pollution was responsible for most of several fatal diseases, which led to the death of seven million people worldwide. Nine of ten people breathe air which go beyond WHO recommendations. Photocatalysis[7] (a process where the absorption of light-by-light sensitive elements and adding catalysts which add to the chemical reaction, amongst others have proven capable as a green technology to the collection and elimination of air pollutants.

The advances made by nuclear physicists and biophysicists in research have seen growth in science that removes or reduces three primary air polluting particulates (molecules) including CO2, NOx, and VOCs (Volatile Organic Compounds) using photo catalysts.[vii]

Again, size does matter regarding molecular physics. Particles with a size below 80 nm can break the membrane of a cell, while particles over 80 nm find it difficult if at all to enter a cell, which is why a 120 nm influenza particle does not break down cells like a 50 nm airborne SARS-CoV-2 particle can, which can cause far more serious health issues than does influenza.

[7] Nature Portfolio. Photocatalysis. Web: https://www.nature.com/subjects/photocatalysis

Air quality and health[8]



Air Quality inside the buildings, at home and at work

According to. South Coast air quality management district air pollution In and around your home can come from a variety of sources and can cause health problems for your family and your neighbors.[viii] Things that you don't normally believe are critical to air quality have become common items regarding efforts by the state of California to reduce harmful air pollution. Air pollution, such as wood smoke, cigarette smoke, and other pollutants contains fine particulate matter and other fine particulate air pollutants that cause health problems in the lungs, heart, and brain.[ix] Cooking smoke from BBQ grills and typical kitchen cooking instruments can cause high levels of air pollution, especially in areas with not enough ventilation.[x] Smoke and secondhand smoke from cigarettes, cigars and pipes contain thousands of chemicals, including P M 2.5, benzene, and arsenic. In the business environment, cleaning supplies can contain. Harmful volatile organic compounds that can irritate the eyes, nose, and throat. [xi]

Some fragrances and cleaning products can trigger asthma symptoms. In the state of California, it is quite well known within the state as well as outside of the state that the authorities dealing with the environmental. Pollution control organizations such as South Coast Air Quality Management District are formed to find ways to battle industries and businesses polluting the air and, in many cases, they do not even know it. [viii]

[8] Minnesota Population Control Agency. Air quality and health. Web: https://www.pca.state.mn.us/air-water-land-climate/air-quality-and-health – Retrieved: January 21, 2023.

Applications for indoor air quality improvement used most often indoors are air scrubbers (centrifugal force application) and Ionization. Ionizers are devices that remove certain airborne molecules using negative ions (also called anions, meaning the molecule atoms in the air have more electrons than protons). These anions are electrically charged and are attracted to the walls, flooring, furniture etc. in a room and they also attract other molecules in the air and "carry" some of them downward because they become heavier than air and fall. [xii]

Populations most at risk of health problems related to air pollution:[xiii]

- people with lung diseases, such as asthma, chronic bronchitis, emphysema, and chronic obstructive pulmonary disease
- infants and young children
- people who work or exercise outdoors
- adults over 65
- people with a cardiovascular disease
- people in poverty; people who lack access to health care
- people who smoke or are exposed to second-hand smoke
- people working in occupations where there is high exposure to contaminated air
- people who spend a lot of time near busy roadways

Basic Information on Pollutants and Sources of Indoor Air Pollution [xiv]

- Asbestos
- Biological Pollutants
- Carbon Monoxide (CO)
- Cookstoves
- Formaldehyde/Pressed Wood Products
- Lead (Pb)
- Nitrogen Dioxide (NO2)
- Pesticides
- Radon (Rn)
- Indoor Particulate Matter
- Secondhand Smoke/ Environmental Tobacco Smoke
- Volatile Organic Compounds (VOCs)
- Wood Smoke

Air Quality Issues Outside

It's important to also be aware of the outdoor air quality. Oftentimes, people are not aware of the variety of different ways that air pollutants are created. The causes of Poor air quality include exhaust from ships, planes, trains, and truck emissions. Industries such as factories and manufacturing centers with smokestacks. Fires are a major source of air pollution both in the US and worldwide. It's important to understand where air pollution comes from and what are the sources of air pollution so that one can identify? The mechanisms that possibly could react in control their pollution causes for detection and removal of specific types of air particulates.

Outdoor air quality is an area of great concern where there are many challenges. Country governments look for ways such as AirNow which is an EPA (USA – Environmental Protection Agency – organization which publishes an Air Quality Index online to provide real time information regarding the local air quality. Like the weather and wind conditions, air quality can change from day to day. Still till this day, there are many more active efforts and technologies to clean indoor air than there is for outdoor into the atmosphere technologies. [xv, xvi]

Those tall smokestacks you often see are essentially stacks as tall as 500 feet, usually seen at coal power plants, that are primarily used to release obnoxious air pollutants such as sulfur dioxide (SO2) and nitrogen oxides very high into the atmosphere above you to reduce or limit the effect or impact of the emissions of air pollutants at ground level air quality. [xvii]

What are the effects from pollutants and their impacts on health and the environment?

It's also important to understand the health impacts from poor air quality and to understand both monetary and human cost of pollution in our air. The health impacts from air pollution can include asthma, increased likelihood of infection, irritation of eyes, nose, and throat, coughing or shortness of breath, bronchitis and even cancer.

The Affected Masses

People that are affected from poor air quality most prevalently or on a more chronic basis are generally from poorer environments or unsupervised situations, including children, older adults, pregnant women, etc. People who exercise outdoors are exposed to the elements and have shown to be vulnerable to air pollution.

The Minnesota Pollution Control Agency has determined that air pollutants can enter bloodstreams or contribute to respiratory issues along with itchy eyes and cause breathing issues and catalyze lung diseases. [xiii]

Evolution of Government Policy and Technology for Particulate Removal for better Health and cleaner Air

In London UK, the smog was so bad back even as far as 1956, the UK created the Clean Air Act of 1956, because of air quality was so poor due to the burning of coal and other industrialized activities. Deaths dramatically increased with 4,075 more for that year, due to chronic lung and heart disease and conditions. The implementation of policies such as reducing the use of coal, setting regions where coal was not allowed to be burned for energy and other new regulations of those times greatly reduced illness and deaths from the former “smog city” reference numbers.[xviii]

Both policy through regulation and rules enforcement along with advances in technology have evolved over the years for the improvement of both indoor and outdoor air quality. A couple of the first technologies were (EGR Valve) exhaust gas recirculation that recirculated airflow and another was catalytic converters in vehicles and other fossil fuel engines. Even though catalytic

converter basic technology was invented in the 1930s, By the year 1975, catalytic converters were required in cars sold in the US. Catalytic converters break down toxic exhaust into water, nitrogen, and carbon dioxide. Catalytic converters are made to reduce toxic particulates from the exhaust of vehicles powered by gasoline or diesel fuel. The converters also have in them, small amounts of expensive metals, often including platinum, palladium, and rhodium (all catalysts which sped up the oxidation of exhaust fumes) which speed the reactions of vehicle exhaust gases such as CO, NOx etc., and convert them to less harmful gases. Catalytic converters are very expensive to replace due to their contents.

The inventor of the catalytic converter, Eugene Houdry had invented them in the 1930s, in support of the Allied military effort, to extract more gasoline from crude oil. In the 1950s, he attacked the removal of smog in Los Angeles and other cities. What is not said, is that carbon dioxide (CO2) is also produced by catalyst converters, converting carbon (C) and carbon monoxide (CO). Congress in the US in 1970 through the Clean Air Act forced the removal of lead from gasoline where lead would coat the inside of the catalytic converters and essentially block the exhaust gases from oxidizing due to its lack of contact with the "catalyst materials such as the platinum". Evolution of the catalytic converter evolved honeycomb structures inside the catalytic converters which were called three-way converters, which removed NOx, hydrocarbons, and CO at a ratio of 98%.[xix]

Other early innovative technologies through the evolution of pollution and air quality control since the mid-fifties included the removal of lead from petrol fuels, forcing manufacturers to design engines to burn cleaner, making oil and gas companies to improve the octane levels of their gasoline products, the use of EGR Valves with ICE (internal combustion engines) motivated vehicles, etc. EGR valves first showed up in vehicles in 1973, invented by GM in 1972. They caused great concern by the public due to the limited performance of vehicles first using them.[xx]
EGR valves effectively lower the burn temperature of engines, thereby reducing the oxidation process of Nitrogen creating less Nitrous Oxide (NO2) gases. EGR valves accomplish this by recirculating some of the exhaust from engine exhaust airflow and inserting small amounts of it back into the intake of the engine, effectively changing the chemical mixture of the airflow into the combustion chamber, which then has less oxygen, diluting the air to gasoline mixture, lowering the burn temperature, and then reducing the NOx production. Nitrogen (N) and Oxygen (O) mixed at high temperature oxidizes and forms NOx which is released into the atmosphere through the exhaust pipe of the vehicle which leads to heavier smog and air pollution. Therefore, the EGR valve does reduce NOx in the exhaust of cars, but it also weakens the combustion process and decreases the efficiency of the process.[xxi]

Global/National Regulation Policy and Compliance for Air Quality and Pollution

The US Congress passed the initial Clean Air Act in 1970, which required a 90% reduction in emissions from newly manufactured automobiles by 1975. President Richard Nixon established the EPA (Environmental Protection Agency). As far back as the 70's, the US government was trying to eliminate NOx and SO2 from the outside air as much as feasibly possible. The first testing of automobiles was in 1971. Exhaust recirculation valves for automobiles were developed in 1972 to reduce NOx emissions. In 1973, the EPA was targeting the US's largest cities. The Energy Policy Conservation Act setup the economic goals through CAFÉ standards. By 1990, new limits on diesel fuel sulfur content were established. Lead was banned entirely from gasoline in the beginning of 1996. In 1997, diesel locomotive diesel engines were given new emission standards for NOx, HC, CO, PM, and smoke. SUVs and light duty trucks were subjected to the same standards as cars in 1999. Small spark ignition outdoor lawn tools were ordered to reduce emissions with a final order in 2000. 2004 saw school bus operations rules standardized to reduce idling, etc., and motorcycles were forced to have reduced emissions by 50%. By 2005, existing emission standards were revised regarding NOx for new commercial jet engines. Tighter emissions standards were greatly reduced for locomotives and marine diesel engines in 2008. As of 2010, greenhouse reduction standards were introduced by the EPA and NHTSA for cars made through 2012 and 2016. Waivers were allowed for E15 (15 percent ethanol) to be used in 2007 or newer vehicles in 2010. This was coordinated with international organizations and institutions. In 2012, extensions of the national program to reduce greenhouse gases (NOx, SO2, O3 and others) for most vehicles made through 2025.The EPA and NHTSA both proposed lower greenhouse gas emission standards for medium and heavy vehicles made from 2018 through 2027. In 2016, aircraft standards were further addressed addressing carbon dioxide emissions and air quality globally.[xxii]

The EPA (Environmental Protection Agency in the US and the EEA (European Environment Agency) and many other country national ministries/departments or even provincial/state regulations that develop, adopt, implement and evaluating environmental policy, but also to help provide information to the general public on what is required to manage air quality which helps support both the environment and human health. These institutions often have the authority to both enforce and fine offenders who violate the rules and violations. The EPA has many state and local partners as shown by this link: (https://www.airnow.gov/partners/state-and-local-partners/).

There are multiple international organizations that are highly involved in the regulation and rulemaking for air quality and environmental protection which include the Global Environmental Facility (GEF), Intergovernmental Panel on Climate Change (IPCC), The International Union for Conservation of Nature (IUCN) and the United Nations Environmental Programme (UNEP).

Other national environmental institutions for other larger countries include the EA for the UK, Department of Climate Change, Energy, the Environment and water for Australia, KECO for Korea, SEMARNAT for Mexico, Ministry of Environment for Colombia, EAD for the UAE, National Environmental Environment Agency for Singapore, Department of Environmental Affairs for

South Africa, EEAA for Egypt, Ministry for Ecology and Environment for China, Department of Waterways and Environment for Fiji and countless more.

United States Goals and Targets

The US has the active participation and leadership provided by the EPA to control and manage pollution controls, monitor performance and to regulate the rules and regulation along with establishing compliance standards. The

The rules and regulations of the EPA are codified into governmental jurisdiction, which means there are criminal provisions for certain violations of those rules and regulations enforced by the EPA. They are found at https://www.epa.gov/enforcement/criminal-provisions-clean-air-act.

The EPA has multiple rules and regulations, and, in some cases, they work very closely with state organizations, including Southern California Air Quality Management District which manages an area with 17 million people. The state of California works very closely with the agency and the others in the state in setting rules and regulations. The list of rules and regulations that the EPA approved in cooperation with the state organization are numerous and highly detailed creating a need for business to fully understand how to comply with these regulations, for violations can be very costly.[xxiii]

European Goals and Targets

In Europe, the EEA has a focus on zero pollution through its zero-pollution plan and it serves as a key element of Europe's intentions to progressively work toward improving both the well being and health of its citizens and future generations under its European Green Deal. It has a vision of having reduced air and other types of pollution to the point both natural ecosystems and human health are no longer at risk due to the air quality and environmental pollution in Europe by 2050. Europe has set goals to accelerate this activity by 2030.[xxiv]

The most Common EPA violations

a. Improper containers
b. Inadequate aisle space
c. Incorrect labeling, including misclassified waste and omitting the start date.
d. Waste generation volumes exceed the generator capacity category including storage limits and/or monthly volumes.
e. Corrective Actions are delayed.
f. Plans are not updated when operational changes are made.

The Costs to Businesses and Institutions due to Air Pollution

The fines associated with violations can be expensive and sometimes they are so much they can force companies to close and go bankrupt. Air pollution fines are typically releasing too much

Nitrous Oxide (NOx) and Sulphur Dioxide (SO2) along with Ozone (O3), which often makes up most of the smog one may see on a cold stale day over the horizon In Los Angeles, Beijing, and other large metropolitan areas with huge concentrations of population and cars and industry. What hurts Los Angeles is that it has mountains encircling it against the ocean and the photochemical smog (ground level smog) has nowhere to go, for it is trapped against temperature inversions often. This phenomenon is only increased in industrial urban areas where sulfur oxides (SO2) associated with coal burning and nitrous oxides (NOx) that are associated with car exhaust are released by burning fossil fuels. Other attributes are heat (summertime) and sunlight.

The increase of toxins in the air combined with temperature inversion (a phenomenon where cool air is trapped at ground levels under a layer of warm air (radiation has a role of cooling air that is trapped at the ground) during the winter which causes cities with lots of industrial production and automobiles and trucks to have layers of light brown colored air above cities like Denver (high altitude does not help), Los Angeles (mountain rings around the metropolitan area), Beijing (such density of urban industrial production and automobiles along with mountains to the north which trap the air for it has nowhere to go) etc.[xxv]

A fine of $650,000 in civil penalties was assessed against Continental Carbon Company in 2015 that had three carbon black manufacturing plants in Oklahoma, Alabama, and Texas. They were fined for excessive amounts of sulfur dioxide (SO2) and nitrogen oxide (NOx) and particulate matter. The real punitive costs are more than $98 million USD, which was the cost of the injunctive relief. They were forced to install catalytic reduction and many other processes to reduce their NOX and SO2 and other particulate exhaust into the air. [xxvi]

Another fine posted for 16 continued violations for a company with only 75 employees was $255,344 which can be highly damaging to a company's bottom line if not fatal. [xxvii]

One of the largest EPA fine for violations of air quality rules and regulations was $1 Billion US dollars against seven diesel engine manufacturers violating the Air Quality rules and regulations and even civil fines were assessed, such as an $83.7 Million civil penalty in 1998. This pales in comparison with the globally assessed regulator and civil court fines that Volkswagen AG paid.[xxviii]

Volkswagen America itself was fined by the EPA a record $14.7 Billion USD for what was called diesel gate just in the US, which essentially was about installing software in cars that through the software's ability to recognize how EPA tests were performed, would turn on certain pollution controls and then when not testing, would operate in normal driving without the government mandated pollution controls allowing the diesel burning cars and trucks to perform better but also fouling the air much more.[xxix]

Globally, other regulators also took Volkswagen to court and won large civil penalties and fines against Volkswagen. Upwards of 11 million cars worldwide were affected by the software. Overall, a minimum of six Volkswagen AG executives were arrested and governments went to

take their piece of flesh from the company. People like Oliver Schmidt were sentenced to seven years in jail and fined personally $400,000. The damage was extensive globally financially and to the brand of Volkswagen worldwide.[xxx]

The Challenge

The technology that has been available till now has seen continuous advancements to the industry's credit. Much has been developed to help drive downsize of systems, ability to detect even smaller particulates and to create more efficient technologies that had higher efficacy rates. The mild continuous innovation of the current leader technologies involving ionization (trying to find ways to engineer ionization to where it would generate lower dangerous O3 amounts into the air) and other means continued.

It was getting onerous though, and perhaps lacking in ingenuity to just try to innovate on the two most popular means of cleaning airflows to benefit both the health of humans and the environment of the planet by staying with the same old technologies that seemed to less yield with each improvement. Sometimes, the use of technology that is often not fully proven or tested or simply rushed to market much too fast proves to be doing more harm than good. After full review of most of the known and popular methodologies to provide benefits for both health of people and to also do this without harming the environment it became evident much improvement was still needed to truly detect the smaller ultra-fine molecules that are made up harmful particulates that are very small and are elusive to most of today's technology.[xxxi]

The Primary Methods currently used to Detect and Remove Pollutants

Bipolar Ionization and its limitations – .3 microns (Mpps)

Ionization as it is commonly referred to is the most common form of air cleaning and purification, especially indoors. Air ionization is effectively the process(es) molecules are split with the electronically induced deletion and addition of an electron. Electrons are transported between electric current and molecules in the air which in this case is primarily oxygen. Positive ions (those molecules with atoms that have extra protons and negative ions (those molecules with atoms that have extra electrons) are created (referred to as bipolar (Corona Discharge or Needlepoint) ionization) where the output is a uniform mixture of +/- air ions. [xxxii] The more than plausible side effects from Corona discharge (bipolar ionization) which is generally inclusive of all air ionization is the potential creation of ozone, which while having bactericidal elements, has capacity to damaging respiratory organs in humans. The higher the induced electric charge to the airflow, the higher the potential of colliding and recombination of oxygen into ozone (trioxygen O3).[xxxiii]

The grouping of ionized gas is developed by changing the naturally occurring oxygen and moisture (humidity) in the air. This tends to create a pleasant feel and smell in the air emulating a fresh after rainy night morning. The mixture of ions interacts with the immediate environment in ways that improves air quality but as stated, with higher inducement of charging power, ozone

can be created. The fix to this is that manufacturers try to lower the "energy charge" which limits the potential of ozone creation, but then the air cleaner or purifier is far less effective.

Polymers and Coulombs Law - .3 microns (Mpps)

The use of new technologies such as the coupling of force action laws with Polymers and Coulomb's Law are now being used for indoor air purification and for antimicrobial purposes. Coulomb's law stated that the electrical force between two charged objects is directly proportional to the output or resultant of the quantity of the charge on the objects, therefore building an opposites attract activity. Most all viruses and bacteria have a negative charge (extra electrons in the atom nucleuses of the molecules themselves), which allows proton heavy positive charged elements to "attract" the negative charged elements which is used to "collect" the molecules targeted. In 1785, Charles-Augustin de Coulomb distributed his work through three editions of research on both electricity and magnetism when he illustrated electrostatic force, which was just years after Joseph Priestley stated that the electrical force between two charged objects decreased with the square of the distance between them in 1767. Priestley invented carbonated water, largely related to his discovery of (O) Oxygen. Coulomb's Law states like charges repel each other and opposite charges attract, much like the opposite ends of a magnet, the negative and positive poles. The repulsion and attraction act linearly between the charges and the magnitude of the force is directly proportional to the product of the charges, and as to repulsion, they act inversely proportional to the square of the distance between them. This electrostatic force through the inverse-square basis is exactly like that of gravity (Sir Isaac Newton's law of universal gravitation).[xxxiv]

Consequently, the use of Coulomb's Law led to the invention of the first photocopiers (Xerox – Haloid Corporation). It is the electrostatic process that makes copies possible. Essentially a negative charge is induced under a thin layer or tier of selenium (positively charged when exposed to light). This was the start of the copy machine. The same technology has evolved to now where certain electronic charged and noncharged particulates can be manipulated through either same charge or opposite charged molecules. Coupling this polymer science, has produced the ability to build electrostatic based polymers which filter particulates from HVAC airflows, a now patented process itself.

DFS (Electronically Enhanced Stimulated Air Filtration and its limitations) – 7nm

A military-based grant produced the ability to create the technology, which is a patented disinfecting filtration (DFS) technology, based on microbiostasis conditions being developed which prevents living microorganisms living or growing in the filter. This essentially is a counter to biofouling, which is the status of a filter that collects and destroys most fine and ultra-fine particulates in the filter but then the formerly live microorganisms or particulates decay in the filter and create disruption in the performance of the filter. This is called Biofouling. This type of technology is said to have an efficiency of 99.97% at .3 micron (300 nanometers).

The design of DFS is limited in size of the handling capacity, does not integrate inside the HJVAC systems and the electrification or charging of materials tends to wear off over time, thus rendering the products ineffective.[xxxv]

HEPA (High Efficiency Particulate Air) Filters and their limitations - .3 microns (Mpps)

HEPA filters are popular filters that are effective with particulates as small as .3 microns and utilize materials that are ultra-dense to block and collect fine particles. They are built for both residential and commercial applications and generally used for indoor air treatment.

Limitations to HEPA filters are multiple. They are not able to eradicate or eliminate VOCs and other viruses, microorganisms, and pollen, which can lead to biofouling. HEPA filters essentially are specially built ultra-dense fabric-based filters that have NO means or methodology to destroy these elements. Biofouling can create an incubation environment which can result in the dispersion of VOCs and other harmful particulates, which could create a biohazardous environment for workers, especially in commercial settings. HEPA filters are more expensive than normal non-HEPA filters and due to their design, are replaced three to four times a year, where the replacement costs alone are 300 to 400 USD each. Due to their ultra-dense materials in the filters, they can cause higher levels of power usage, causing HVAC systems to have to work harder to push air flow through the HEPA filters. This causes higher utility invoices. Additionally, HEPA filters cannot be utilized for Fan Coil Units.

Ultraviolet (UVC) Radiation and its limitations

Ultraviolet light (electromagnetic radiation) was first discovered in 1801 by Johann Wilhelm Ritter[9] and is often used in light applications to act as an antimicrobial agent to eliminate pathogens inherent in the air, most often indoors. It serves as radiation which disrupts the DNA in viruses and pathogens or molecules. The absorption of photons by non-DNA chromophores. This is achieved by ultraviolet light destroying molecules such as nucleic acids and proteins, inactivating them. The covid pandemic brought on a lot of UV light applications.

The pitfalls of ultraviolet light (UVC) are centered around both time of real efficacy and dosage amounts that are not well understood by users of the systems. UVC requires nearly 25 minutes to inactivate 99.99% of viruses.[xxxvi] Additionally, filter degradation, according to ASHRAE, the ultraviolet light used in HVAC applications can result in filter material degradation. There are safety concerns also, where ultraviolet light has a history of causing ocular (eye) damage.

The New York Education Department has blocked the use of Bipolar UVC or any form of UVC is not recommended. “Concerns center around the potential for these devices to generate byproducts such as ions, fine particles and reactive chemicals that would likely decrease indoor air quality and present a health risk to students and staff.”[xxxvii]

[9] Cosmos – The SAO Encyclopedia of Astronomy. http://astronomy.swin.edu.au/cosmos/U/Ulytraviolet

ULPA (Ultra Low Particulate Air) Filters and their limitations - 1 micron or 100 nm

ULPA filter systems are used in the same environments generally as HEPA filters are. ULPA units are very similar but are different in some important ways. They both utilize densely packed fabrics assimilating a deep and intense filter system that receives airflow. As per Air Innovations, they use three primary means to accomplish their role and collect contaminants: diffusion, interception, and inertial impaction. ULPA filters collect a higher quantity of smaller particulates than HEPA filters at a rate of 99.999% efficacy for particulate matter scaling from .12mm (micrometer) and larger where HEPA filters have an efficacy rate of 99.97% for particulates .3 micron or larger. Pre-filters can be set up in front of the HEPA filter trapping larger particulates prior to reaching the main filter system.

The primary difference between the HEPA and the ULPA is the density of the filter itself, but also causes a drop in air pressure than HEPA filters which is up to 50% less. The lifespan of HEPA filters is up to ten years but ranges from five to eight years for the ULPA filter. The backpressure caused by both the HEPA and the UPLA filters creates issues for HVAC systems, causing the electrical systems and motors to work much hard and creates a need for higher and more expensive maintenance and air conditioning units themselves that can handle the increased workload. ULPA filters have higher efficacy but require more power from HVAC systems to push equal amount of air to HEPA filters therefore can be considered less effective in overall elimination of general particulate matter in certain environments due to less airflow and less interactions of the physical air in the room.[xxxviii]

Both HEPA and ULPA still are not able to catch, collect or eliminate the even smaller ultra-fine particulates that make up VOC carbon-based gases and vapors (solvents, gasoline fumes, PM2.5, ground level ozone (O3), and many others, up to about 150 different hydrocarbons but do not include carbon dioxide (CO2), carbon monoxide (CO), methane (CH4), and chlorofluorocarbons such as CC12F2 and CC13F (halo carbons). HEPA and ULPA filtration systems also are not able to catch and collect other particulate matter such as NH3 (ammonia) or H2S (hydrogen sulfide) which are two extremely toxic chemicals and are dangerous to human health.[xxxix]

Wet or Dry Scrubbing (use of centrifugal force) limitations – 100 to 500 nm

Scrubbers can be wet or dry, and work using centrifugal force, can be efficient dust collectors. They are very different technologies. Dry collectors of particulates are usually cartridge-based collectors that are most widely used for dust collection. They have been able to work to high efficiencies regarding certain fine particulate matter. Often, the addition of a HEPA filter secondary filter can be added to achieve better results overall. [xl]

The reference of wet or dry is referring to the material used as a carrier, that impacts the particulates in the air medium that contains the dust and micro particulates. Usually for wet scrubbers, water is used. Wet scrubbers are sometimes used to remove acid gas and collection of particulate matter. There are three tiers of power with scrubbers, which regulate the medium

flow used under pressure to remove different levels of particulate matter. These systems can be small, but the most effective ones are rather large requiring longer and larger flows or air or water (wet or dry) to impact the collection of particulates which are collected when they collide with the matter used for scrubbing them out. The most prevalent HIGH energy scrubber is called the venturi, although being able to be utilized at lower medium pressure such as medium scale units. They sometimes use mist and other types of entrainment separators removing entrained droplets. The reason these wet and dry scrubbers are not often used for commercial applications is the limited ability to catch and collect ultra-fine particulates less than .3 microns (300 nanometers) in size and their tendency to malfunction over time.

These systems are open to operating problems due to the moving parts and multiple pieces of the machines that can fail. Blockage of the medium (water most usually) is very common and poor contact with the water medium, rusting (corrosion) and of obvious nature, nozzle blockage where they are in the system.[xli]

The Ground Level Ozone – O3 - Problem

The problem with Ozone is quite impacting to human health, where it can cause life threatening sickness to people who have been exposed to it for too long of a period, or to very strong dosages of it in the air. Most people don't understand that there is a good Ozone and a Bad Ozone. Ozone is a gaseous matter, made up of three atoms of Oxygen (O3). Good ozone is called stratospheric ozone where it happens naturally in the upper atmosphere and provides a shield for life on earth from the sun's harmful ultraviolet rays (radiation). [xlii]

The Bad Ozone however is O3 that is at ground (tropospheric) level, which is an air pollutant harmful to humans, animals, and the environment, and in common "lingo" is the ingredient that is most populous in smog. It is caused largely by the mixing and reactions of various chemical molecules such as oxides of Nitrogen (NOx) and volatile organic compounds (VOC). Cars, power plants, industrial boilers, refineries, chemical plants, factories, large warehouses etc. react to sunlight. The wind is also responsible for the spread of ozone because it carries the O3 and other particulates from urban to rural areas. (https://www.epa.gov/ground-level-ozone-pollution). As stated earlier, it has been determined by studies that ionization technologies for both indoor and outdoor air cleaners and purifiers create ozone at ground level which is harmful. Ozone is considered a lung irritant. People with asthma, bronchitis, emphysema, COPD are highly susceptible to exposure of ozone, and can cause coughing, lung and throat pain or irritation, difficulties in breathing, wheezing and other symptoms. [xii, xliii]

Summary of Methods Used

It was important to exploit the weaknesses from these current underperforming technologies to understand where the performance output from the new engineering services and technologies would have to focus and energize better results. Some of those weaknesses included harmful side effects (such as the output of ozone (O3) from ionization), a lack of the ability to integrate the technology within place HVAC systems, excessive number of airflows runs through the

systems, exceptional loud noise, untimely consistent and often filter maintenance, as well as the overtly large footprint of the systems themselves. These limitations all had to be addressed.

Additionally, was the minimum performance that was provided for the large size of the investment and time that was spent to implement and operate those same technologies was simply inadequate and inefficient. Research showed that many harmful ultrafine particulates such as NOx, Sox, NH3, H2S and others that were less than 100 nanometers in size were not able to be detected or removed by either the employment of ionization technologies or the methods brought by centrifugal scrubbing which are currently typical in many commercial applications. The solution had to arrive at a capability to detect and collect these smaller ultrafine harmful particulates. The collection of these harmful particulates was also important to ensure that safe handling of the collection of those harmful particulates would enable continued safety from any impact these particulates could share with internal or external environments harmful to the operators of the system or those that existed or worked or lived in the environment.

Solution

A revolutionary solution has been built. Its use of specific history tested electromagnetic force law formulas provides the foundation for success regarding detecting particulates that are as small as 1 nanometer. This capability has been demonstrated multiple times and evidence has been posted publicly. Over 25 years of engineering and design research have gone into the delivery of technology that is patented in country's worldwide, with the EU even taking lead administration of the Patent. There are 65 patents established worldwide, with two remaining pending patents in the United States and Canada.

That research unveiled the behavior in the properties of fine and ultra-fine dust. This led to the development of the air cleaning capabilities for indoor situations that maximized performance. The technology attacks the weaknesses of other known technologies, and the long-term research enabled the capability to understand how Important the management of the airflow was regarding the entire operation. This technology enables the system to be focused on providing not only marginal improvements to existing systems and technologies, but to maximize the ultimate capability in the detection of particulates in the air and collection and elimination of those same particulates.

This solution involves the use of four distinct activities. These four activities or events are Newton's Second Law of Motion, Van Der Waal's Force, a new innovative revised type of filter that is 95% more effective than HEPA filters with a twist where exhaust airflow is pushed rather than what some others do using the Pull method of sucking air through a system. All four of these elemental attributes of the Cirqulair system create an overall capability to be highly effective with the detection and collection (removal) of particulates as small as 1 nanometer. The technology contributes clean air to the environment and in support of human health while not contributing to any harmful side effects. Below explains how all four activities contribute to the success of the solution regarding the collection and elimination of fine and ultra-fine particulates work together.

Newtons Second Law of Motion

The second law of motion by Sir Isaac Newton, along with his first law of motion are critical laws of nature and play major roles in our environment. The second law of motion states "the acceleration of an object as produced by a net force is directly proportional to the magnitude of the net force, in the same direction as the net force, and inversely proportional to the mass of the object". The law essentially means acceleration is equal to Net Force (the sum of all the forces on an object, not just one) divided by the Mass of the object. In the case of the resultant being Force, the equation is F (Force) = F (Mass) times A (Acceleration).[xliv]

The application of this law toward the solution is that magnitude of the motion of an object (mass) change with the deacceleration and acceleration of the object (mass) which then considered together with the Force under Van Der Waal's Equation of State provides the foundation of the solution.

Van Der Waals "Force"

A special scientific theory of the definition of how the attraction of intermolecular forces between molecules is called Van Der Waals Force named after a Dutch physicist Johannes Diderik van der Waals, winner of the 1910 Nobel Prize in Physics. His contribution here was his cognizance that atoms had specific physical consequences from specific actions due to their size using the Van der Waals equation of state, which is the underlying science of molecular physics till this day.[10]

The primary description of Van der Waals theory on Force(s) is essentially based on the intermolecular forces between molecules. There are two versions of Van der Waals forces, by definition the first was weak London Dispersion Forces and the stronger dipole-dipole forces.[xlv]

Dipole-Dipole (having equal and opposite electric charges or magnetic poles having opposite signs and separated by a small distance interactions occur after two dipolar molecules interact with one another.[11] There is a pulling force (attraction) due to the "poles" (slightly negative part of one of the charged molecules is attracted to the similar type of partially positive part of the other molecule. It is true, opposites attract. The weaker form of Van der Waals Force, referred to as London Dispersion Force is weaker than the permanent dipole molecules generally due to the temporary nature of the either negative or positive charge of the molecules involved.[xlvi]

The cause and effect of both the Newton Second Law of Motion (acceleration and deacceleration of molecules causing collisions) and the added inclusive intended nature of Van der Waals Force, which induces further attraction of "neutral charged molecules" (remember that Van der Waals only works when molecules and atoms are very close to each other) forces continued collision of those same molecules, creating adhesion of sorts with the molecules,

[10] Wikipedia – Van der Waals radius. https://en.wikipedia.org/wiki/Van_der_Waals_radius
[11] Definitions of dipolar via Vocabulary.com

thus creating temporarily “larger” clumps of particles where the clumps are made up of similar or type of molecules and thus creating a larger dimension for the “clump” of molecules where advanced filtration systems are able to catch and collect these particles and eliminate them from the airflow stream.

Adaptive Means of Filter Design provides greater Efficacy.

Innovation is the primary evolving factor with the advent of building specialized filter systems that perform 95% better than even standard industry common HEPA filters, which then catch and collect the particulates in the airflow, many of which are much larger than their singular molecules are, given the engineering design of the system which creates much larger particles than they are as standalone molecules. The design form factor delivers high performance by forcing molecules to collide with one another, and then with a brief short lived but long enough attraction to each other, speeding through the filter at much larger sizes and getting collected, where if they had gone through the filter by themselves, they would have been too small to have been collected.

Airflow design and Management

Furthermore, the additional innovation to the solution is to create an environment that is an incubator of further opportunities for the molecules/particles to collide, effectively then attract each other so that efficiencies and efficacy metrics can improve to nearly 100% of all particulates are collected once in the filtration system. The innovation was to create an environment that would drive the airflow differently than most other system technologies. Most technologies utilize suction of air to “pull” air through mechanisms and filters which would create a more linear direction of the airflow.

The innovation is to “push” the air through which catalyzes further disturbance in the airflow causing additional collisions of molecules. Liken this to pulling a piece of paper underneath a pen or other light weight object. The piece of paper slides smoothly while it is pulled. However, if you push the piece of paper, the paper will often start to roll up, change direction and not go straight forward.

This activity causes further colliding of molecules allowing the application of Van der Waals Force to take effect, thereby allowing a higher efficiency and efficacy in catching even more particulates.

Conclusion and Summary

The solution is twenty-seven (27) years in the making, where extensive research into current methods of air cleaning produced the Cirqulair series of products and capabilities. The contribution of both Sir Isaac Newton’s Law of physics and influence from the Dutch scientist Van Der Waal Law of Force plus innovative design of filtering systems and distinctive airflow management methods have produced truly a revolutionary capability to remove air particulates

as small as 1 nm in size from the air in only one take and in a very efficient manner. The ability to integrate patented science with the real-world situation has produced a very effective and adaptable technology which will assist in bringing about a cleaner global environment and a healthier human population. Scaling from 300 m3/hr airflow to 30,000,000 m3/hr airflow provides a certain latitude in design and form factor to answer most any critical requirement to detect and remove air pollutants from the air before it can cause additional harm to the environment and to human health.

The Cirqulair unit technology provides significantly improved power efficiencies over other designs. Its cleansing of the volume of air passing through the system in one run, where if any pollutant can be removed in one run, then energy wise, the unit will use less energy than other systems which must "cycle the same air through the systems multiple times" to get to optimized performance levels. This allows less energy consumption, for example, if a comparison of 99% efficiency with the results of a Cirqulair unit, then power use is ten times more efficient.

Added to the above technology, another activity produces further results in improved productivity where prior measurements are the foundation in addressing the final commercial solution for the removal of any ambient air pollutant. Combinations of new and existing techniques with the Cirqulair units allow custom applications which will address problems that were considered impossible to deal with otherwise.

Summary of Program Development

- Twenty-Seven years of research and design
- Newton's Second Law of Motion
- Dutch Scientist Van der Waal's Physics Contribution
- Adaptive Means of Filter Design provides greater Efficacy.
- Airflow design and Management

Differentiation Points – Why is Cirqulair for You

- Scales from Exhaust Pipe to entire Warehouse to Industrial Size Smokestacks
- Patented Technology leveraging Science, Math, and Real-World Dynamics
- Proven Demonstration of Performance
- Does NOT harm the Environment in its effort to Clean the Air
- Performs as Promised, produces ZERO particulates as small as 1 nm.

Benefits to the User

- Produces zero particulates as small as 1 nm.
- Filter changes are required at longer intervals.
- Reduces business exposure to government fees and fines.
- Cleans the air for the home and the business and the environment.

In closing, the technology which provides solutions to detect and remove particulates harmful to both health and the environment is the base foundation for the Cirqulair Unit which is a patented air cleaning device that will take out any kind of ambient air pollution in one run with an efficiency of over 99,99999997%. The Cirqulair is capable of scaling to large industrial applications that none of the competition can match.

The advantages of clean ambient air are many but include:

- Better General Health
- Less Illness
- Less Headaches
- Better Sleeping and Rest Cycles
- Less chance of developing Cancer, Dementia, Parkinson's disease, etc.
- Provides direct benefit and relief to those suffering from Asthma, COPD or Hay fever

The technology has multiple use forms, including both the Cirqulair which is considered the SMOG killer and the QuBA (Quick Breath Analyzer). The QuBA is a registered trademark and fully validated to detect any communicable virus. It does so without the need for prevalent testing, without waste material and 99,99999997% accurate. QuBA can detect Corona, Sars, RS, bird flu, influenza or any other humanly spread airborne virus, and the Cirqulair can detect and remove most fine and ultrafine particles (from 1nm (nanometer)) and up as well as big dust particles (from 1 nanometer upwards) is taken out in just one run (one airflow run through the system).

- Airflow Management and Customization from 300m3/hr to 30Mil m3/hr
- Adaptable application to the use case environment
- Measurable results that show impact of improvement of air quality
- Maintenance costs are low, given filters can last six months or longer before cleaning.
- The airflow restrictions due to pressure drops constituted by filtration systems are managed positively, given to multiple reasons:
    - Ventilation system power can handle up to 1200 Pa in pressure drop is more than able to handle the pressure metrics.
    - Efficiency in performance of one run for air cleansing is much more efficient in the Cirqulair system than others who must run the same amount of air sometimes up to thirty times before arriving anywhere near the level of particulates removed from the airflow that Cirqulair does.
    - The efficiency of the one run to cleaning air provides longer life spans for filters.
    - Due to the number of runs (30) of same airflow needed by other systems 200 Pa each run-in comparison to Cirqulair's one run of the same air, means the Cirqulair can collect an estimated three times more mass in particulates and still be five (5) times more efficient.

Applications for Cirqulair:

Hospitals, offices, workshops, home use, transport for boats and road use, industrial exhaust cleaning, open ambient air pollution cleaning (Cirqulair Smog killer), generators, military protection against dirty bombs, field hospitals, mining industry etc. Governments, Institutions and Enterprise may even be able to qualify for carbon credits depending on their situation.

The above capabilities are based on the principle to let particles collide and to accumulate and scale in size, so they can be detected and collected in a safe and easy way. The system is patented in over 50 countries and pending in another 19 countries. The possibilities to put the Cirqulair Units to use are endless.

If the information above provides you with positive feedback on the issues you are having with your commercial production environment, please give Cirqulair's team a call. There is something for everyone.

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