DIAGNÓSTICO DE MADUREZ TECNOLÓGICA Y EVIDENCIA CIENTÍFICA SOBRE:

“GENERADORES DE IÓNES PARA SU USO EN LA SANITIZACIÓN DE ESPACIOS CERRADOS”

La presente investigación tecnológica especializada, corresponde a un análisis detallado de la evidencia científica disponible para evaluar la tecnología de iones negativos en general y en particular de la tecnología integrada en el equipo FB MASK (iON GO), distribuido por Diasa Internacional S.A. de C.V., como una tecnología adecuada para la protección personal contra partículas nocivas y patógenos. Se sabe que en el mercado existen gran cantidad de filtros que funcionan a través de iones negativos los cuales se encuentran en una fase 9 de desarrollo según la escala TRL de la NASA, es decir, son productos completamente desarrollados y disponibles para la sociedad.

Abarcando 4 puntos principales:
1) Qué son y cómo se producen los iones negativos para la mejora de la calidad del aire. Tecnología incluida en FB MASK (iON GO).
2) Tipos de partículas eliminadas con la tecnología iónica: humo, polen, alergenos, bacterias y virus.
3) Tipo de partículas, iones generados, cantidad y límites de toxicidad.

En general, esta revisión describe la tecnología de iones negativos para la purificación del aire en interiores.

✓ Proporcionan una comprensión común del estado de madurez de una tecnología.

✓ La gestión del riesgo de un determinado proyecto podrá tener en cuenta el grado de madurez de la tecnología.

Tecnología de iones negativos del equipo Mask (iON GO) distribuido por Diasa Internacional, de acuerdo con el distribuidor.

El Mask (iON GO) es un PAP diseñado para colgarse alrededor del cuello (Figura 1), distribuido por Diasa Internacional y comprende:

1. Un generador de iones.
2. Un conjunto de eliminación de ozono que contiene un catalizador para eliminar el ozono del aire.
3. Un sistema de control que mide una cantidad de partículas en el aire y energiza el generador de iones basándose al menos en parte en la cantidad medida de partículas en el aire;
4. Un dispensador de iones de acero inoxidable configurado para recibir corriente eléctrica en respuesta al funcionamiento del sistema de control,
5. Un electrodo interno acoplado eléctricamente al dispensador de iones, comprendiendo el electrodo interno una hoja de aluminio perforada,
6. Un tubo de vidrio dispuesto al menos parcialmente alrededor del electrodo interno, y
7. Un electrodo externo dispuesto al menos parcialmente alrededor del tubo de vidrio, comprendiendo el electrodo externo una pantalla de malla tubular de acero inoxidable, comprendiendo el método los pasos de:
    a. Activar el generador de iones del sistema de ionización para generar iones negativos, en donde el generador de iones genera más iones negativos que iones positivos, el generador de iones dispuesto al menos parcialmente dentro de un conducto de calefacción, ventilación y aire acondicionado (HVAC, por sus siglas en inglés);
    b. El aire pasa por el generador de iones y adquiere iones negativos; y
    c. Hacer pasar el aire a través del catalizador de eliminación de ozono rodeando al menos parcialmente el generador de iones para eliminar el ozono del aire.

Figura 1. Imagen del purificador de aire iónico Mask (iON GO), distribuido por Diasa internacional.

PALABRAS CLAVE: iones negativos, iones negativos para la sanitización, generación de iones negativos, purificadores iónicos reducción de aerosoles en espacios confinados, ionic air purifiers health effects.

REVISIÓN TECNOLÓGICA

Se revisaron distintas bases de datos e información comercial disponible en la web, de los cuáles a continuación se muestran los resultados más relevantes, junto con un extracto de la información:

BASE DE DATOS / SITIOS	RESULTADO DESTACADO	RESUMEN
ACADÉMICO/ INVESTIGACIÓN Springer link Science direct Google scholar Google patents	Evaluation of ionic air purifiers for reducing aerosol exposure in confined spaces	Ionic air purifiers have become increasingly popular for removing dust particles, aeroallergens and airborne microorganisms from indoor air in various settings. While the indoor air cleaning effect, resulting from unipolar and bipolar ion emission, has been tested by several investigators, there are still controversial claims (favorable and unfavorable) about the performance of commercially available ionic air purifiers. Among the five tested ionic air purifiers (two wearable and three stationary) producing unipolar air ions, the units with a higher ion emission rate provided higher particle removal efficiency. The ion polarity (negative vs. positive), the particle size (0.3-3 microm) and properties (NaCl, PSL, Pseudomonas fluorescens bacteria), as well as the body temperature and breathing did not considerable affected the ionization-driven particle removal. The data suggest that the unipolar ionic air purifiers are particularly efficient in reducing aerosol exposure in the breathing zone when they are used inside confined spaces with a relatively high surface-to-volume ratio (such as automobile cabins, aircraft seating areas, bathrooms, cellular offices, small residential rooms, and animal confinements). Based on our experiments, we proposed that purifiers with a very high ion emission rate be operated in an intermittent mode if used indoors for extended time periods. As the particles migrate to and deposit on indoor surfaces during the operation of ionic air purifiers, some excessive surface contamination may occur, which introduces the need of periodic cleaning these surfaces.
	Negative Air Ions and Their Effects on Human Health and Air Quality Improvement	Some studies have suggested that Negative air ions (NAIs) had multiple health benefits on humans/animals, might inhibit the growth and/or kill some of microorganisms and promote plant development, but some of the results need to

		be further verified, some references might overestimate its benefits and no consistent or reliable evidence in therapeutic effects were achieved. However, to our knowledge, no data showed the harmful effects of NAIs on humans/animals. Superoxide ions are key members of NAIs and have been involved in the biological effects of NAIs by regulating the serotonin level and other biological actions but some reports showed no significant effect of NAIs on the concentration or turnover of serotonin. On the other hand, evidence showed that NAIs could high-efficiently remove PM including ultrafine PM, providing an alternative way to clean indoor air especially during haze episodes. We have also reviewed the plant-based NAI generation system by PEF stimulation. More efforts should be input into this system to further improve it and to use it as a high-efficient NAI generator and PM removal system.
	Particles Removal by Negative ionic Air Purifier in Cleanroom	This study investigated effectiveness of negative ionic air purifier in lowering the concentration of particles in a closed test chamber. The performance test was carried out in a closed test chamber under natural decay, as well as with an air mixing mechanism. Compared with natural decay, the air mixing mechanism could reduce particles concentration better (under the flow field condition). However, air change rate effect is limited in super cleanrooms that require suitable approaches to enhance control of particles concentration and to raise the effective cleaning rate of negative ionic air purifier. This study investigated the concentration gradient of particles at various heights and distances from the source of negative ions. Experiment results indicate that performance near the negative ionic purifier was better than in the rest of the cleanroom. In terms of height, the highest removal efficiency was observed at a height of 60 cm from the floor; it decreased substantially with increase in height. The empirical curves fit based for the concentration gradient of NAI generated was developed for estimating the NAI concentration at different heights and distances from the source of negative ionic air cleaner.
	Bactericidal action of positive and negative ions in air	In the study seven bacterial species (Staphylococcus aureus, Mycobacterium parafortuitum, Pseudomonas aeruginosa, Acinetobacter baumanii, Burkholderia cenocepacia, Bacillus subtilis and Serratia marcescens) were exposed to both positive and negative ions in the presence of air. In order to distinguish between effects arising from: (i) the action of the air ions; (ii) the action of the electric field, and (iii) the action of ozone, two interventions were made. The first intervention involved placing a thin mica sheet between the ionisation source and the bacteria, directly over the agar plates. This intervention, while leaving the electric field unaltered, prevented the air ions from reaching the microbial samples. In addition, the mica plate prevented ozone produced from reaching the bacteria. The second intervention involved placing an earthed wire mesh directly above the agar plates. This prevented both the electric field and the air ions from impacting on the bacteria, while allowing any ozone present to reach the agar plate. With the exception of Mycobacterium parafortuitum, the principal cause of cell death amongst the bacteria studied was exposure to ozone, with electroporation playing a secondary role. However in the case of Mycobacterium parafortuitum, electroporation resulting from exposure to the electric field appears to have been the principal cause of cell inactivation.
	Application of corona discharge-generated air ions for filtration of aerosolized virus and inactivation of filtered virus	The effect of corona discharge-generated air ions on the filtration of aerosolized bacteriophage MS2 was studied. A carbon-fiber ionizer was installed upstream of a medium-efficiency air filter to generate air ions, which were used to charge the virus aerosols and increase their filtration efficiency. After the virus aerosols were captured by the filter for a certain time interval, they were exposed to a newly incoming air ion flow. Captured virus particles were detached from the filter by sonication, and their antiviral efficiency due to air ions was calculated by counting the plaque-forming units. The antiviral efficiency increased with ion exposure time and ion concentration. When the concentration of positive air ions was 107

		ions/cm3, the antiviral efficiencies were 46.1, 78.8, and 83.7% with exposure times of 15, 30, and 45 min, respectively. When the ionizer was operated in a bipolar mode, the number concentrations of positive and negative ions were 6.6×106 and 3.4×106 ions/cm3, respectively, and the antiviral efficiencies were 64.3, 89.1, and 97.4% with exposure times of 15, 30, and 45 min, respectively. As a quantitative parameter for the performance evaluation of air ions, the susceptibility constant of bacteriophage MS2 to positive, negative, bipolar air ions was calculated as 5.5×10−3, 5.4×10−3 and 9.5×10−3, respectively. These susceptibility constants showed bipolar ion treatment was more effective about 1.7 times than unipolar ion treatment.
	Effectiveness of Negative Air Ionization in Removing Airborne Porcine Reproductive and Respiratory Syndrome Virus (PRRSV)	Porcine Reproductive and Respiratory Syndrome virus (PRRSV) causes a disease that is endemic in the hog industry. Aerosol transmission of PRRSV is a possible way for outbreaks of PRRSV to occur in hog barns. It is critical for contaminated aerosols to be removed from ambient air entering hog barns to prevent airborne transmission of PRRSV. Chamber experiments were performed to determine if Negative Air Ionization (NAI) was an effective method of removing aerosols containing PRRSV from the air. The effectiveness of NAI was determined at ventilation rates of 34.0 m3 h-1 and 135.9 m3 h-1and aerosol generation rates of 14.8 and 33.0 ml hr-1 by assessing the aerosol concentration and PRRSV concentration before and after the activation of the NAI system. The aerosol concentration was measured with an aerosol particle size spectrometer. Air samples collected with Biosamplers were analyzed using Quantitative Reverse Transcription Polymerase Chain Reaction (qRT-PCR) to quantify the PRRSV concentration in the air. The effectiveness of the NAI system at reducing aerosol and PRRSV concentration was dependent on the ventilation rate of the chambers. The mean reduction in aerosol concentration was 96% and 68% to 78% for ventilation rates of 34.0 m3 h-1 and 135.9 m3 h-1, respectively. The mean reduction in PRRSV concentration was 90% and 68% to 73% for ventilation rates 34.0 m3 h-1 and 135.9 m3 h-1, respectively.
	Evaluation of Pollutant Emissions from Portable Air Cleaners	A new generation of portable standalone air cleaners relies on photocatalytic oxidation, plasma generation and microbial thermal inactivation. These technologies can generate potentially harmful byproducts, including volatile organic compounds (VOCs), ozone, ultrafine particles (UFP) and/or reactive oxygen species. Emissions originating from six portable air cleaners were investigated using a 20-m3 room-sized environmental chamber under realistic conditions. Pollutant concentrations were determined with the air cleaners operating in clean air and in the presence of a challenge VOC mixture. Four devices removed between 8% and 29% of VOCs at rates between 600 and 1700 µg h-1, while the other two emitted VOCs at rates of 300 – 1400 µg h-1. Two devices showed good particle removal efficiency, reducing the UFP number concentration by 35% to 90%. Primary emissions (e.g., 85 µg h-1 toluene) and secondary oxidation byproducts (e.g., 16 µg h-1 formaldehyde) were observed. One device emitted very high ozone levels (up to 6 mg h-1), which also produced UFP in the presence of VOCs, reaching concentrations of 3 x 103 particles per cm3. Modeling results using chamber-derived emissions rates suggested that ozone emitted by one device can exceed regulatory levels.
	Unpowered portable negative-ion air purification method CN104329757A	The invention discloses an unpowered portable negative-ion air purification method and belongs to the fields of air purification and building environment science. A negative ion purification technology is taken as a principle, a battery is used for driving a negative ion generator to generate a large number of negative ions, the negative ions are discharged into the air and are combined with the air to form negative oxygen ions, and various physical and chemical processes are generated to remove pollutant particles, so that a clean and healthy local microenvironment is created without fan power. The power suitable for battery usage and human body carriage is selected by checking the power, equipment is integrated and the battery

		is arranged to realize convenience in carrying. The whole set of method comprises the negative ion generator, the battery and a brush for releasing the negative ions. The method has the characteristics of no pollution, no mechanical power, no noise, high efficiency, convenience in carrying, generation of negative oxygen ions beneficial for human body health and the like. Through actual detection, PM2.5 can be reduced from 200mu g/m<3> to 35mu g/m<3> in ten minutes. Meanwhile, the set of method can be combined with different equipment and used in different places, the structure is simple and the price is low.
	Bactericidal effects of negative and positive ions generated in nitrogen on Escherichia coli	The bactericidal effect of both negative and positive ions generated by a dc electrical corona in nitrogen were investigated. Tryptic soy broth agar plates inoculated with Escherichia coli (E. coli) (strain DH5-α) were placed into a custom-built multi-point-to-plane ion generator situated within a glass chamber. Under a nitrogen atmosphere the plates were exposed to either negative or positive ions for various time periods. The plates were then removed and incubated at 37°C for 15 h and the colonies counted. Exposure to either negative or positive ions produced significant reductions ($p<0.05$) in colony number. Bacterial plates exposed to a constant 200 μA negative current for 30 min demonstrated a 65% reduction in colony number compared to unexposed plates. Increasing the exposure current to 400 μA, further increased the level of disinfection at 30 min to 91%. Exposure to 200 μA current of positive ions produced a 72% reduction after 10 min and virtual sterilisation after 30 min with a 98% reduction in colony number. These results indicate that exposure to negative and particularly positive ions has a lethal effect on E. coli cells. Cell death could be due to a physiological change in the outer membrane as a result of ionic interactions.
	Bactericidal effects of negative and positive ions generated in nitrogen on starved Pseudomonas veronii	Bacterial cells in natural populations are rarely at exponential phase due to insufficient availability of nutrients. Suppression of cell division due to starvation is one of the most common forms of initiating stationary phase. Once initiated, cells at stationary phase are considerably more resistant to a host of challenges. The bactericidal effect on stationary phase cells of both negative or positive ions generated by a d.c. electrical corona in nitrogen was investigated. Bioluminescent Pseudomonas veronii cells, resuspended in sterile water and starved for , were inoculated onto aluminium foil coupons and placed into a custom-built multi-point-to-plane ion generator situated within a plastic chamber. Under a nitrogen atmosphere the coupons were exposed to either negative or positive ions for various time periods. Following exposure, cell viability was determined by the measurement of light output recorded from foil coupons using a luminometer and converted to colony forming units per millilitre. Exposure to either negative or positive ions produced significant reductions ($p<0.05$) in cell viability. These results indicate that exposure to either negative or positive ions has a lethal effect on starved Pseudomonas veronii cells. Cell death could be due to ionic puncturing of the cell wall as a result of ionic accumulation at the outer membrane.
	Ozone emissions from a "personal air purifier"	Ozone emissions were measured above a "personal air purifier" (PAP) designed to be worn on a lapel, shirt pocket, or neck strap. The device is being marketed as a negative ion generator that purifies the air. However, it also produces ozone within the person's immediate breathing zone. In order to assess worst-case potential human exposure to ozone at the mouth and nose, we measured ozone concentrations in separate tests at 1, 3, 5, and 6 in. above each of two PAPs in a closed office. One PAP was new, and one had been used slightly for 3 months. Temperature, relative humidity, atmospheric pressure, room ozone concentration, and outdoor ozone concentration also were measured concurrently during the tests. Average ozone levels measured directly above the individual PAPs ranged from 65–71 ppb at 6 in. above the device to 268–389 ppb at 1 in. above the device. Ozone emission rates from the PAPs were estimated to be 1.7–1.9 μg/minute. When house dust was sprinkled on the top grid of the PAPs, one showed an initial peak of 522 ppb ozone at 1 in., and then returned to the 200–400 ppb range. Room

		ozone levels increased by only 0–5 ppb during the tests. Even when two PAPs were left operating over a weekend, room ozone levels did not noticeably increase beyond background room ozone levels. These results indicate that this "PAP," even without significant background ozone, can potentially elevate the user's exposures to ozone levels greater than the health-based air quality standards for outdoor air in California (0.09 ppm, 1-hour average) and the United States (0.08 ppm, 8-hour average).
	https://news.mit.edu/2019/mit-process-could-make-hydrogen-peroxide-available-remote-places-1023	They developed a process could lead to a simple, inexpensive, portable device that could produce hydrogen peroxide continuously from just air, water, and electricity, providing a way to sterilize wounds, food-preparation surfaces, and even water supplies.
	Negative air ionisation and the production of hydrogen peroxide	The present study focuses on the production of H2O2 in relation to small negative air ion generation in indoor air, by using a corona discharge from a carbon fibre thread emitter attached to an extra high-tension (EHT) negative voltage generator. A specially designed interactive gas-phase reactor (IGPR) was used to assess in real time, the concentration of gaseous H2O2 in indoor air (with varying relative humidity levels), exposed to negative ionisation. The air in the IGPR was ionised by corona discharge from a carbon fibre thread emitter, charged with a variable negative voltage (7.5–0 kV). Small negative air ion concentrations measured within the IGPR ranged from 0–21,000 ions cm3 of air. H2O2 concentrations ranged from 0.46 mg l1 in ordinary air (RHB40%) to 936 mg l1 in wet air (RHB96%). This study demonstrates that it is possible to produce and measure in real time, low concentrations of gaseous H2O2 in indoor air, exposed to negative air ionisation.
	Sensitivity of Candida albicans to negative air ion streams	Negative air ions (NAIs) are known to kill C. albicans; however, their precise mechanism of action is uncertain. Elucidation of this has been hampered by a lack of reproducibility between results obtained by different investigators. The aim of this study was to determine the influence of variation in experimental parameters on the sensitivity of C. albicans to negative air ions and the role of ozone in this process. Ten strains of C. albicans were exposed to NAIs generated at different emitter distances, exposure times, relative humidities and under aerobic and oxygen-free conditions. In further experiments, ozone levels were measured under the same conditions. The effect of NAIs on C. albicans growth was assessed by measuring the area of the zone of inhibition generated around the electrode of the ionizer. There was a significant reduction in area of zone of inhibition with increasing emitter distance ($P < 0{\cdot}05$), relative humidity($P < 0{\cdot}05$) or under oxygen-free conditions($P < 0{\cdot}05$). Increases in exposure time resulted in a significant increase in growth inhibition ($P < 0{\cdot}05$). Ozone levels increased with increasing exposure times ($P < 0{\cdot}01$) but were significantly reduced as emitter distance increased ($P < 0{\cdot}01$). When utilized in a nonventilated room, levels of ozone produced did not exceed recognized safety limits. These results (a) demonstrate the importance of careful control of experimental parameters if reproducibility of studies involving NAIs is to be achieved, and (b) highlight the possible role of ozone in the microbicidal effects of NAIs.
	Efficacy of radiant catalytic ionization to reduce bacterial populations in air and on different surfaces	Air contamination by biological agents is often observed in medical or veterinary facilities and industrial plants. Bioaerosols may sediment and pose the surface contamination. Microorganisms present on them may become a source of infections among humans and food contamination. This study determined the use of oxidative gases, including ozone and peroxide, generated by the Radiant Catalytic Ionization (RCI) cell for the inactivation of Acinetobacter baumannii, Escherichia coli, Enterococcus faecalis, Pseudomonas aeruginosa, Salmonella Enteritidis, Listeria monocytogenes, Staphylococcus aureus, Streptococcus epidermidis, Bacillus subtilis, Clostridium sporogenes, Candida albicans, Aspergillus niger and Penicillium chrysogenumon in air and on different surfaces.

		Results showed that oxidative gases produced by the RCI cell reduced all tested microorganisms. The full elimination of studied microorganisms from the air was obtained for E. coli and C. albicans. RCI also proved to be an effective method of eliminating microbes from the examined surfaces. Regarding of the species, strains origin and the type of surface, the reduction rate ranged from 19.0% for C. albicans to over 99% for A. baumanii. For both, air and surface, the most resistant to RCI was C. sporogenes spores, for which the percentage reduction rate ranged from – 2.6% to 71.2% on the surfaces and was equal 71.7% in the air.
	Ionized hydrogen peroxide comprehensive plasma sterilization technology CN103920176A	The invention discloses an ionized hydrogen peroxide comprehensive plasma sterilization technology (normal temperature and pressure dissociation technology) and relates to the technical field of sterilization. Equipment used in the ionized hydrogen peroxide comprehensive plasma sterilization technology mainly comprises a machine and a control system, wherein the machine mainly comprises a sterilizing agent conveying system, a carrier gas conveying treatment system and a plasma generation module. The ionized hydrogen peroxide comprehensive plasma sterilization technology is used for solving the problems of long formaldehyde fumigation time and harm of residues to human bodies and meanwhile solving the problems that a gasified hydrogen peroxide sterilizer (high-temperature dissociation technology) needs to perform turbulence on sterilization environments, and otherwise, the problems of slow gas diffusion, sterilization dead angles and high requirements on environment temperature and humidity exist (the requirements on environments, facilities and the level of operators are high). The equipment for realizing biological purification through the ionized hydrogen peroxide comprehensive plasma sterilization technology has the advantages of small size, low energy consumption, low requirements on space, small corrosivity, relatively fast sterilization speed and good sterilization effect.
Productos en el mercado	Intelligent HEPA UV ionizer air purifier CA-510Pro Green Air Encore HEPA and Odor Fighting Filter Air Purifier with IonCluster Technology 1000 sq. ft. Envion by Boneco – Ionic Pro Platinum – Negative Ion Air Purifier Tower	Very silent and sleepmode! 10dB(A) Efficiency of the filter of 99,97% / 0,3 µm 8fold OFT filtration system Digital monitoring of air quality! CADR certified See more at: https://www.cleanairoptima.com/air-purifiers/intelligent-hepa-ionizer-air-purifier-ca-510pro/i/313/#sthash.kbs6Zig9.dpuf Three-stage air filter system along with IonCluster technology Comes with four operating modes Has an air quality color changing light indicator Has an automatic air filter change indicator This Ion Air Purifier Tower is suited for medium to large-sized rooms and is great at sanitizing and removing 99.9% of allergens. It starts by creating negative ions before releasing them into the air and providing you with air that's both clean and fresh. Since it has got a compact size it also seamlessly fits into a variety of areas easily.

NOTAS DE LA REVISIÓN

Efectividad de las NAI's contra bacterias y mohos.

Diversos estudios (Digel y col., 2004; Noyce y Hughes, 2003; Noyce y Hughes, 2002; Shargawi y col., 1999; Pratt y Barnard, 1960) mostraron que los gases oxidativos producidos por los generadores de iones negativos, incluido el ión superóxido, pueden tener una función en la inactivación de:

- Acinetobacter baumannii, Escherichia coli, Enterococcus faecalis, Pseudomonas aeruginosa, Salmonella Enteritidis, Listeria monocytogenes, Stacourecusclococo. epidermidis, Bacillus subtilis, Clostridium sporogenes, Candida albicans, Aspergillus niger y Penicillium chrysogenumon en el aire y en diferentes superficies.
- Siendo más resistentes las esporas de C. sporogenes.

Efectividad de las NAI's contra los virus.

Son pocos los estudios de los efectos de las NAI's sobre los virus, uno de los más completos fue el llevado a cabo por La y col., 2018, quienes estudiaron los efectos del virus del síndrome reproductivo y respiratorio porcino (PRRSV, por sus siglas en inglés) causa una enfermedad que es endémica en la industria porcina.

Ellos realizaron experimentos en cámara para determinar si la ionización de aire negativa (NAI) era un método eficaz para eliminar aerosoles que contienen PRRSV del aire:

La efectividad de NAI se determinó a tasas de ventilación de 34.0 m^3 h^{-1} y 135.9 m^3 h^{-1} y tasas de generación de aerosol de 14.8 y 33.0 ml h^{-1} evaluando la concentración de aerosol y la concentración de PRRSV antes y después de la activación del sistema NAI.

La concentración de aerosol se midió con un espectrómetro de tamaño de partículas de aerosol. Las muestras de aire recolectadas con Biosamplers se analizaron usando la Reacción en Cadena de la Polimerasa de Transcripción Inversa Cuantitativa (qRT-PCR) para cuantificar la concentración de PRRSV en el aire.

Encontraron que la eficacia del sistema NAI para reducir la concentración de aerosol y PRRSV depende de la tasa de ventilación de las cámaras.

La reducción media de la concentración de aerosol fue del 96% y del 68% al 78% para tasas de ventilación de 3.0 m^3 h^{-1} y 135.9 m^3 h^{-1}, respectivamente. La reducción media en la concentración de PRRSV fue de 90% y 68% a 73% para tasas de ventilación de 34.0 m^3 h^{-1} y 135.9 m^3 h^{-1}, respectivamente, demostrando la efectividad de la tecnología.

Efectividad de las NAI's en la remoción de partículas finas o micropartículas.

Las micropartículas son uno de los principales contaminantes del aire que afectan la salud humana, siendo aquellas partículas con un tamaño de 2.5 micrómetros las más nocivas, con datos de mortalidad que estiman que, en 2010, 3.2 millones de personas murieron a causa de este tipo de partículas. Asociándose además con enfermedades del sistema respiratorio y del sistema cardiovascular (Jiang y col., 2018).

Encontrándose que la deposición de partículas en el tracto respiratorio solo se mejora para partículas con muchas cargas, lo que solo se puede lograr con un ionizador en un espacio cerrado.

En este sentido las NAI son capaces de cargar eléctricamente a estas micropartículas provocando su precipitación y depósito al adherirse a superficies cercanas y adherirse entre sí y asentarse más rápido por cuestiones de densidad y gravedad (disponible en línea: https://www.epa.gov/indoor-air-quality-iaq/guide-air-cleaners-home).

Ahora bien, un efecto secundario de los ionizadores es la emisión de ozono, que es un oxidante poderoso. El ozono tiene el potencial de dañar nuestra salud por exposición prolongada y/o en dosis altas. Los estudios mostraron que muchos generadores de NAI provocan la generación de ozono, pero lo hacen en dosis muy bajas dentro de los límites de tolerancia permitidos, no habiendo encontrado evidencia de toxicidad documentada. De hecho, este efecto secundario puede considerarse como un desinfectante adicional (Phillips y col., 1999).

Límites de exposición en purificadores de aire personal.

Como se mencionó en el párrafo anterior las emisiones de ozono son un efecto secundario que pueden presentar estas tecnologías y se vuelven más relevantes en dispositivos purificadores de aire personal (PAP). Este tipo de purificadores se colocan alrededor del cuello, en la solapa o en el bolsillo de la camisa, quedando la emisión de NAI's en la zona de respiración inmediata de la persona.

Diversos estudios han medido la exposición al ozono por la boca y nariz, así como factores ambientales como temperatura, humedad relativa, presión atmosférica. Encontrándose que (Grinshpun, 2005; Phillips y col., 1999):

- Los niveles promedio de ozono medidos directamente por encima de los PAP individuales oscilaron entre 65 y 71 ppb a 6 pulgadas por encima del dispositivo y 268 a 389 ppb a 1 pulgada por encima del dispositivo.
- Las tasas de emisión de ozono de los PAP se estimaron en 1.7–1.9 µg/minuto.
- Estos resultados indican que este PAP, incluso sin ozono de fondo significativo, debe usarse de manera intermitente para evitar, con el uso prolongado del equipo, elevar la exposición del usuario a niveles de ozono mayores que los estándares de calidad del aire basados en la salud para el aire exterior en California (0.09 ppm, promedio de 1 hora) y los Estados Unidos (0.08 ppm, promedio de 8 horas).
- Los productores de estos PAP han subsanado este problema al incluir en los filtros generadores de NAI's un catalizador eliminador de ozono.

Conclusiones

1. La tecnología NAI tiene múltiples beneficios para la salud, comprobándose la reducción de alergenos y microorganismos.
2. No se han demostrado efectos nocivos de las NAI en humanos o animales.
3. Los iones superóxido son unos de los principales iones involucrados en el proceso de desinfección.
4. No se han encontrado problemas relacionados con cambios en niveles de neurotransmisores como serotonina por las NAIS.
5. La evidencia demuestra que los NAI llevan a cabo una eliminación eficiente de micropartículas ultrafinas (menores a 3 micrómetros), por lo que es una tecnología eficiente en la purificación del aire interior.

En caso de dudas o no contar con la versión digital completa de este documento, puede solicitarlo al Centro de Patentamiento IPN "Ing. Guillermo González Camarena" a la extensión 57014 con la Dra. Amor Monroy Villagrana correo amonroyv@ipn.mx

Nota: Cabe señalar que este informe es solo una opinión del especialista que la elaboró, y serán únicamente los inventores quienes tengan los elementos finales para juzgar la pertinencia de la relevancia y diferencia de los antecedentes, y el uso de los mismos para la toma de decisiones posteriores en el proceso de Patentamiento.

¿Esta búsqueda cubrió sus expectativas?

El Centro de Patentamiento IPN, para poderle brindar un mejor servicio, desearía escuchar su opinión. Cualquier comentario o sugerencia acerca de este servicio de Información Tecnológica son bienvenidos.

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Ciudad de México, a 03 de febrero de 2021
SECTEI/DGDIT/026/2021
Asunto: **Evaluación de dispositivos de emisión de peróxido de hidrógeno**

DRA. AMOR MONROY VILLAGRANA

P R E S E N T E:

Por medio de la presente la Dirección General de Desarrollo e Innovación Tecnológica de la Secretaria de Educación, Ciencia, Tecnología e Innovación (SECTEI), amablemente le comunica que recibió a través de correo electrónico el informe técnico “Reactor Fotocatalítico Generador de Peróxido para su uso en la sanitización de espacios cerrados” en atención a la solicitud hecha por esta Dirección mediante el oficio SECTEI/DGDIT/323/2020 para la evaluación técnica de dispositivos de emisión de peróxido de hidrogeno, a través de procesos de fotocatálisis, emisión, limites de toxicidad y eficiencia para la eliminación de virus y bacterias.

Como experta en el área de transferencia tecnológica y fotocatálisis, su informe nos permite conocer el adecuado funcionamiento de las tecnologías que ponen a consideración de la SECTEI en atención a la pandemia por COVID-19, como es el caso de los generadores de peróxido de hidrogeno, equipos distribuidos por la empresa DIASA INTERNACIONAL S.A. de C.V., por lo que agradezco su apoyo para evaluar dicha tecnología.

Sin otro particular, aprovecho la ocasión para enviarle un cordial saludo.

ATENTAMENTE

DR. JOSÉ BERNARDO ROSAS FERNÁNDEZ
DIRECTOR GENERAL DE DESARROLLO E INNOVACIÓN TECNOLÓGICA

C.c.c.e.p. **Dra. Rosaura Ruiz Gutiérrez**. Secretaria de Educación, Ciencia, Tecnología e Innovación de la Ciudad de México.

Ciudad de México, a 09 de febrero de 2021
SECTEI/DGDIT/034/2021
Asunto: **Evaluación de dispositivos de emisión de peróxido de hidrógeno**

C.P. JOSÉ LUIS VILLAR ARGUERO
DIRECTOR GENERAL
DIASA INTERNACIONAL S.A. DE C.V.

P R E S E N T E:

Por medio del presente, la Dirección General de Desarrollo e Innovación Tecnológica de la Secretaria de Educación, Ciencia, Tecnología e Innovación (SECTEI), amablemente le comunica que recibió los resultados de la evaluación hecha por la Dirección de Servicios Empresariales y Transferencia Tecnológica (DSETT) del Instituto Politécnico Nacional a través de la Dra. Amor Monroy Villagrana, mediante el informe técnico "*Reactor Fotocatalítico Generador de Peróxido para su uso en la sanitización de espacios cerrados*" y en el cual se analiza la Fotocatálisis Oxidativa en lo general a los dispositivos de emisión de peróxido de hidrogeno, a través de procesos de fotocatálisis, emisión, limites de toxicidad y eficiencia para la eliminación de virus y bacterias.

Estos resultados favorables realizados por la Dra. Monroy, experta en el área de transferencia tecnológica y fotocatálisis, a través del informe nos permite conocer el adecuado funcionamiento de las tecnologías que se ponen a consideración de la SECTEI en atención a la pandemia por COVID-19, como es el caso de los generadores de peróxido de hidrogeno, equipos distribuidos por la empresa DIASA INTERNACIONAL S.A. de C.V., por lo que agradezco su iniciativa en poner a disposición dicha tecnología.

Sin otro particular, aprovecho la ocasión para enviarle un cordial saludo.

ATENTAMENTE

DR. JOSÉ BERNARDO ROSAS FERNÁNDEZ
DIRECTOR GENERAL DE DESARROLLO E INNOVACIÓN TECNOLÓGICA