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Novel Application of High Voltage Electrostatics Corona Ions Discharge Related to Treatment, Sanitization and Disinfection of Biological Matter Such HIV-AIDS Infected Blood

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Abstract: A novel high-voltage electrostatics corona ions pre-charger apparatus and methods were invented earlier by Hamade related to treat various types of receptors such as but not limited to electret polymer, air filters, particulates, catalytic converters, bioaerosols, fluids, pollutants, virus, and bacteria. It is shown in this article that his work led to the construction of various prototype chargers, customized differently for each type of a receptor. In particular his recent development of biological matter corona charger (BMCC) prototype related to expose, treat, sanitize, and disinfect bioaerosols, virus, bacteria, and contaminated fluids and blood such as human immunodeficiency virus (HIV) - acquired immune deficiency syndrome (AIDS). It is shown in this paper that each previous investigated research contemplated ionized corona charger attendant to a charging process and the corona, imparts and provides enough treatment charges to receptors including the aforementioned receptors. Researchers often relied on adopting prior corona charger methods that do not necessarily and effectively solve the problems associated with them or utilize them for optimum treatment effect. The inventor exhaustively studied the characteristics of corona discharge, and has found that the greatest difficulty in corona discharge has to do with the maintenance of the corona, particularly when the receptor is being charged. This is due to variations in either the dielectric value between the corona electrode and a grounded base or flaws in the design as the receptor passes there between suppressing or hindering corona and its effectiveness. What is needed in-the-art is an apparatus and method to achieve maximum possible charge on a receptor, a charge order of magnitude greater than that used by other investigators. This often requires customizing each apparatus and method and does not just merely use one type of a charger to satisfy all applications. To satisfy this need, we build a low cost prototype BMCC that generates self-sustaining charge corona, eliminates many previous design flaws such as spark over, and make it ready for testing remotely or with apparatus.

Key words: high voltage, corona ions discharge, disinfection, acquired immune deficiency syndrome (AIDS), infected blood, electret, emission catalytic converter
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0 Introduction

It has been known that corona charge and electrical fields can be utilized in various applications to impart charge into receptors for various treatment purposes. This is similar to the common applications of laser, except that conventional chargers and electrical fields are intruded with the presence of a receptor, while laser radiation zaps a receptor without the receptor affecting the radiation source. Early on, Hamade[1] realized the need of developing a corona and high voltage electrical field that can genuinely affect a receptor but without the receptor affecting and intruding the charger or the electrical field (similarly to using laser non-intrusively). Even with and without such development, corona and high voltage electrical fields are commonly used in research and fabrications to treat receptors, such as electret fabrication, in printing, air filtration, bioaerosols, biological and contaminated blood fluids treatment, catalytic and chemical conversions, and so on.

What remained in the art was to develop sources of corona charger and electrical fields that would deliver maximum charge on a receptor with tasks to keep the sources unaffected, self-sustainable, can be controlled and used stationary or remotely, deliver optimum charge, and be free from flaws that can cause spark over, electrical short and hazards. These seem impossible tasks to accomplish in one prototype, however,

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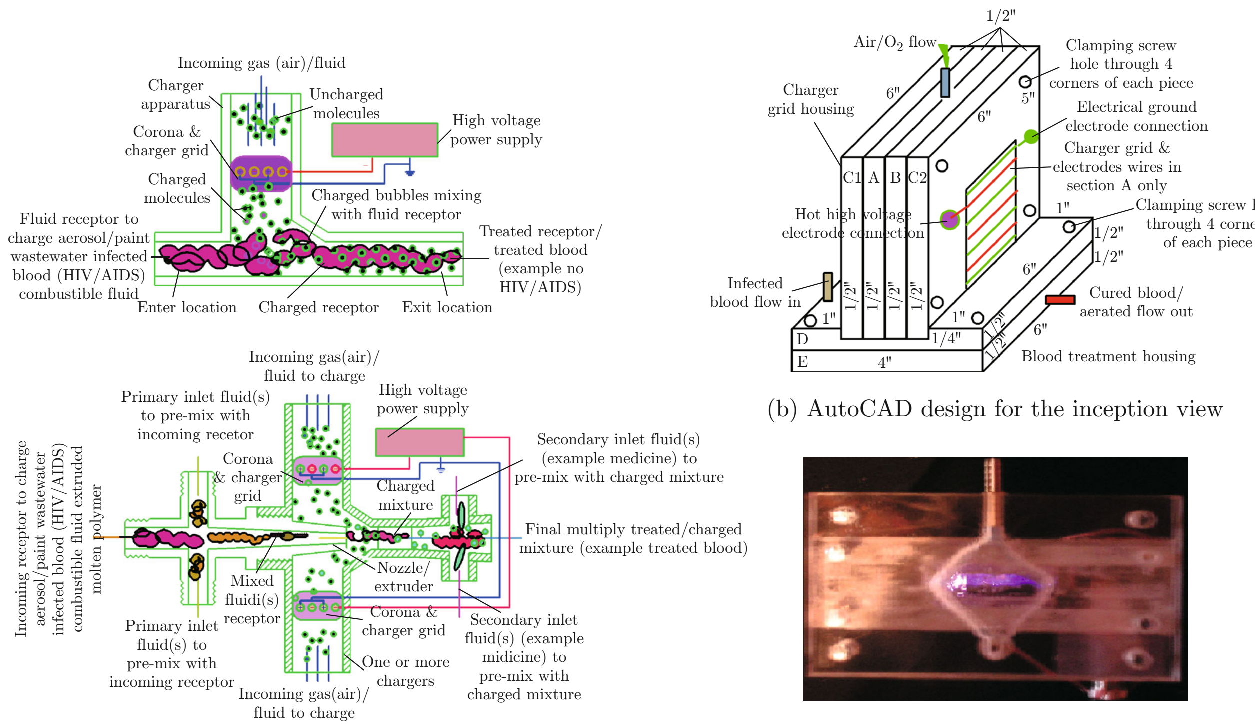
our exhaustive investigations showed that many of such tasks can be achieved by carefully balancing research concepts with practice and come up with a genuine effective workable prototype. As an example, Fig. 1(a) shows our patented[1] concept view (sketch) of biological matter corona charger (BMCC), Fig. 1(b) shows conversion of concept to design (1 inch (1″) = 2.54 cm), and Fig. 1(c) shows the constructed prototype in action creating air corona ions that transported into a receptor treatment section. In Fig. 1(c) air was the receptor which would be substituted by biological fluid to mix with the blown corona ions. In either view, the receptor does not intrude the charger section, however, corona charges (ions) can be transported innovatively into the receptor without affecting the self-sustaining corona generator (charger electrode wires).



(a) Inception view

(b) AutoCAD design for the inception view

(c) Actual bottom view of corona action with air (no biological matter ever tested)

Fig. 1 Biological matter corona charger perception as shown by the invention[1]

The schematics and photo in Fig. 1 are simulated views where no actual receptor was present and no activities were ever conducted with any biological matter since this part of testing is to be left to qualified medical researchers. The inventor[1] is the author of this paper and only had to relate the invention to treatment of biological substances to get the patent, and such treatment is not recommended. Also, it is beyond the scope of this paper to conduct medical research and treatment of biological matter.

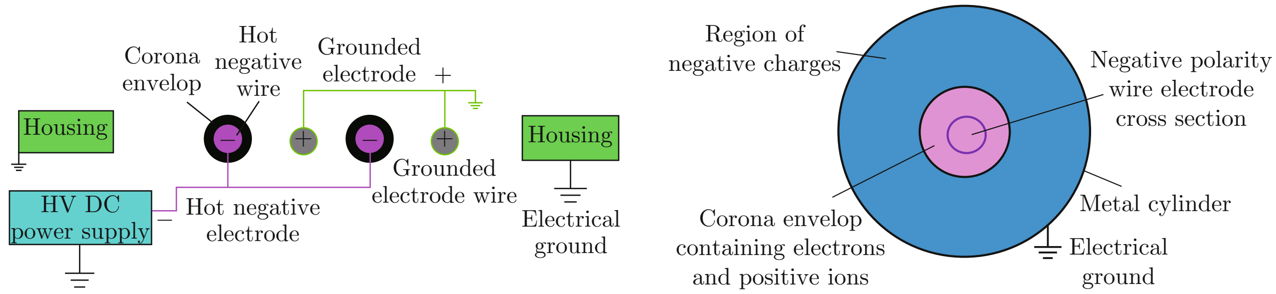
We developed novel charger designs that can be stacked to deliver 3-dimensional corona fields to engulf a receptor (such as an auto exhaust catalytic converter[2]) for maximum treatment without suppressing the corona source[1-3]. We built prototypes where the charger and electrical fields sections can be attached or detached from the receptor housing (in case of needed maintenance and reuse). The developed prototypes can be adopted remotely or intimately with an apparatus for the treatment of receptors. Some of the work published and patented[1-3], while other designed prototypes are still to be investigated for diverse applications related to treatment of receptors.

All the references in this paper used corona and electrical fields to treat some sort of a receptor. Important applications relating corona and electrical fields to treat and disinfect receptors include: bioaerosols, bacteria, viruses, and contaminated blood with human immunodeficiency virus (HIV) - acquired immune deficiency syndrome (AIDS). AIDS, first reported in the early 1980s, has been a center of concern in global and has taken the lives of almost 25 million people. Its etiological agent HIV is threatening over 60 million persons who have been infected and even more people with infection[4]. A vast number of researchers developed apparatuses and methods to treat and disinfect the HIV-AIDS, in particular the use of corona and electrical fields for such treatments and for disinfecting other viruses, bacteria, and biological substances. In this paper we investigated apparatuses and methods seldom used by researchers to show the benefits and the flaws in adopting their methods to treat biological matters with corona ions. In References [5-9], the apparatus showed a biological receptor intruding the charger source, hindering the charger effectiveness in treating the receptor. While our BMCC apparatus (see Fig. 1) was designed to prevent such intrusion to treat receptors more effectively than the intruded case and to provide self-sustaining coronas, which do not get diminished by a receptor.

1 Description of Prior Work

1.1 Corona and Electrical Field Mechanisms

The first book about this work can be found by White[10] when he attempted to electrically separate particles from gases using negative corona discharge from a wire. However, no precise theory is found in literature describing transport corona for multiple wire corona chargers such as those deployed in our work. How corona ions interact with other matter such as a receptor is more complicated to predict, particularly when electrical fields are applied in conjunction of the charger and a receptor matter. The theoretical work is beyond the scope of this paper. Hilczer and Malecki[11], and Moore[12] also investigated wire and sharp objects corona generation and transport. Most emitters use positive (+) polarity because corona ions are more stable than the case when negative (–) polarity emitters are used. More complicated process is involved when a negative polarity emitter is used to cause similar ionization of gas molecules but a much more complicated process is involved with secondary electron emissions made possible by increases in the charge intensity[12]. Positive polarity emitters are selected and emphasized in previous work because they have the ability to hold much higher currents and voltages for charging[10]. As far as we know the construction of an effective charger that treats a receptor matter is the art of our work. Construct chargers with alternated polarity of grid wires between (+) and (–) as shown in Fig. 2. Reverting the design to another uniform polarity electrodes of (+) or (–) polarity is easy. This creates an optimum operating environment for treatment of a receptor since we are able to separate the charger wire grid section from grounded surrounding to prevent spark over. Corona discharge and high voltage (HV) electrical fields are subjects of great interest for our applications because of their possible commercialization. Next sections demonstrate some of the applications.



(a) Hamade[2] multi-wire charger (b) White[5] single wire charger

Fig. 2 Corona charger wire patterns

1.2 Electrically Stimulated Filtration (ESF) Corona and Electrical Field Effects on Air Filters

Masuda[13], Jaisinghani and Hamade[14], investigated corona and electrical fields influence on gaseous fluids (mainly air), with or without pollutants such as suspended aerosol particles and particulates in the open and across air filtration media. They concluded that exact theory and mechanisms on how electrical fields and corona presence treated receptors such as aerosol and air pollutants, are complicated to predict. Their multi-wire two dimensional corona field chargers outperform the charging effect of single wire and the charger performance of Masuda. Jaisinghani et al.[14-16] and Kuplicki[17], also concluded that dielectric receptors such as dioctyl phthalate (DOP) aerosol particles are more susceptible to be charged from corona ions than the polarization of electrical field. Jaisinghani et al.[14-16] showed that an ESF apparatus produced the greatest filtration efficiency when compared with similar test but in the absence of the electrical stimulation. Their ESF apparatus involved the positioning of multi-wire grid charger upstream of a filter and the filter sandwiched between two opposite polarity perforated metals electrodes connected to the same power source as the charger.

Their ESF produced high filtration efficiency compared to similar tests without electrical enhancements. This work showed that ordinary filter efficiency can be enhanced to be as effective as a high efficiency penetration air (HEPA) filter but much less pressure loss and longer lifetime before replacement. The ESF work solved many grid design problems and many flaws in previous designs, spark over, minimized effect of humidity on power consumption by insulating the filter media from the electrodes, and optimized charger design but the charger wires had the same polarity. A typical ESF test apparatus is shown in Fig. 3.

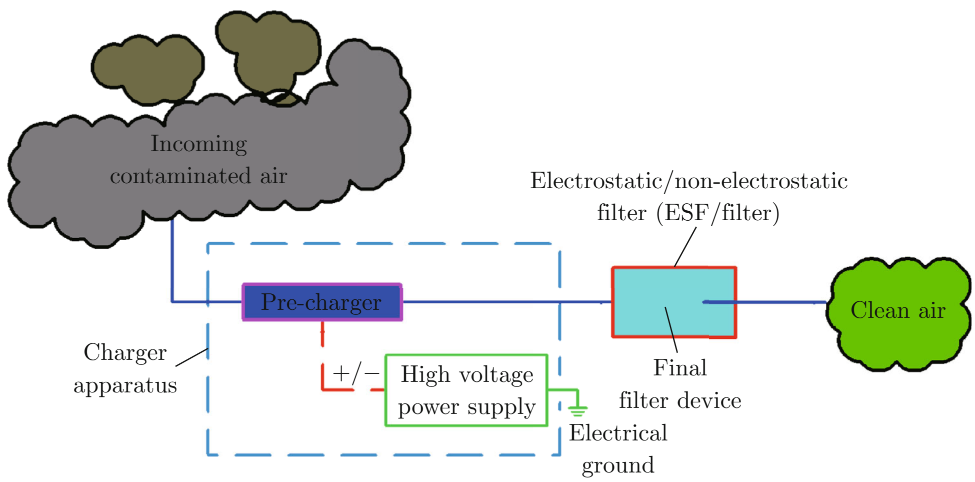


Fig. 3 Typical ESF test apparatus (electrodes powering ESF filter not shown)

Later, Hamade[1] and Kuplicki[17] found alternative wire grid design that outperforms the prior ESF chargers and gives better insight on optimizing corona chargers in treating a receptor such as an aerosol. We practically adopted their charger technique but innovatively converted the charger concept for the treatment of different receptors such as those deployed in enhancing a catalytic converter or making an electret.

1.3 Novel Electrically Stimulated Catalytic Converter (NESCC)

In automobile vehicle exhaust systems, catalytic converters are widely used to reduce unwanted emissions from internal combustion engines but they are bulky and expensive. Catalytic converters are also used on many engine-equipped machines including generator sets, forklifts, mining equipment, trucks, busses, trains, etc., to treat the exhaust from engines of these machines and to reduce pollutants. Since our chargers in the patent were designed and modeled to treat a receptor matter during fabrication of electret material (see next section), this work was extended to treat an automobile catalytic converter with corona.

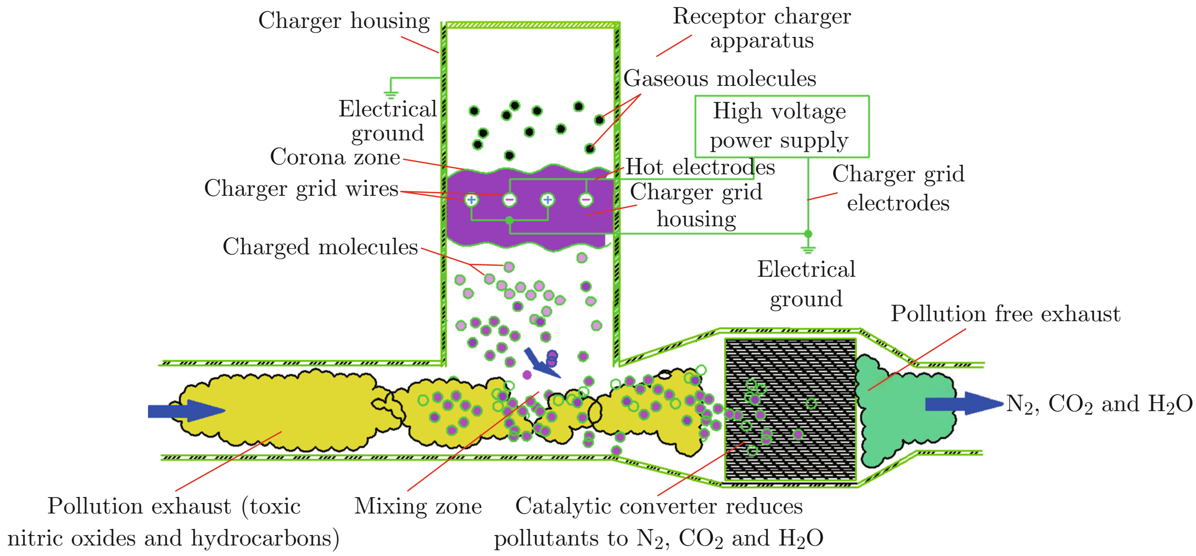
A conventional catalytic converter was electrically stimulated with corona using a novel prototype that was built recently but described as a concept design in the granted patent[2]. The prototype has commercialization potential since it relates to reduction in auto exhaust emission relative to conventional converters, reduction in size, weight, and pressure loss across the converter. Also, the prototype development can be seen in the patent review paper was submitted for pending publication with this paper[18]. The novel constructed prototype resulting from exhausted efforts in converting a concept patented[2] design (Fig. 4(a)) to practical auto computer-aided design (CAD) design ((Fig. 4(b)), is then followed by an actually constructed prototype (Fig. 4(c)).

1.4 Fabrication of Electret

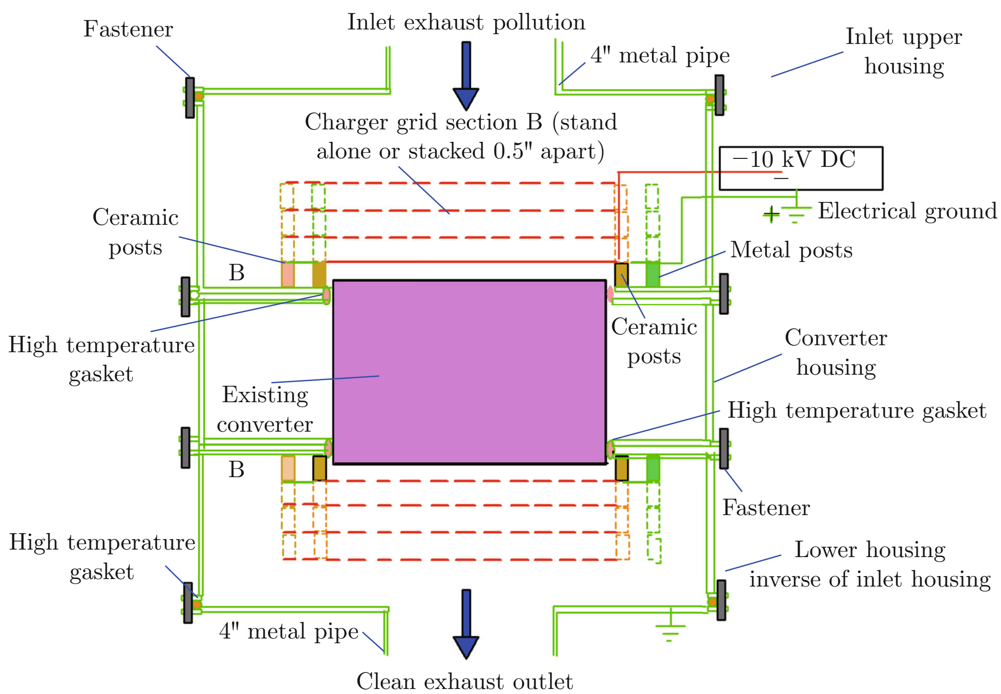
Electret fibers are commonly used to replace HEPA filters because of their lower pressure loss and enhanced filtration efficiency. They are commonly used in cigarettes as filters and also in hospitals as surgical masks. Conventional fabrication includes charging a dielectric polymer (plastic) such as Teflon with corona ions or an energy radiation source. Depending on the charger application and on the electric properties of the polymer, treated polymers tend to hold an electric charge that is much greater than the triboelectric static charge. So, electrets have potential in many commercial products. Electret charge mechanism, how electret fibers capture aerosol and pollutants, and electret commercialization can be found in literature[5,19-21].

Our invention described a novel apparatus that was used to generate an electret. The same concept apparatus was also used to treat receptors in general such as the catalytic converters or for use with BMCC.

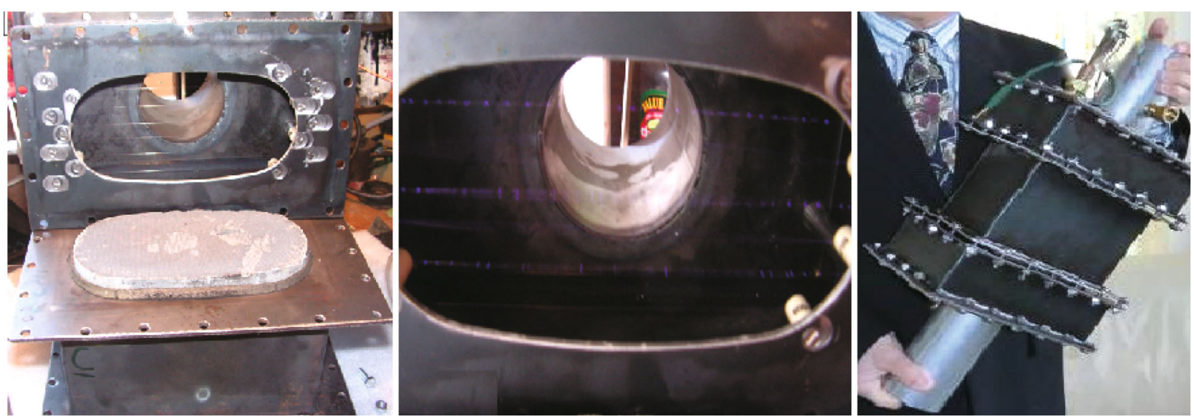
Hamade and Pickwick[19,22] showed that their corona chargers can be more effective in charging electrets than conventional corona charge methods since the electret receptor does not intrude the charger section and thus avoids suppressing the corona. A typical schematic for the charging apparatus is shown by Fig. 5(a). In the apparatus, corona was blown over the surface of an electret polymer to be treated, in a way as to prevent the polymer from suppressing corona. This was a clear advantage over conventional electret corona charging methods that fed the electret between corona electrode wire and its electrode collector, suppressing corona depicted by view of Fig. 5(b).



(a) Patented concept

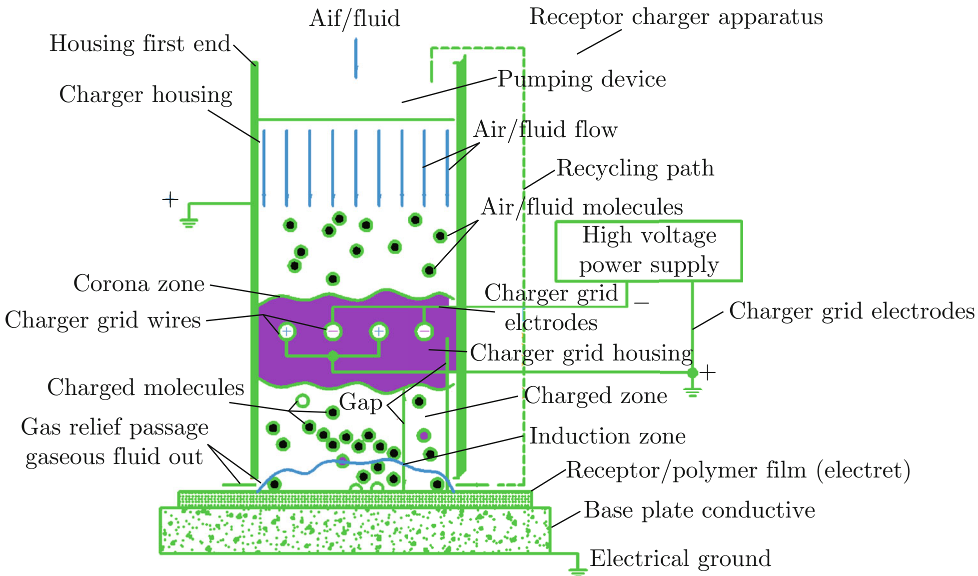


(b) Conversion of concept to AutoCAD design

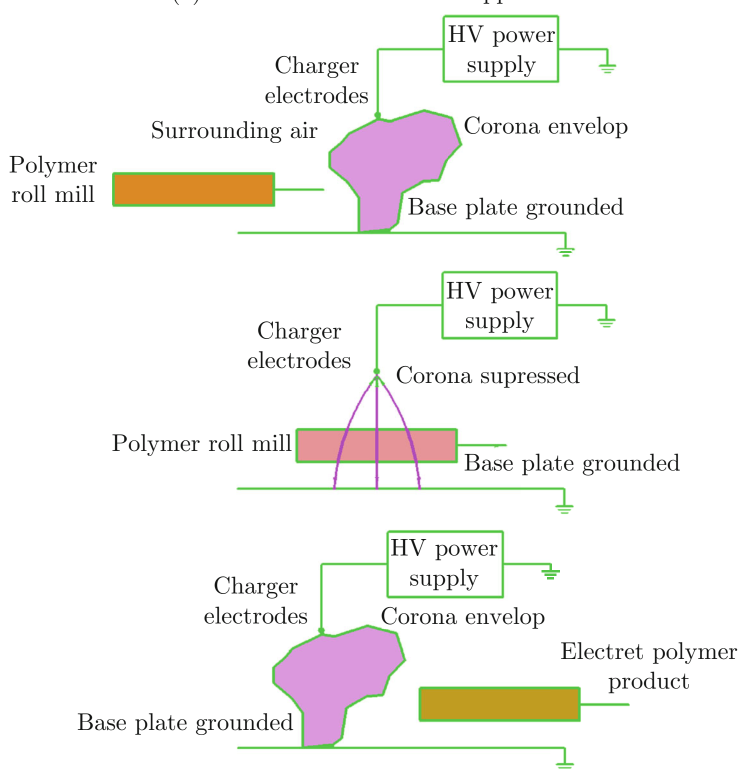


(c) Converted design to actual prototype

Fig. 4 Invented[2] electrically stimulated catalytic converter



(a) Hamade and Pickwick's apparatus



(b) Conventional apparatus

Fig. 5 Electret fabrication methods

1.5 Relating Corona Work to Treatment of Biological Receptors

A prior invention[2] described the utilization of various concept designs of corona charger apparatus using high voltage electrostatics for optimally charging, treating, sanitizing and disinfecting biological substances such as pollutant fluids, animal organisms, bacteria or virus, bioaerosols, infected blood with various diseases including AIDS and other sexually transmitted diseases (STD), and so on. The biggest obstacle was to convert such concepts into a real prototype in use. The prototype was built and presented in the next section. The receptor would only occupy the reception area without interfering with the charger grid wires. Because of our exhaustive work on investigating corona and electrical fields, we decided to focus on deployment of chargers for treatment of receptors and not to add external high voltage electrical fields this time since at the same conditions, corona chargers are more effective in charging a receptor[14-17].

There was some doubt on how the invention and the prototype would relate to the treatment of biological substances since we never conducted any research related to treatment of biological matters with corona. However, that did not prevent us from obtaining patents[1] that relate to the potential applications of our charger to treat biological matter. During patent search we found another patent of Kaali et al.[5] that showed their electrically conductive methods of using two wire electrodes inserted into a test tube vial containing contaminated blood with HIV-AIDS can effectively treat the virus, even with the small available currents (mA) and 1.5 V direct current (DC) battery. The results were not conclusive and did not provide clear evidence on that corona will treat the HIV-AIDS. But it was a sufficient evidence to argue that our corona chargers have so much high voltage power and corona ions that can eliminate HIV-AIDS. The United States Patent and Trademark Office granted us the patent that clearly outlines how our invention is related to the treatment, disinfection and sanitization of biological matter, such as virus, bacteria, and so on. That encouraged us to build a prototype for possible commercialization and licensing.

1.6 Corona Treatment of Biological Matter, Bioaerosols, Viruses, and Bacteria

We needed much greater evidence from the literature to promote the invention without having to conduct medical research with contaminated biological fluids since we are not qualified medical professionals or licensed to do so. Recently, we found the evidence of the effectiveness of corona in treating or eliminating virus and bacteria in literature[6-9], that we believe are sufficient enough to promote the prototype illustrated in Fig. 1 and detailed in the latter sections. This created the hope that our prototype can relate directly to the treatment of the biological matter including treatment of blood infected with HIV-AIDS. This topic is highly sensitive and controversial because of the harm and danger of this virus and any work with such blood fluids are highly regulated and restricted. We only want to present a charger apparatus prototype that can relate to testing and possible treatment of HIV-AIDS. The treatment is beyond the scope of our works to do that. However, qualified medical researchers in this field may want to investigate very carefully the utilization of our prototype.

It has been proven by research in the past several years that the corona charger has profound applications in medical field and has potential applications in treatment of virus. Lee et al.[7] showed that the process of electrical discharge as water treatment effectively inactivates a wide spectrum of microorganisms by multiple lethal actions caused by the formation of plasma ions. Also, they found effects of chemical oxidants, ultraviolet (UV) radiation, and pulsed electrical field were insignificant and the electric using a streamer corona discharge process (SCDP) does not produce toxic byproducts. The rapid inactivation of phage MS2 increased with the applied voltage streamer voltage. The emitter electrodes from the streamer were directly submerged in the water solution containing the microorganisms. This intrusion hinders the effectiveness of the streamer when compared to an ionized air corona charger. Our prototype would eliminate the intrusion problem since the generated corona mixes with the receptor away from the charger emitters so there is little chance of intrusion (see Fig. 1). We expect our corona charger can be much more effective in sanitizing and disinfecting water contaminants than the intrusive SCDP method.

This paper reintroduces our patented design that has higher efficiency of generation corona discharges than any other devices and investigated its potential applications in medical field, such as the treatment of virus-infected biological fluid.

Hyun et al.[6] studied the effect of corona discharge-generated air ions on the filtration of aerosolized bacterio phage MS2. Their experiments showed that the antiviral treatment efficiency increased as the amount of air corona ions increased. The test is indirect evidence that corona treated the virus since they used method similar to ESF to show that the presence of higher corona ions concentration reduces virus count. Also, they found that bipolar ion treatment was more effective than unipolar ion treatment. Their charger method was directly intrusive but somehow recessed into the duct and only few corona ions can treat the virus since corona is not across the entire flow section. Eventually, the receptor would contaminate the charger emitter and reduce its effectiveness. In contrast, our prototype charger in similar situation would avoid that and directly mix corona ions with the virus for maximum possible treatment (see Fig.1) and without possibly contaminating the corona emitters. In addition, our prototype can have much more corona emitters close to the proximity of the virus target receptors for greater charging effect.

Singh et al.[8] used pulsed corona plasma charger emitter needles for treatment and degradation of microorganism pollutants in aqueous solution. The pollutants are emerging contaminants from water bodies such as pharmaceutically active compounds (PACs), pesticides and personal care products contributing to environmental and detrimental health problems. The investigators treated the PACs with plasma that confirmed complete detoxification after 6 minutes of treatment. The plasma emitter electrodes were stationed above the solution (not intruding), however, the receiving electrode was submerged at the bottom of the solution to be treated. With their plasma generation set up, the plasma will be suppressed and not as effective as if the receiving electrode is near the emitter electrodes and not submerged in water. If they did that then plasma will also have minimum effect on treating PACs. However, if they used an apparatus similar to our charger in Fig. 1, then we expect the emitter corona to mix with the PACs solution and deliver much better treatment effect than the method of Singh.

Stepczynska[9] used a corona charger apparatus where the emitter of the charger was suspended above a receiver electrode, and then a contaminated slide sample of bacteria and fungus was conveyed between the electrodes to be treated. She showed that the applied corona discharges reduced the bacterial cells of *S. enteritidis* by three orders of magnitude, which also proves the effective biocidal action of the corona discharges. However, we can see from Fig. 5(b) that if we pass a substrate between the emitter then coronas can be suppressed if not eliminated. Then to induce corona, excessive high voltage must be applied that causes substantial flaws in the application such as spark over that diminishes the corona if not ceases it. So, investigators would have no choice but to operate a much lower voltage. Then the corona concentration decreases rapidly and the apparatus becomes not as effective in charging a receptor as the case we presented during fabrication of an electret (see Fig. 1(a)). If our method in Fig. 1(a) is used for her apparatus then we expect even much more effective treatment and elimination of the bacteria.

2 Development and Performance of BMCC

The corona charger grid wire concept design for BMCC was essentially the same as that was described in our patent[2] for the catalytic converter except it was reduced in size and retrofitted as shown by Figs. 1(b) and 1(c). The patent showed the performance of various charger grid designs we evaluated and also their charge performance. The final concept design for constructing the ESCC and the BMCC was influenced by various factors. For the ESCC charger, more emphasis was placed on optimizing the corona charge design to fit inside a metal housing that matches existing catalytic converters housing and also to prevent electrical shocks. The design is already shown in Fig. 4(b) and the prototype in Fig. 4(c).

Figure 6 shows more detailed design of the BMCC prototype. We opted to use a scaled down charger and the entire charger housed or encapsulated inside acrylic plastics (clear Plexiglas) housing. The entire apparatus without the power supply and its cables fit in a hand. The emitter electrode wires were tungsten metal, 4-mill standard strands for one prototype and another 6-mill one for the second prototype. Both prototypes used $-10\,\text{kV}$ and $-12\,\text{kV}$ subsequently before spark over (electrical breakdown). The wires were spaced 1/2 inch apart as detailed in Fig. 6. The charger section was recessed away from a receptor section so that a receptor can be hosted below the charger emitter and then the generated corona can be blown over the receptor without the receptor interfering with the charger emitter wires (see Figs. 1(b) and 1(c)). The details of BMCC are summarized in Fig. 6 and the detailed performance of similar charger grid design including their charging efficiency of a receptor such DOP aerosol are detailed in 2 inventions[1-2]. An important feature of the BMCC prototype is its light weight, very low cost (without the power supply), ability to separate the charger grid section from the receptor housing in case of need for replacement and reuse. The entire charger head and receptor housing can be easily separated from the power supply feed cables, disposable or reusable, and to be used remotely or in conjunction with an apparatus or machinery. This is an important feature if the BMCC is ever used for approved medication treatment in order to avoid transfer of treated contaminants from one application to another one.

3 Simple Procedure for Operating BMCC

Exact specifications and operation of the BMCC need to be developed when biological receptors are to be treated and also procedure of use may be regulated by government agencies and subject to safety rules requirements such as obtaining Underwriter Laboratories (UL) approval license. This is beyond the scope of our paper. However, special attention to the following should be noted:

(1) Charger grid design, wire spacing and position from ground plates.

(2) Charger power applications (kV and mA).

(3) Exposure or treatment time, frequency and recycling effect.

(4) Position of charger grid wires from the surface of treated fluid.

(5) Fluid flow channel design and depth.

(6) Flow rates of fluids and corona.

(7) Avoidance of operational problems such as excessive voltage and flooding of charger grid section with the receptor to be treated.

(8) Effect of purging and mixing during charging.

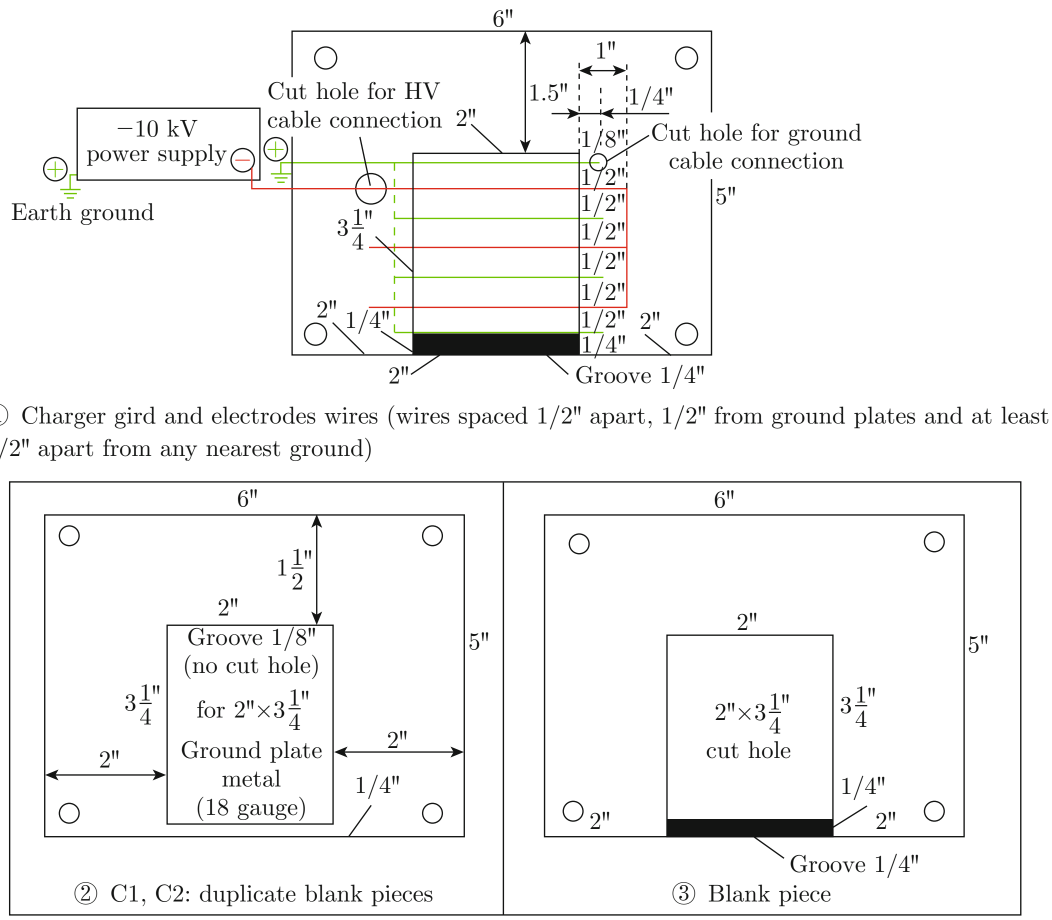
(9) Composition of corona fluid (air or oxygen feed).

(10) Addition of other enhancement fluids that may improve treatment of receptors.

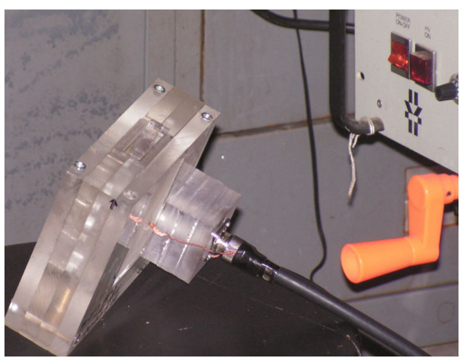
(11) Effects of temperature, humidity and pressure.

(12) Effect of sanitization prior to and during treatment.

(13) How often to repeat treatment.



(a) Detailed design of charger top portion



(b) Actual prototype

Fig. 6 BMCC AutoCAD design and actual prototype

4 Conclusion

This study has presented a charger grid wire design that outperformed any of the prior art chargers in generating the highest possible corona ions. Compelling evidences were shown that our BMCC has potential related to the treatment, disinfection, and elimination of various types of biological matter, including but not limited to viruses, bacteria, and infected blood with HIV-AIDS. Substantial efforts were exhausted in searching the literature and researching corona and electrical fields. Many patents were obtained and publications were written to show the expertise in designing and developing prototypes starting from inception to production. We conclude that the BMCC prototype and its similar prototypes have breakthrough potential related to biomedical treatment and fluid disinfection.

However, since we lack the medical research background and we didn't claim any expertise in the above medical research information, the medical applications of our corona charger grid design are only proposed for further research and information purposes. Future investigations are needed to find the interactions between coronas discharged receptors and human body cells and virus. Also, further evaluation is needed of the BMCC with or without a receptor such as using DOP aerosol in experimental setup similar to that described by Jaisinghani et al.[16], Hamade[22] and Kuplicki[17].

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