Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 11 [9] August 2022 : 23-27

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
REVIEW ARTICLE **OPEN ACCESS**

Thermal and Non-Thermal Plasma Technology for Human Health & Waste Management

O. Akbar Basha*, S. Mohammed Ghouse,
Annamacharya Institute of Technology and Science,Rajampet-516126
*Corresponding Author

ABSTRACT
Recently, the waste management needs new technology with enhanced environmentally friendly and cost free. Over a decade the disposal of waste materials became more valuable. Plasma technology seems to be promising way to treat waste materials in environmental benign without any adverse effects of combustion. The plasma technology makes use of energy of partially ionize gas, it referring to as the fourth state of matter. The excited and partial ionization of atom or molecules of gaseous state provides activated atoms which employee in the process of sterilization, synthesis and decomposition of materials. Thermal plasmas have been used for sterilization purposes in medical field. Irreversible plasma technology has been used in the purification of volatile organic pollutants. Now a days cold plasma technology has significant attraction towards researchers and it is still under investigation for its ability for sterilization of biomaterials. The non-equilibrium plasma is used to synthesis O_3 *, which can be used to oxidation of organic molecules and kill bacteria*
Keywords; thermal plasma, non-thermal plasma

Received 22.04.2022 Revised 11.06.2022 Accepted 24.07.2022

INTRODUCTION
The treatment of waste materials is one of the huge problems in the present days. Most of the countries some strict regulations have been implemented to restrict the dumping into landfills and in oceans [1]. Most of the waste materials are combustible and they have been degraded by burning which causes high gas flow rates and consequence high cost of off gas clean up. Besides most of wastes have been heated at low heating values and it the combustion of them consumes more fuel [2]. The plasma technology has the of high energy content of partially ionizable gas, mostly referred to as the fourth state of matter. In the plasma, the neutral or excited partial ionization of atom can be used as an electrical conductor.
The important differences between ideal gas and plasma is that plasma particles do interact [3-5], because of the electromagnetic coupling among charged particles and electrical, magnetic collective perturbations. The plasma can be varied from ideal gas by nonthermal plasma in which quite different temperature have been assisted with different species. In the case of cold plasma, the neutral or ions may be present at room temperature however, electrons may reach high temperature near to 104K. It is projected that 97.9% of planets and stars present in our universe are in the plasma state which have enormously huge surface temperatures. Our earth has not been excluded to the presence of the state of plasma. The intense cosmic rays coming from universe has been bombarding on the surface of our earth continuously [5]. The cosmic and solar wind radiation charges the species present in our earth which leads to the formation of an atmospheric shell, called the ionosphere which absorbs the UV rays arrived from sun. this absorption process further generates the charged particles like electrons which have been bounced by the magnetic field of the earth to poles which leads to formation of spectacular on northern hemisphere. Recent days the plasma state of matter can be generated in our laboratory by raising the mechanical, thermal, chemical, radiant and electromagnetic energies [6].
However, the fact is that numerous plasma waste treatment installations have been in operation for many years, and it is clear that prudent use of plasmas can offer distinct advantages in waste treatment[7]. The realization that waste streams can be a source of energy, and that plasmas can be useful to tap this source through controlled gasification ion processes, has further increased the number of plasma process developments[8]. One of the most widely used techniques for wastewater treatment is the advanced oxidation process (AOP) [9]. This method, which is based on the formation of reactive species ,is used in the inactivation of some bacteria such as *Pseudomonas aeruginosa*, *Cholera gravis*,

Escherichia coli, and *Salmonella typhi* because it can quickly oxidize and disinfect contaminants. Like photocatalysis, the AOP is a type of clean technology, wherein water pollutants are converted into CO2 and H2O. In 2018, Miklos et al. [10] reviewed the recent AOPs and main reaction mechanisms, as well as the formation of by-products in some main groups for contaminant removal from water. They showed that hydrotherapy, osmotic power, halophilic species, and evaporation ponds are the most efficient methods of eliminating by-products. AOPs produce large numbers of OH radicals for decomposing an extensive range of chemical compounds (e.g., halogenated hydrocarbons, pentachlorophenol, pesticides, herbicides, aromatic compounds, and more recently pharmaceuticals) [11–14]. Due to their high reactivity, OH radicals provide an effective means of decomposing complextoxin structures using a series of chemical reactions[15]. Free radicals and reactive oxygen and nitrogen species (RONS) are produced via the decay of water molecules by methods such as radiation and photolysis and then attack the pollutant molecules. Ozonation and use of hydrogen peroxide (H2O2) immediately assault the pollutants in combination with radiation, photolysis, or sonolysis. Catalytic technologies, such as photocatalysis, anodicoxidation, photoelectrocatalysis, fenton measures, and reactant ozonation, use combinations of irradiation, oxidation (ozone (O3), H2O2), and electrons, and serve as methods of creating free radicals and reactive species [16-20]. However, conventional advanced oxidation is not one of the best available or most cost-effective treatment techniques due to its requirement for additional equipment. For instance, AOPs that produce O3–H2O2 require O3production apparatus and H2O2 storage tanks. Therefore, extensive research has recently been conducted on finding a suitable method of cheap and efficient one-step production of RONS [21–24]. Undoubtedly, AOPs are worthy eco-friendly techniques for obtaining freshwater, but setting up the sources, such as UV sources, causes the initial cost to remain problem.To overcome these issues, a cost-friendly, versatile means of OH radical production that has been attracting increasing interest is plasma technology. Plasma is considered to be a fourth state of matter and is used in physics and chemistry to describe the condition of an ionized gas [25]. Plasma consists of electrons, ions, neutrals, photons, and electric fields. It is essential to provide energy to gas for ionization [26,27]. At high pressure, electron–neutral collisions occur frequently, and neutrals are got ionized. Energy transferfrom the electrons to the gas molecules leads to a thermal equilibrium state called thermalplasma. The electron density (ne) in thermal plasma is in the range of 1016–1019 cm−3[28]and is thus almost equal to the neutral density (nn = 1019 cm−3); further, the electron temperature (Te) and gas temperature (Tg) remain in the order of a few electron volts(eV) [29]. A few examples of thermal plasmas are corona discharge and electric arc [29]. At low pressure, ne of non-thermal atmospheric pressure plasma (NTAPP) is approximately108–1014 cm−3[29–31] and the electron–neutral impact energy is not sufficient to reach thermal equilibrium. Consequently, Tg is close to room temperature [29], Te remains in the range of a few electron volts, and only a few watts of power are consumed [32–35]. NTAPP can be produced in ambient air at standard temperature and pressure with the help of gases such as He, Ne, Ar, O, N, and air; thus, it does not require an expensive vacuum device. It is necessary to supply energy to ionize the gas [36–41]. After ionization, NTAPP is a bulk source of a mixture of various RONS such as OH radicals, superoxide (O2−), H2O2, atomicO, O3, singlet O (1O2), nitric oxide (NO), nitrite (NO2), nitrate (NO3), dinitrogen trioxide(N2O3), dinitrogen pentoxide (N2O5), atomic N; radicals, including charged particles such as ions and electrons; neutral O atoms; UV radiation; and an electric field [42].

The main useful advantages that a plasma offers to treatment processes are

(a) high energy densities and high temperatures, characteristics which allow:

- rapid heating and reactor start-up,
- high heat and reactant transfer rates,
- smaller installation size for a given waste throughput,
- melting of high temperature materials,
- high quench rates to obtain non-equilibrium compositions or metastable materials, and

(b) use of current as the energy source, resulting in:

- decoupling of the heat generation from the oxygen potential and the mass flow rate of oxidant or air,
- control of the processing environment,
- more options for the process chemistry,
- lower off-gas flow rates and consequently lower gas cleaning costs,
- the possibility of producing saleable co-products.

DISCUSSION

Plasma processing has been utilized in many industries such as cleaning and waste management, automotive and textile. Plasma involves green processes. when compared to wet chemical treatments , plasma is environmentally benign and it can producing small level by products in industry. Various classifications of plasma and their applications in health and medicine were broadly discussed.

Thermal Plasmas

The word cold plasma represents a condition were the energy of elections are much greater than ions [9]. By using appropriate power sources, both hot and cold plasmas were generated in laboratory. Some deposited films cannot withstand high temperature. Fragmentation of organic molecules to atomic levels have been induced in hot plasmas which has enormously high energy. when generating an arc discharge in a gas produces the thermal plasma further this can be altered with electric fields of varied frequency[42]. The thermal modification of a material can be done by ionizing a bundle of gas at high temperature. The uses of thermal plasmas require temperature gaseous reagents. The plasma processing technology mostly used in the extraction of metals the refining/alloying of metals/alloys, the synthesis of fine ceramic powders, spray coatings, and the consolidation and destruction of hazardous waste. Thermal plasma may involve some complex chemical steps in synthesis of nanoparticles and quenching chemistry.

Thermal Plasma in Waste Management

Almost 2.6 billion people need safe and affordable sanitation. many poor people are lack of good sanitation and health. The sanitation problems kindles lot of researchers universally to find the solutions that do not require water, energy or sewage infrastructure.

The small-scale processing facility gasifies the biomass in microwave produced temperature. Before the gasification step, optimal feed quality should be created. The generated off gas is fed to gas cleaning unit followed by solid oxide fuel cell to get back the energy required to generate microwave field.

the fast-heating rates, high processing temperatures, low off gas flow rate are some merits of plasma waste treatment. The waste materials are heated at high temperature and this involves combustion, pyrolysis, gasification and vitrification. Final result of the process depends on atmospheric conditions and nature of the material and on the quantity of atmospheric oxygen present in surroundings.

Solvents which have been used to remove oils, fluxes from surface cleaning process can promote corrosion and large volumes of waste. This large-scale cleaning process lead to generate huge volumes of solvents with different contaminants. Among these solvents, few of them can be recycled remaining should be disposed by some alternative ways such as plasma cleaning. In the alternative method, an object is immersed in a glow discharge plasma of suitable gas followed by bombardment of the surface with energetic ions which results in the removal of contaminates. Most of the industrial reactors are cleaned by applying oxygen or argon plasma to remove organic contaminants. The gas such as sulfur hexa fluoride is added to enhance the activity of oxygen plasma.

Thermal Plasma in Human Health and Medicare

The process of tissue removal, sterilization and cauterization have been treated by using heat and high temperature in a medicine. In previous days the wounds of warriors were treated by applying hot metal objects. Now a days the wounds have been treated by applying heat to surface layers of tissue by passing enough high electricity through it. Electrocautery is a new technique which applies controlling heat to surface area of tissue by sending sufficiently more current through it. However, contact of tissue with metal surface of a cautery machine often results in adhebit of charred tissue to the metal. Subsequently removal of the metal can peel the charred tissue away re-starting bleeding. The charred tissue has got adhesion to the metal. Hot plasma is employed to cut tissue which has been used for cosmetic re - structuring of tissue.

Non-Thermal Plasma

Cold plasmas, including low-pressure Direct Current and Radio Frequency discharges (silent discharges), discharges from fluorescent (e.g., neon) illuminating tubes, dielectric discharge-barrier plasma may be found both at low pressure or atmospheric pressure. There are several methods to generate cold plasmas. When charged particles are in the minority, heating of neutral molecules is limited. The effect of low pressure is double: in rare gas ionization events are scarce, which keeps the charge density low. Moreover, the frequency of elastic collisions between electrons and atoms/molecules is low, so electrons do not have much chance to convey their energy to the gas.

Non-Thermal Plasma in Waste Management

The phosphates and nitrates existed from fertilizers can affect the environment like water illness, eutrophication of the water bodies etc. these pollutants are treated with cold plasma by gliding electric discharge named glidarc. The 41.55% for phosphates and 86.24% fornitrates of above pollutants are abated by 20 minutes exposing to gliding discharge process. The pollutants exhausted by vehicle are harmful organic components which can be removed by plasma driven catalysis. The technology of low temperature plasma driven catalysis of nano-titanium dioxide and Au/Al2O3 catalysts were effective to the clearance of the vehicle exhaust gas

Non-Thermal Plasma in Human Health and Medicare

Some of sub lethal purposes such as genetic transfection, cell detachment, wound healing can be treated with non-thermal plasma. Non thermal effects can be used selectively for some living matter, while little effect on surrounding tissue. Most of the research focusing on the application of direct or indirect plasma treatment. Living tissue or organs play the role of one plasma electrodes, but some current may flow through living tissue in the form of either a small conduction current, displacement current orboth.A variety of water-containing solutions have been tested so far including pure water and water with various organic compounds. Our method of application of dielectric discharge-barrier plasma, reported previously, is unique and known as floating electrode dielectric discharge-barrier plasma . This discovery led us to develop this application to create an antimicrobial solution that can possibly be used to flush the contaminated surfaces of indwelling catheters to eradicate bacterial/fungal..

CONCLUSION

The treatment of waste materials and sanitation can be done with plasma process in both society as well as industries. The inert gasses and electricity is enough to operate. Most of waste materials can be degraded by using high temperatures. These things make plasma system very interesting for the treatment of hazardous waste. The organic gases exited during the process can be utilized as a fuel for energy. Plasma process can be handled to treat the process of sterilization and the treatment of different kind of skin diseases. The non-equilibrium plasma was shown to be non-destructive to tissue, safe, and effective in inactivation of various parasites and foreign organisms.

Acknowledgement

Authors acknowledge the great help received from the scholars whose articles are cited and included in references of this manuscript.

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CITATION OF THIS ARTICLE

O. Akbar Basha, S. Mohammed Ghouse. Thermal and Non-Thermal Plasma Technology for Human Health & Waste Management. Bull. Env. Pharmacol. Life Sci., Vol 11[9] August 2022: 23-27