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Evaluation of a Plasma Torch in the Inhibition of Escherichia Coli Bacteria in Water

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Abstract. In our study, a plasma torch was used through gas flow and discharge to observe the change in the sterilization of the water in which there are bacteria, especially Escherichia coli bacteria, to obtain the best sterilization taking into account the standard time, which amounted to one minute.
It was found through the work that there are types generated from the plasma flame that are active such as (NO, H_2O_2), which has an important role in killing bacteria and sterilizing water.
Keywords: Bacterial inactivation, active particles, plasma torch, ionizer.

INTRODUCTION

Plasma is an ionized gas that has an ionized state of partial or total gas, and it represents a mixture of photons and ions in addition to atoms and electrons[1].

Through previous studies, several methods have been used for sterilization and removal of contamination of both types (bacterial, viral), this depends on the efficiency and accuracy of examination and diagnosis, this leads to the destruction of these bacteria so that they are completely or partially destroyed, and thus pollution is eliminated inside and outside the body[2].

Plasma is one of the modern medical applications, especially cold plasma, which is one of the types of jet plasma, which plays an important role in getting rid of bacteria that cannot be easily eliminated through traditional methods[3].

In plasma physics, it was shown that atmospheric pressure plasma has a fundamental role in treatment and industrial deposition, as in thin films, which have a distinct property that makes them used in the sterilization of bacteria, especially Escherichia coli bacteria[4].

Escherichia coli bacteria spread widely in nature, polluted places, hospitals and health centers, and cause infections and injuries[5]. They may cause large infections spread in the form of colonies and in contaminated water and fermentation[6,7].

Experiment and Re-Install It Practically

Cold plasma at atmospheric pressure is considered one of the easy applications for medical and industrial work due to its low cost. It is a material that is sensitive to temperature and does not cause harm to all materials that it touches because it works at normal temperature (room temperature), including a plasma torch that works with argon gas or helium, which is non-thermal[8].

Figure (1) shows the design of the plasma torch, which is a cylindrical tube from which the needle is made and designed with a material of ordinary glass with a length of (120 mm) and a circular diameter of (1.5 mm), inside this glass material is an iron tube with a diameter of (2.7 mm).

The iron tube is connected to a power source (6.9 KV) with specific current values and a frequency (22 kHz), this is considered a positive electrode through which the argon gas is passed to the needle in order to create the plasma used in the experimental work.

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FIGURE 1. Plasma needle & glowing torch

EXPERIMENTAL WORK

In laboratory work, the bacteria were isolated by taking drops of water contaminated with Escherichia coli, after isolation and cultivation, they were exposed to non-thermal plasma to see the effect of cold plasma before and after treatment[9].

The results showed bacterial growth without exposure to plasma, while that was exposed to plasma. The physical study showed that this type of plasma and plasma parameters have an important and essential role in affecting the volume of sterilization that was performed[10]. This was shown through incubation in the laboratory for a full day (24 hours) when exposed to cold plasma.

RESULTS & DISCUSSION

The Role of Gaseous Flow on Bacterial Inhibition

In figures (2 and 3), the flow rates of argon gas were used for different values, after determining the temperature of the gas using a thermometer , from various dimensions of the plasma electrode and its torch.

Through non-thermal plasma parameters such as time, distance, voltage and frequency, in addition to the flow of Argon gas (1-5 liters / min).. The plasma torch was directed at Escherichia coli bacteria present in the isolated water in the laboratory, through a frequency (22 kHz) , applied voltage Up to (1.75 kv), time (10-50 seconds), and torch distance (2.5 cm).

The high flow of argon gas causes the particles to accelerate and penetrate into the outer wall of bacteria, this leads to the disruption of the bacterial wall and its destruction by the plasma torch. Through figures (2 , 3) the role of the presence of bacteria and the percentage of decrease appears with the effect of the flow of argon gas, as the plasma torch has an important role in the interaction of the particles and the distribution of the charge on the cell and the outer membrane, thus the destruction of this wall and the liberation of the cytoplasm, and this causes the destruction of the cell and its non-survival[11].

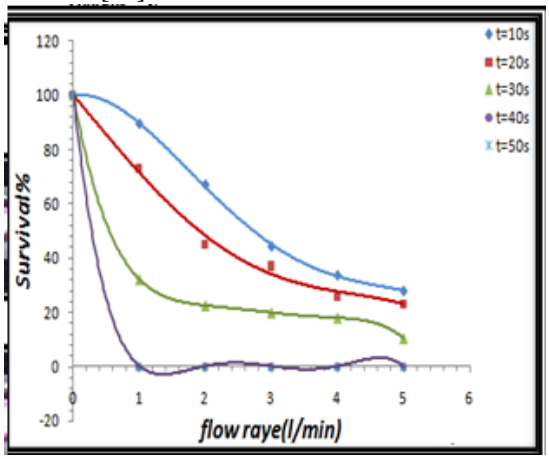

FIGURE 2. The effect of argon gas flow on the survival of Escherichia coli bacteria

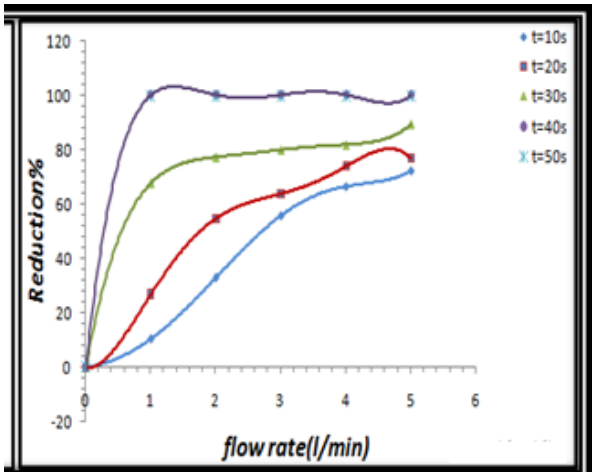

FIGURE 3. The effect of argon gas flow on the reduction of Escherichia coli bacteria

The Role of Voltages Applied to Bacterial Inhibition

Figures (4,5), under constant laboratory conditions, at a plasma torch distance (2.5 cm) and a frequency and voltage (22 kHz, 1.75 kV), respectively. It appears that the plasma torch has an important role in inhibiting Escherichia coli bacteria that are abundant in hospitals and contaminated water.

With the change of time and the flow of Argon gas to create a non-thermal plasma capable of reducing and inhibiting these bacteria, it is evident that when the treatment time increases for each case of applied voltage, the percentage of bacteria decrease increases with the increase in the treatment time with this type of cold plasma. This is shown in Figures (4,5) during the theoretical , practical conditions and studies of the experiment.

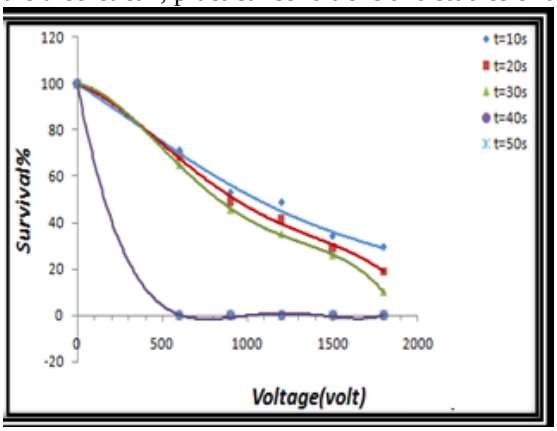

FIGURE 4. The role of applied voltage on the survival of Escherichia coli

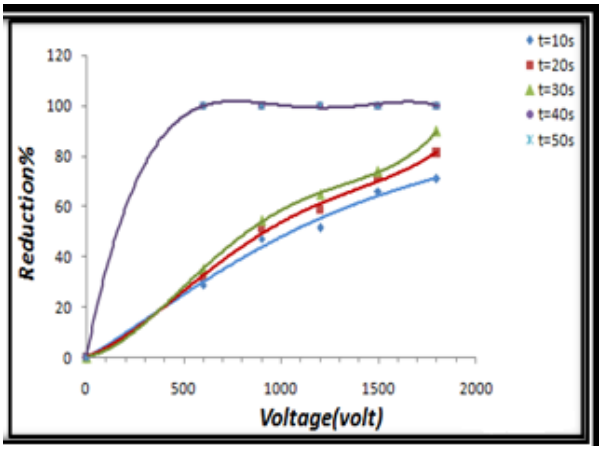

FIGURE 5. The role of applied voltages on the decrease of Escherichia coli bacteria

Figure (6) shows the role of the plasma torch in the decrease of the bacteria Escherichia coli, it turns out that the high voltage applied and the role of charged particles is an important [12] , essential factor for the destruction of the cell membrane, that the applied voltage with a high degree of ionization generated an increase in the reaction intensity, that charged particles and particles such as (H2O2, OH) a significant role and effect in destroying the cell wall and thus sterilizing the water from these bacteria and changing their path[13,14].

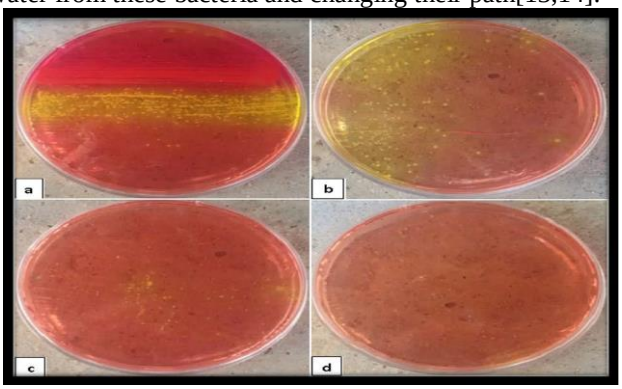

FIGURE 6. Bacterial decline of Escherichia coli with variable times

a: 10 sec. ; b: 20sec.; c: 30sec. ; d: 40sec.

CONCLUSIONS

Non-thermal plasma is considered one of the important applications in medicine and the environment. At atmospheric pressure, Argon plasma is created at the lowest cost to generate an electric field and gaseous ionization used to remove environmental pollution and kill bacteria.

By measuring the applied voltage and the flow of Argon gas, a plasma torch was used for bacterial sterilization, it was found that the increase in this flow and voltage leads to a high speed of the active materials(OH,H2O2) , their penetration of the wall of Escherichia coli bacteria, and thus inhibition of these bacteria.

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