Results of Experimental Studies on Electric Corona Gas Discharge of Bulgarian Lavender Oil

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Abstract
The study's aim was to create a brightness histogram based on the electrical effects of a 1% solution of lavender essential oil dissolved with 5% ethyl alcohol in distilled water compared to a control sample of 5% ethyl alcohol in distilled water.
Corona gas discharge (CGD) is a glowing corona with a bluish color that appears because of a high concentration of ions and electrons. The corona discharge is connected to ionization processes in the gas phase, which depend on the electric field and gas composition. CGD occurs in laboratory conditions. Corona can have a positive or negative charge. Both types are used for wastewater cleaning, fruit juice sterilization, surface disinfecting, and medicine. A high-voltage electrode usually ranges from 3 to 30 kV. The frequency range was from 10 to 20 kHz. The electric current is commonly in mA. Ignatov et al. have studied signal power ranges from one to two-tenths of a watt. Antonov et al. have shown that CGD parameters depend on the object's dielectric permittivity, underscoring the importance of this research. The work of Pesotskaya et al. is also of significance to this study. It indicates that BH can be created with black-white registration and that brightness is linked with dielectric permittivity. This finding is particularly relevant to this research about the effects of CGD on lavender oil (LO) from the *Lavandula angustifolia* mill., as it provided a method for quantifying observed changes in brightness. The formula is $Y = C\varepsilon$, where Y is brightness, C is coefficient and ε is dielectric permittivity.

Keywords: brightness; CGD; histogram; LO.

Introduction•

Bulgarian essential LO is known for its antimicrobial, anti-inflammatory [1], antifungal and insecticidal activity [2].
The effects of CGD on a 1% solution of LO in distilled water with 5% C_2H_6O were herein studied, opening up new possibilities for applying corona in the study of natural compounds. Distilled water with 5% C_2H_6O was used as control sample. Results were obtained under laboratory conditions with $CaCO_3$ [3].

•The abbreviations list is in page 310.

In CGD, there is an electrical breakdown in the air and the object. The experiments involved conductive liquid drops during electric CGD. The air gap broke with one electrode in CGD process on water drops or solutions. The electrical process occurred in a water medium or solutions of inorganic and organic compounds [3, 4]. Pashen's law describes this phenomenon as [5]:

$$V_B = f(pd) \quad (1)$$

where V_B is gas breakdown voltage, f is function, p is gas pressure, d is gap length, and V_B depends on p and d.

CGD is connected with dielectric permittivity of the medium where the effect occurs, and to ionization processes in the gas phase, which depend on the electric field and gas composition [4, 6]. Laboratory conditions must be standardized, with consistent temperature and humidity [7]. CGD is used for pasteurizing fruit juices [8], water disinfection, and in medicine [9].

Corona can have a positive or negative charge. The polarity of the electrode and object performs a negative [10] or positive corona [11]. Negative CGD produces the following species: $O_2^{\cdot -}$ (superoxide ion), OH^- (hydroxide ion), and molecular O_3. Compounds formed in positive corona discharge include the following species: O_2^+ (oxygen molecular cation), N_2^+ (dinitrogen cation), and NO_x (nitrogen oxides). Positive CGD produces molecular O_3 [12-14]. CGD has applications in computer proceedings for medical doctors to diagnose diseases [15-17].

The goal of the drops survey in CGD conditions was to show changes in the electric glow of a sample with LO prepared in water with C_2H_6O. The control sample was placed in water with C_2H_6O. The comparison between the sample and control indicated changes in its electric parameters due to LO effects.

This study aimed to create BH caused by the electrical effects of the investigated 1% LO solution with 5% C_2H_6O oil in distilled water compared to the control sample.

Methods and materials

Lavandula angustifolia mill

Brightness parameters during the CGD effect of LO [1] from *Lavandula angustifolia* mill (Fig. 1) were studied herein [18, 19]. A 1% LO solution in distilled water with 5% C_2H_6O was examined. Distilled water with 5% C_2H_6O was investigated as the control sample.

Figure 1: *Lavandula angustifolia* mill in flowering phase (orig.).

Fig. 2 illustrates oil extract from *Lavandula angustifolia* mill.

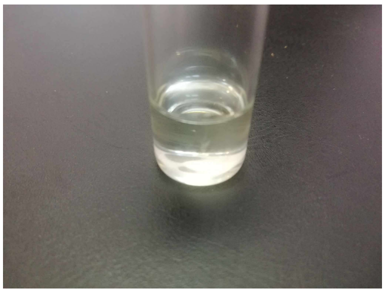

Figure 2: Oil extract from *Lavandula angustifolia* mill.

Samples were prepared at the University of Forestry, Sofia, Bulgaria. Experiments were performed at the Dnipro State Medical University, Ukraine. Analyzes were made at the Scientific Research Center of Medical Biophysics, Sofia, Bulgaria, and Dnipro University of Technology, Ukraine. A 1% (v/v) LO solution was prepared. By adding LO, 15 drops of a control sample of distilled water and an experimental sample were obtained for the X-ray film. A patented device obtained CGD photographs of water sample drops [20-23].

Parameters of the device for CGD glow

Fig. 3 illustrates the device for researching CGD with H_2O drops [23, 24].

Figure 3: Device for researching CGD with H_2O drops.

The parameters of the device for registering a CGD glow (on an X-ray film) are presented in Table 1.

The research focused on CGD in gas and its applications for research of LO with water and C_2H_6O solutions. The glowing CGD effect was explored in laboratory conditions. BH is widely used in image processing and analysis [23, 24]. X-axis represents brightness data, with gradations from black to white. Y-axis represents the count of pixels of a certain brightness.

Table 1: Instrument parameters for registration.

Parameter, unit of measurement	Value
Amplitude of the exposure pulse, kV	3.0-5.0
Frequency	12.0 kHz
Pulse duration, µs	5.0-10.0
Number of exposure pulses	1-10
Dimensions of the exposure electrode (working part of the device)- (mm)	90±0.5/130±0.5
Time of continuous work (h), not less than	8.0
Battery supply voltage	3 V
Average earnings per refusal, photographing cycles, not less than	25100
Overall dimensions of the device, mm, no more than	150 x 200 x 60
Power consumption (VA), no more than	3

Physical parameters

Developed information methodology was based on constructing BH images and calculating median values in their intervals [23, 24]. It involved calculating medians for 12 BH columns and differences between medians in their adjacent intervals. The distribution law of brightness in samples of CGD radiation images did not correspond to standard Gaussian distribution model. Therefore, to compute average brightness pixel values within certain division intervals, median values instead of arithmetic means were estimated, for an even number of images in the sample:

$$Med_n = \frac{1}{2}\left(x_{n/2} + x_{n/2+1}\right) \tag{2}$$

$$Med_n = x_{\frac{(n+1)}{2}} \tag{3}$$

and for an odd number,

Median values indicate the number of pixels within a specific brightness interval. The difference between median parameters of adjacent intervals was also determined (difference of medians).

According to spectroscopy method, high-frequency components of obtained profiles were programmatically separated, and power spectra were calculated for brightness parameters.

Results and discussion

BH of distilled water is shown in Fig. 4.

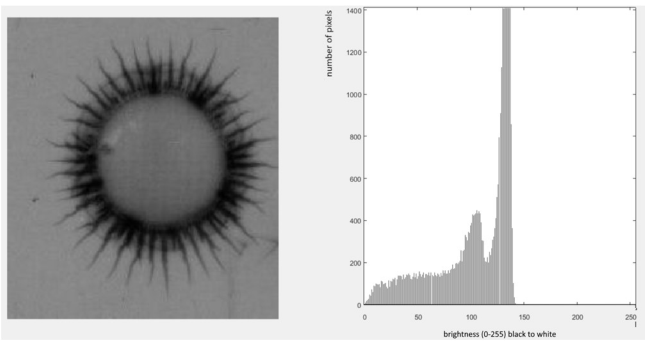

Figure 4: CGD photograph and BH of a drop of distilled water with 5% C_2H_6O.

Fig. 5 shows a CGD photograph and BH of a LO drop.

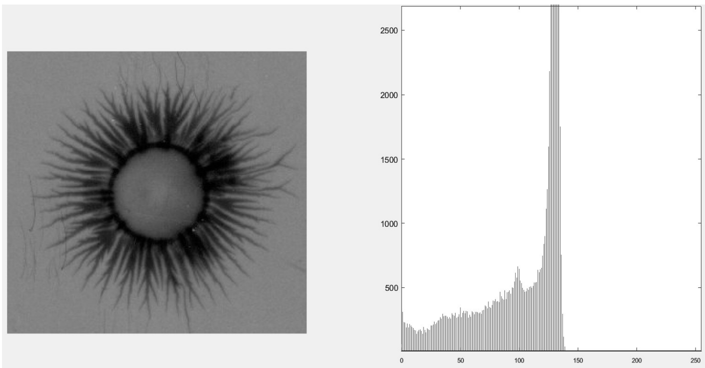

Figure 5: CGD photograph and BH of a drop of 1% LO solution with 5% C_2H_6O in distilled water.

When LO was added to water with 5% C_2H_6O, a change in electric crown was observed. In particular, brightness occurred at drop location, density of streamers decreases, and an outer luminescent layer appeared in the crown around the drop. Tables 2 and 3 present BH parameters from CGD of control sample and LO. They show differences in BH parameters values from CGD between samples.

Table 2. Median and difference of BH values from CGD between experimental samples.

No. BH	Median		Difference of values
	Control	LO	
1	790	1347.5	+557.5
2	480	1326.5	+846.5
3	539	1810.0	+1271.0
4	776	2270.5	+1494.5
5	1051	3481.5	+2430.5
6	1739	4602.5	+2863.5
7	2325	4617.0	+2292.0
8	4066	6276.0	+2210.0
9	8949	8357.5	-591.5
10	41506	36477.0	-5029.0
11	11718	15523.5	+3805.5
12	20	0	-20

When adding LO to a control sample of distilled water, median values of indicators were observed in all histogram intervals, reflecting an increase in dielectric permittivity as an indicator of water molecules' restructuring. Table 3 presents values of difference medians of histogram GD glow between experimental samples.

According to presented results of changes in difference in medians between intervals of BH from CGD image of control sample, when adding LO, an increase in indicators in left part (intervals 1-5) and a decrease in right part (intervals no. 6-11) were observed.

Table 3: BH from CGD- difference of medians and values between experimental samples.

No. BH	Difference of medians		Difference of values
	Control	LO	
1	-310.0	-21.0	289.0
2	59.0	483.5	424.5
3	237.0	460.5	223,5
4	275.0	1211.0	936.0
5	688.0	1121.0	1809.0
6	586.0	14.5	-571.5
7	1741.0	1659.0	-82.0
8	4883.0	2081.5	-2801.5
9	32557.0	28119.5	-443.7
10	-29788.0	-20953.5	-8834.5
11	-11698.0	-15523.5	-3825.5

Fig. 6 and Table 4 show spectroscopy of CGD from distilled water.

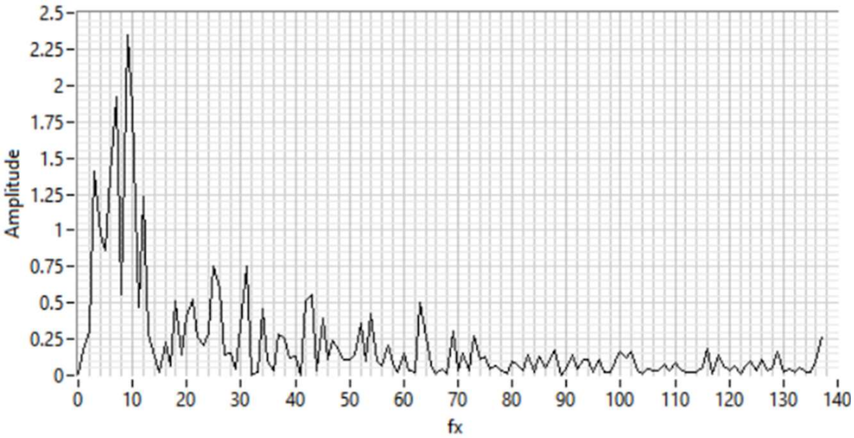

Figure 6: Power spectrum of high-frequency component of sample distilled water (control).

Fig. 7 presents CGD spectroscopy analysis from distilled water with 5% C_2H_6O and LO.

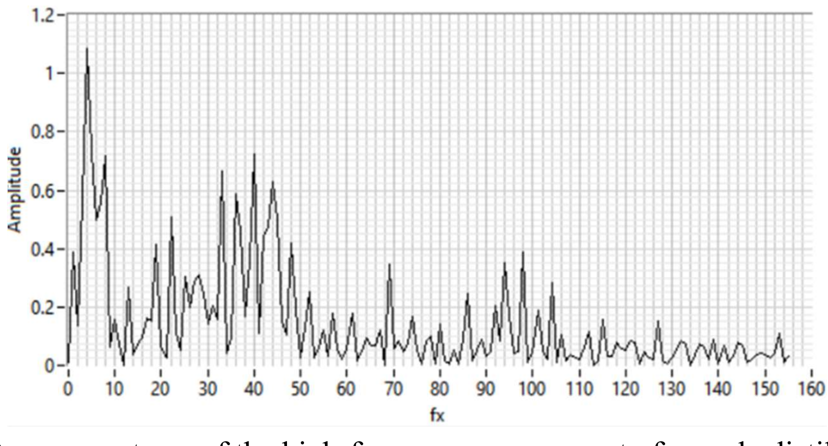

Figure 7: Power spectrum of the high-frequency component of sample distilled water with LO.

Table 4 presents difference of values of spectroscopy parameter GD glow between experimental samples.

Table 4: Analysis of difference of values of spectroscopy parameter GD glow between distilled water samples and one with LO.

Parameter	Control	LO	Difference of values
Mean average value	0.224008	0.144601	-0.0794
Root mean square value	0.432012	0.233619	-0.1984
Maximum extreme	2.343043	1.083961	-1.2590
Minimum extreme	0.00151	0.000405	-0.00111
Maximum amplitude of the pulse	2.341533	1.083556	-1.2580
Sum of power spectrum amplitudes	30.91304	22.55768	-8.3553

Effects of CGD may suggest a more equilibrium state of the water body when LO was added, potentially increasing its coherence, and being associated with a positive biological effect on the body. Coherence explanation of water molecules was assumed by [25].

The effects of corona discharge on a 1% solution of LO in distilled water with 5% ethyl alcohol have been studied, opening up new possibilities for applying corona discharge in the study of natural compounds.

Ultraweak photon emission is a promising physical phenomenon for studying the functioning of systemic energy processes of human tissues at a micro level. Photon emission from living molecules and human tissues occurs during metabolic reactions; accordingly, the more photons are registered, the more intense the metabolic processes in the body. The study of electric photon emission can be considered a potential tool for assessing the functioning of tissues and organs and determining the activity of metabolic processes at the cellular level. The emission from the surface of fingers' skin is recorded and amplified under the influence of a high-frequency electromagnetic pulse of high intensity. This creates a visible emission (glow) in the air, which a digital camera captures. The method is simple and convenient to use in screening studies, which theoretically allows its application in various medical fields [15, 16], including testing the possible biological effects of multiple substances. In the current research, an increase of the dielectric permittivity indicates water molecules' restructuring showing a possible positive impact on biological systems, including the human body, when applying LO.

Conclusions

In this study, the polarity of CGD with a patented device was positive. The compounds generated in positive CGD included O3, O^{2+}, Ni, positive ions and electrons. The high-voltage electrode was U = 3 kV and ν = 12 kHz. The study delved into the impacts of CGD on samples of a 1% solution LO in distilled water with 5% C_2H_6O, according to the control samples. Results under laboratory conditions highlighted BH parameters related to the electric effects of LO. CGD photographs were obtained using a patented device. BH results showed the differences, within reliable parameters, between control and experimental samples. The experiment revealed changes in BH, with added LO highlighting alterations in median values across BH intervals. Analyses confirmed LO beneficial effects. Based on the findings from the analysis of CGD images of experimental samples, a reduction in all parameters was evident. This signifies a more balanced state within the water composition when LO was introduced, which enhanced its consistence. This improved consistence was linked to positive biological effects on the body, explaining the behavior of water molecules as a LO effect.

Authors' contributions

Ignat Ignatov, Lyudmila Pesotskaya, Natalia Glukhova, Teodora P. Popova: conceived the original research paper; collected data; performed experimental work; inserted data or analysis tools; wrote the paper. **Anelia Mladenova, Ralitsa Bankova**: collected data; performed experimental work; analyzed data obtained by experiments. **Alexander I. Ignatov**: collected data; performed experimental work; wrote references.

Abbreviations

BH: brightness histogram
C_2H_6O: ethanol/ethyl alcohol
$CaCO_3$: calcium carbonate
CGD: Corona gas discharge
LO: lavender oil
N_2^+: dinitrogen cation
NO_x: nitrogen oxides
$O_2.^-$: superoxide ion
O_3: ozone
OH^-: hydroxide ion

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