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Effect of a constant electric field on the electromagnetic spectrum structure of eucalyptus oil

Abstract. *Essential oils have found widespread use due to their properties observed back in nature. Eucalyptus oil is obtained from the knobby eucalyptus, grown mainly in Australia and Tasmania. The predominant component of the oil is eucalyptol. The purpose of this study was to determine the extent to which a constant electric field affects the electromagnetic spectrum structure in the visible light range of eucalyptus oil. The experiments carried out showed differences in the electromagnetic spectrum depending on the applied values of the electric voltage parameters and the exposure time of the constant electric field. To generate significant changes in the light transmittance of eucalyptus oil, it should be subjected to electric field exposure with an electric voltage between 4 and 8.5 kV/cm and a time between 0.5 and 1.5 hours.*

Streszczenie. *Olejki eteryczne znalazły szerokie zastosowanie ze względu na swoje właściwości zaobserwowane już w naturze. Olejek eukaliptusowy jest otrzymywany z eukaliptusa gałkowego, uprawianego głównie w Australii i na Tasmanii. Przeważającym składnikiem olejku jest eukaliptol. Celem badań było określenie stopnia oddziaływania stałego pola elektrycznego na strukturę widma elektromagnetycznego w zakresie światła widzialnego olejku eukaliptusowego. Przeprowadzone eksperymenty wykazały różnice w widmie elektromagnetycznym w zależności od zastosowanych wartości parametrów napięcia elektrycznego i czasu ekspozycji stałego pola elektrycznego. Aby wygenerować istotne zmiany przepuszczalności świetlnej olejku eukaliptusowego należy go poddać ekspozycji pola elektrycznego o napięciu elektrycznym między 4 a 8,5 kV/cm i czasie między 0,5 a 1,5 godziny (**Wpływ stałego pola elektrycznego na strukturę widma elektromagnetycznego olejku eukaliptusowego**).*

Keywords: electric field, essential oils, eucalyptus oil, electromagnetic spectrum
Słowa kluczowe: pole elektryczne, olejki eteryczne, olejek eukaliptusowy, widmo elektromagnetyczne

Introduction

Essential oils are natural compounds characterized by a strong fragrance. Known for their antiseptic - bactericidal, virucidal and fungicidal properties, medicinal properties, food preservation and as analgesics, sedatives and anti-inflammatory agents, Essential oils have found wide application due to their properties already observed in nature [1-4].

Eucalyptus oil is extracted from the knobby eucalyptus tree, grown mainly in Australia and Tasmania, and now also in Indonesia, New Zealand and India. The leaves of the tree are used to produce eucalyptus oil, by steam distillation. The predominant component of the oil is eucalyptol (1,8-cyneol), which can be up to 90%. Monoterpenes are also produced in smaller amounts, among them: α- and β-pinene, p-cymene, camphene, γ-terpinene, d-limonene and α-felandrene; sesquiterpenes, including: alloaroma-dendrene, aromadendrene and globulol; aldehydes; and ketones [5,6]. The oil is used primarily in respiratory infections, skin diseases, arthritis and rheumatism [7]. According to studies by various authors, eucalyptus oil has antibacterial, antifungal, antiviral effects, and also acts against protozoa and against insects [8]. The aim of this study was to determine the degree of influence of a constant electric field on the electromagnetic spectrum structure in the visible light range of eucalyptus oil.

Material and methods

Eucalyptus oil was used in the study. Four samples each were prepared from the essential oil in ten replicates: a control sample and three stimulated samples with durations of 1h, 2h and 3h. The samples were then subjected to a constant electric field (Figure 1) with electric voltages of 2.1 kV/cm, 4.2 kV/cm and 8.6 kV/cm in the same stand as in [9], and in 3 interaction variants, i.e. stimulation times of 1, 2 and 3 hours.

Next, the registration of the spectrum of eucalyptus oil was performed using a measuring station equipped with a Hammatsu C5964 multi-channel spectrophotometer (Figure 2). Spectrum recording involves the generation of a continuous spectrum by a light source (a), which passes through a light-proof chamber (b), then through a slit and reflects off a diffraction grating, then the radiation reflects off a mirror and is recorded by the multi-channel spectro-photometer (c). The multi-channel spectrophotometer is connected to a controller that allows the spectrum to be read out in Application Software (d). The measurement is based on placing the test sample in a light-proof chamber located in the axis of light forcing interaction. The generated light passes through the analyzed material and is then recorded by the spectrophotometer.

Fig. 1. Stand for exposure to a constant electric field

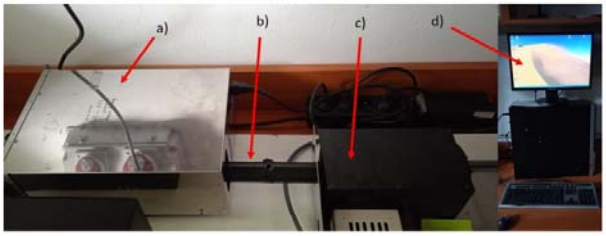

Fig 2. C5964 multichannel spectrophotometer from Hammatsu: a) light source; b) light-proof chamber; c) C5964 multichannel spectrophotometer with controller; d) Applicaton Software

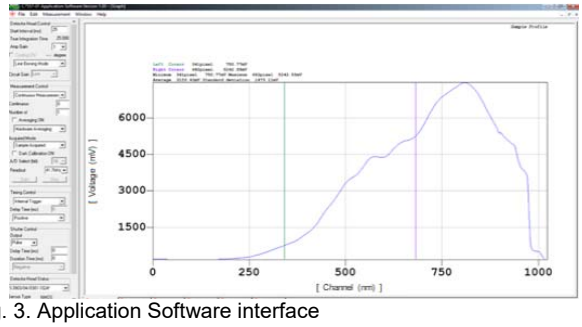

Fig. 3. Application Software interface

The results of the light spectral characteristics are visualized in the computer program interface (Figure 3), where the ordinate axis (Intensity) describes the value expressed in "mV," while the abscissa axis represents the light wavelength expressed in "nm" [10].

Measurement of the optical density of essential oil suspensions was also performed using a DEN-1B densitometer.

Fig 4. Densitometer DEN-1B

Results

The spectral properties of eucalyptus oil exposed to a constant electric field were investigated with different exposure times. For the control sample (Figure 5), a minimum light transmittance value of 158.66 mV was recorded at a wavelength of 338.42 nm, while the maximum value was 4443.73 mV at a wavelength of 809.97 nm. A mean light transmittance value of 1853.52 mV was recorded, with a standard deviation of 1377.46 mV.

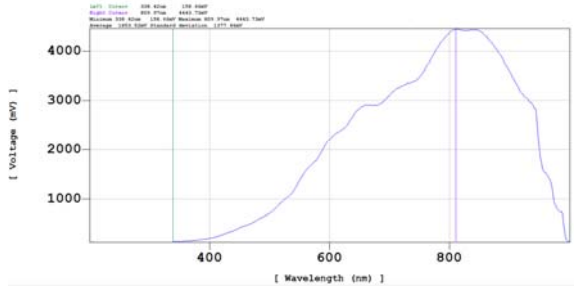

Fig 5. Spectral characteristics of eucalyptus oil before exposure to a constant electric field.

Figure 6 shows the spectral characteristics of eucalyptus oil after exposure to an electric field of 2.2 kV/cm and an hour-long exposure. The minimum value of light transmittance was 151.93 mV at a wavelength of 338.42 nm, while the maximum value was 3583.58 mV at a wavelength of 807.62 nm. A mean light transmittance value of 1503.1 mV was recorded, with a standard deviation of 1086.56 mV. The difference between the mean values of light transmittance between the control sample and the sample exposed to an electric field of 2.2 kV/cm and an hour's exposure was 350.42 mV.

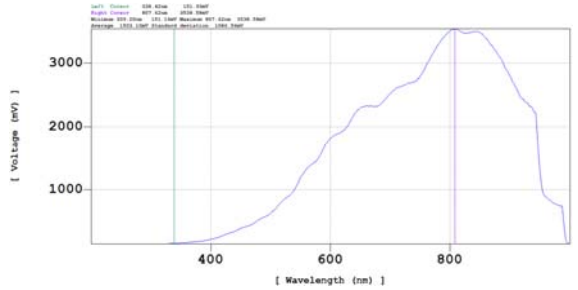

Fig 6. Spectral characteristics of eucalyptus oil after exposure to a constant electric field of 2.2 kV/cm and one hour of stimulation

A minimum light transmittance value of 152.85 mV at a wavelength of 338.42 nm and a maximum value of 3502.17 mV at a wavelength of 807.62 nm were recorded for samples exposed to an electric field of 2.1 mV/cm and a two-hour exposure. A mean light transmittance value of 1504.55 mV was recorded, with a standard deviation of 1081.28 mV. The difference between the mean light transmittance values between the control sample and the sample exposed to an electric field of 2.1 kV/cm and a two-hour exposure was 348.97 mV.

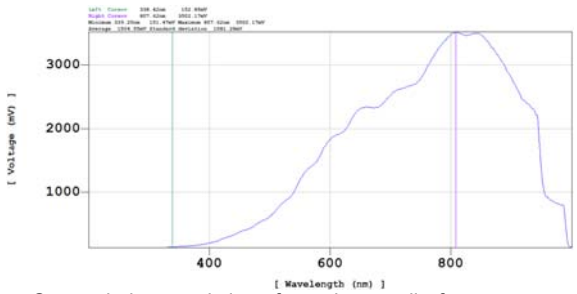

Fig 7. Spectral characteristics of eucalyptus oil after exposure to a constant electric field of 2.2 kV/cm and two-hour stimulation.

Figure 8 shows the spectral characteristics of eucalyptus oil after exposure to an electric field of 2.2 kV/cm and three-hour exposure. The minimum value of light transmittance was 152.23 mV at a wavelength of 338.42 nm, while the maximum value was 3640.48 mV at a wavelength of 838.12 nm. A mean light transmittance value of 1673.25 mV was recorded, with a standard deviation of 1189.23 mV. The difference between the mean light transmittance values between the control sample and the sample exposed to an electric field of 2.2 kV/cm and a three-hour exposure was 180.27 mV.

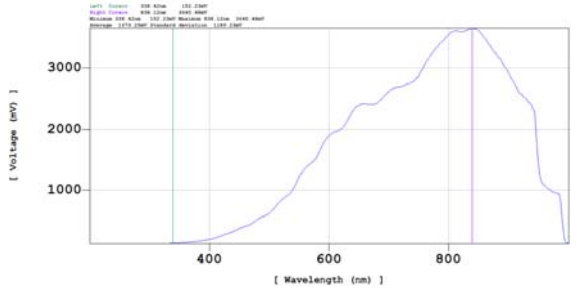

Fig 8. Spectral characteristics of eucalyptus oil after exposure to a constant electric field of 2.2 kV/cm and three hours of stimulation

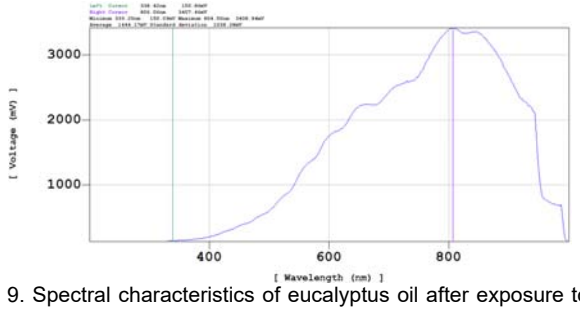

Fig 9. Spectral characteristics of eucalyptus oil after exposure to a constant electric field of 4.2 kV/cm and one-hour stimulation.

A minimum light transmittance value of 150.86 mV at a wavelength of 338.42 nm and a maximum value of 3408.84 mV at a wavelength of 804.5 nm were recorded for samples exposed to an electric field of 4.2 mV/cm and one-hour exposure. A mean light transmittance value of 1444.17 mV was recorded, with a standard deviation of 1038.28 mV. The difference between the mean light transmittance values between the control sample and the sample exposed to an electric field of 4.2 kV/cm and an hour's exposure was 409.35 mV.

Figure 10 shows the spectral characteristics of eucalyptus oil after exposure to an electric field of 4.2 kV/cm and a two-hour exposure. The minimum value of light transmittance was 152.69 mV at a wavelength of 330.42 nm, while the maximum value was 3383.29 mV at a wavelength of 805.28 nm. A mean light transmittance value of 1453.31 mV was recorded, with a standard deviation of 1034.45 mV. The difference between the mean light transmittance values between the control sample and the sample exposed to an electric field of 4.2 kV/cm and a two-hour exposure was 400.21 mV.

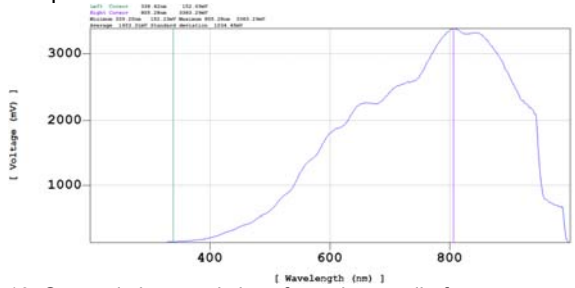

Fig 10. Spectral characteristics of eucalyptus oil after exposure to a constant electric field of 4.2 kV/cm and two hours of stimulation

A minimum light transmittance value of 151.47 mV at a wavelength of 339.2 nm and a maximum value of 3625.03 mV at a wavelength of 838.12 nm were recorded for samples exposed to an electric field of 4.2 mV/cm and a three-hour exposure. A mean light transmittance value of 1668.66 mV was recorded, with a standard deviation of 1185.77 mV. The difference between the mean light transmittance values between the control sample and the sample exposed to an electric field of 4.2 kV/cm and a three-hour exposure was 184.86 mV.

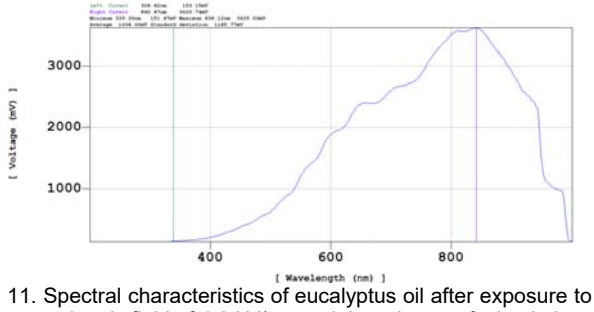

Fig 11. Spectral characteristics of eucalyptus oil after exposure to a constant electric field of 4.2 kV/cm and three hours of stimulation.

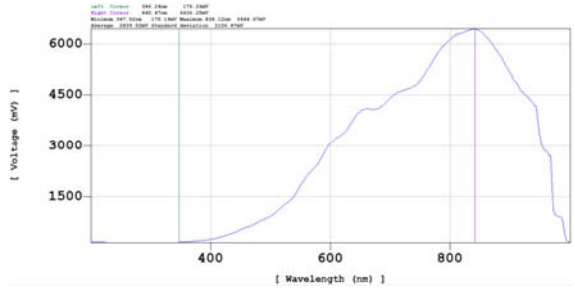

Fig 12. Spectral characteristics of eucalyptus oil after exposure to a constant electric field of 8.6 kV/cm and one hour of stimulation

Figure 12 shows the spectral characteristics of eucalyptus oil after exposure to an electric field of 8.6 kV/cm and one-hour exposure. The minimum value of light transmittance was 175.19 mV at a wavelength of 347.02 nm, while the maximum value was 6444.67 mV at a wavelength of 838.12 nm. A mean light transmittance value of 2839.52 mV was recorded, with a standard deviation of 2106.87 mV. The difference between the mean values of light transmittance between the control sample and the sample exposed to an electric field of 8.6 kV/cm and an hour's exposure was 986 mV.

A minimum light transmittance value of 151.93 mV at a wavelength of 336.07 nm and a maximum value of 3912.97 mV at a wavelength of 809.97 nm were recorded for samples exposed to an electric field of 8.6 mV/cm and a two-hour exposure. A mean light transmittance value of 1634.88 mV was recorded, with a standard deviation of 1210.46 mV. The difference between the mean values of light transmittance between the control sample and the sample exposed to an electric field of 8.6 kV/cm and a two-hour exposure was 218.64 mV

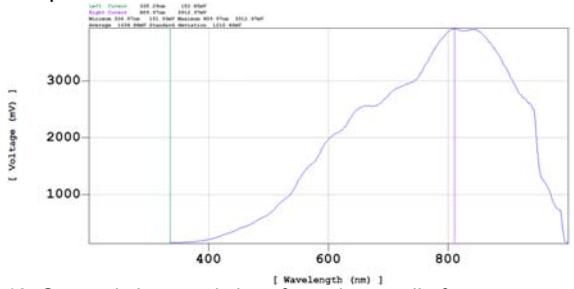

Fig 13. Spectral characteristics of eucalyptus oil after exposure to a constant electric field of 8.6 kV/cm and two-hour stimulation.

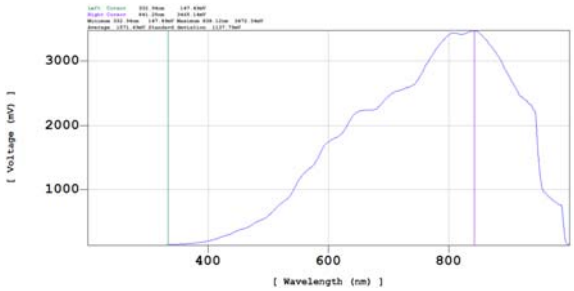

Fig 14. Spectral characteristics of eucalyptus oil after exposure to a constant electric field of 8.6 kV/cm and three hours of stimulation.

Figure 14 shows the spectral characteristics of eucalyptus oil after exposure to an electric field of 8.6 kV/cm and three-hour exposure. The minimum value of light transmittance was 147.49 mV at a wavelength of 332.94 nm, while the maximum value was 3472.34 mV at a wavelength of 838.12 nm. A mean value of light transmittance of 1571.49 mV was recorded, with a standard deviation of 1137.79 mV. The difference between the mean light transmittance values between the control sample and the sample exposed to an electric field of 8.6 kV/cm and a three-hour exposure was 282.03 mV.

Table 1. The magnitude of the light transmittance of the spectrum of eucalyptus oil depending on the value of the electric field voltage.

Voltage of electric field [kV/cm]	Average light transmittance [mV]
0	1853,52[a]
2,1	1560,3[a]
4,2	1522,04[a]
8,6	2015,3[a]

- calculations made at the significance level of α=0.05
a - the first homogeneous group

A one-way analysis of variance (ANOVA) was performed, for which Statistica 13 (StatSoft, Inc., Tulsa, OK, USA) was used. The significance of differences between the means was verified using Scheffe's test (α=0.05). The results are illustrated in Table 1. One homogeneous group of mean light transmittance values of the electromagnetic spectrum was identified, which included all mean light transmittance values. This shows that there is no variation

in the light transmittance values of the electromagnetic spectrum.

To obtain the highest light transmittance (Figure 15) of the electromagnetic spectrum of eucalyptus oil, it is necessary to select the parameters of the electric field voltage and its exposure time so that the combination of these parameters situates the system in the red color region and does not exceed the yellow color limit line. The lowest values of light transmittance (below 1500 mV) were obtained in the range of electric voltage values between 2 and 6 kV/cm and exposure time between 1 and 2.5 hours (dark green color area).

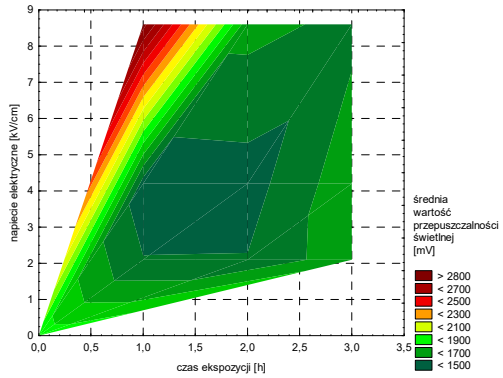

Fig 15: Relationships between voltage and electric field exposure time and average light transmittance of eucalyptus oil.

One homogeneous group of mean optical density values of eucalyptus oil was identified, which included all mean optical density values. This shows that there is no variation in the optical density values of essential oil suspensions.

Table 2. magnitudes of optical density of eucalyptus oil depending on the value of electric field voltage and exposure time.

Voltage of electric field [kV/cm]	Optical density [McF]
0	11,2[a]
2,1	10[a]
4,2	12,3[a]
8,6	10,43[a]

- calculations made at the significance level of α=0.05
a - the first homogeneous group

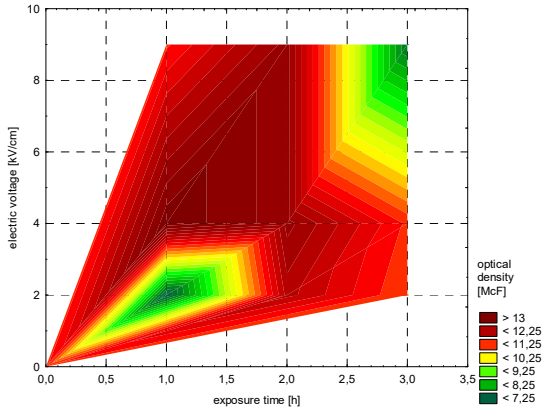

Fig 16. Relationship between voltage and exposure time of electric field and average optical density of eucalyptus oil

In order to obtain the highest optical density (Figure 16) of the eucalyptus oil suspension, the parameters of electric field voltage and exposure time should be selected so that the combination of these parameters placed the system in the red region and did not exceed the yellow limit line. The lowest values of optical density (below 9.25 McF) were obtained in the range of electric voltage values between 1 and 3 kV/cm and 7 and 9 kV/cm and exposure time between 0.5 and 1.5 hours and 2.5 and 3 hours (green color area).

Conclusion

The experiments carried out showed differences in the electromagnetic spectrum depending on the applied values of electric voltage parameters and the time of exposure of a constant electric field. In order to generate significant changes in the light transmittance of eucalyptus oil, it should be exposed to an electric field with an electric voltage between 4 and 8.5 kV/cm and a time between 0.5 and 1.5 hours.

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