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PHYTOTRON CHAMBERS FOR PLANT EXPOSURE TO OZONE

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Communication

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KOMORY FITOTRONOWE DO EKSPOZYCJI ROŚLIN NA OZON

Skonstruowano komory do ekspozycji roślin na działanie ozonu w stałych i ściśle kontrolowanych warunkach. Urządzenie składa się z dwóch identycznych komór o objętości 0,7 m^{-3} każda. Komory usytuowane są w większej, klimatyzowanej komorze fitotronowej zapewniającej zewnętrzne oświetlenie roślin [323 μmol(quantum)·m^{-2}·s^{-1}], regulację temperatury w zakresie od 4°C do 30°C oraz wilgotność względną od 25 do 60%. Przepływ powietrza zapewnia jednokrotną wymianę powietrza w komorach w ciągu jednej minuty. W tych warunkach możliwe jest uzyskanie stężenia ozonu na poziomie do około 5000 ppb. Omawiane urządzenie pozwala na fumigację ozonem zarówno próbek materiałów, jak i roślin i zwierząt.

Summary

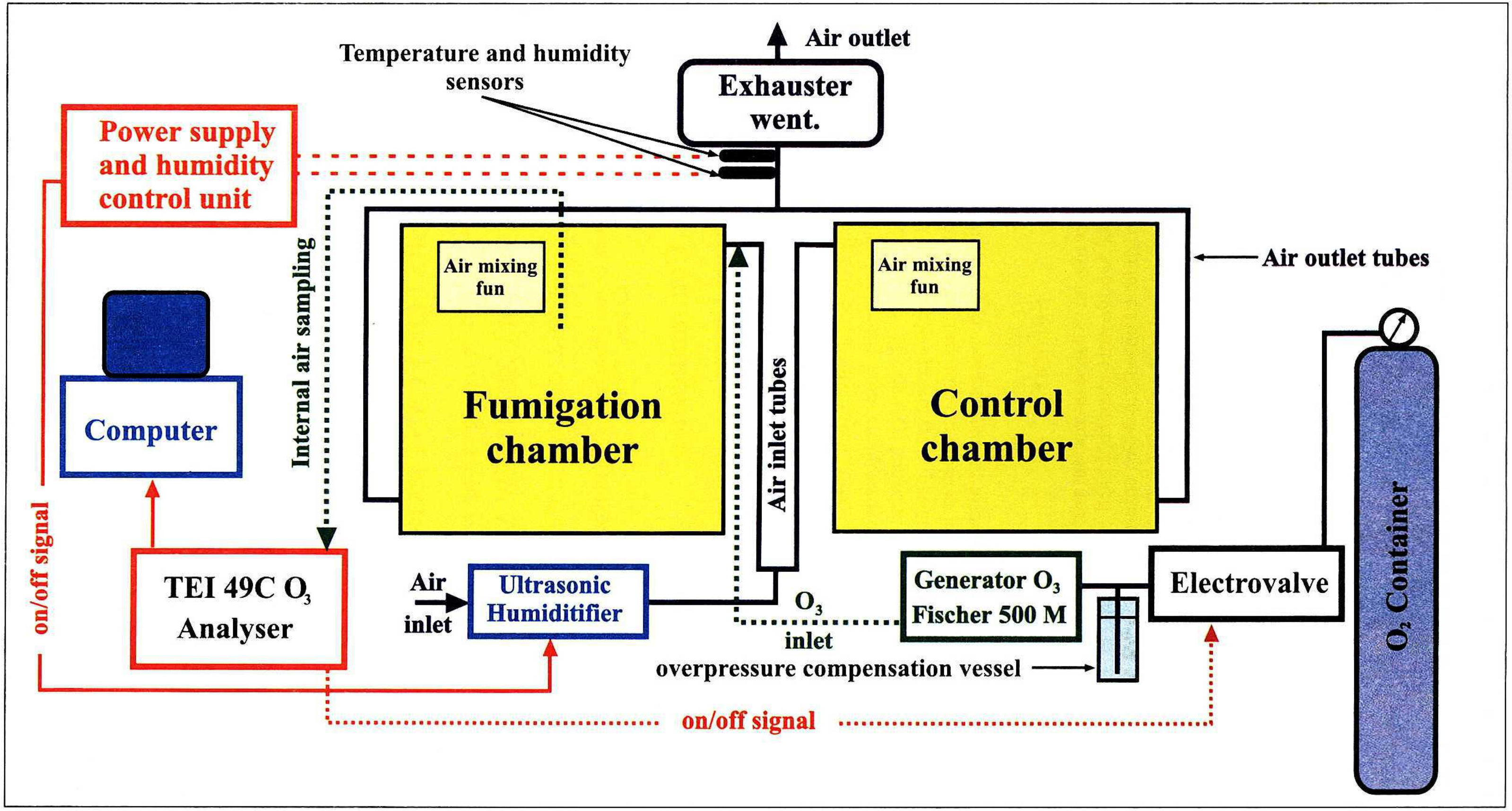
Fumigation chambers which allow expose to ozone in constant and controlled conditions have been constructed. The apparatus consists of two identical chambers, each of about 0.7 m^{-3} capacity. The chambers are placed in a larger, air conditioned phytotron which ensures its lighting from outside [323 μmol(quantum)·m^{-2}·s^{-1}], temperature control in the range of 4°C–30°C and humidity in the range from 25 to 60%. Airflow guarantees a 1-fold exchange of atmosphere per minute. With the maximum airflow an ozone concentration up to about 5000 ppb can be obtained. Both organisms and materials can be exposed in equipment built.

INTRODUCTION

Ozone affects very strongly living organisms and materials. This gas appears often in the environment together with other pollutants (SO_2, CO_2, NO_x). Different pollutants can cause also synergistic effects. Sometimes it is very difficult to establish which effects are due to ozone alone and which come from other factors. For this purpose fumigation chambers are constructed which allow the organisms and materials to be tested in ozone in constant and controlled conditions.

Fig. 1. The scheme of the equipment for exposure to ozone

Schemat urządzenia do ekspozycji na działanie ozonu



TECHNICAL DESCRIPTION

Technical details of the equipment are shown on the block scheme (Fig. 1). The system consists of two identical (exposure and control) chambers, each of about 0.7 m^{-3} capacity, mounted on trolleys, which enable them to be moved easily from place to place (Fig. 2). It permits fumigation to be carried out also outside the building if, for example, we wish to perform an experiment in conditions of natural light and temperature. The top- and side-walls of the chambers are made of polymethyl methacrylate (plexiglas). One side-wall is attached with screws and can be easily removed. The chambers are intended to be used above all for plant fumigation, hence they are equipped with a system for watering the plants. It is possible to do this without opening the chambers. It allows fumigation conditions to be kept constant throughout the experiment.

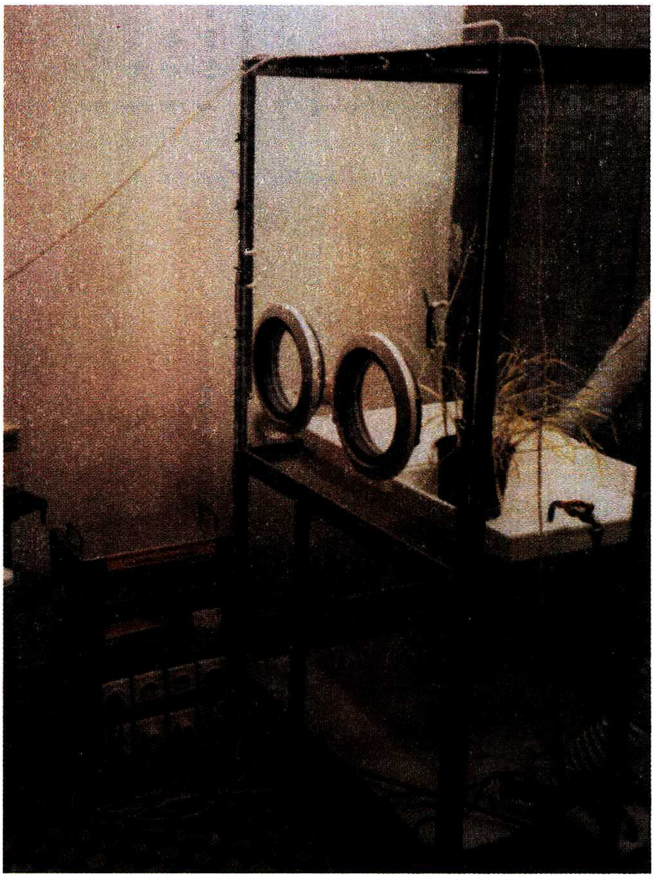


Fig. 2. General view of the O_3 exposure chamber and the power supply with the relative humidity control unit

Widok ogólny komory do ekspozycji na O_3 wraz z systemem zasilania oraz sterowania poziomem wilgotności

The chambers are placed in a larger, air-conditioned phytotron chamber, which ensures its lighting from outside. Using Philips SOD-4 Agro 400W lamps it is possible to reach irradiation at the lowest chamber level, at about 323 µmol(quantum)$\cdot m^{-2} \cdot s^{-1}$. At the middle height of the chamber the irradiation reaches 398 µmol(quantum)$\cdot m^{-2} \cdot s^{-1}$. The irradiance quality used for the chambers is shown in Fig. 3. According to our experience the quality of this light source is good for growing most plants. Only small differences

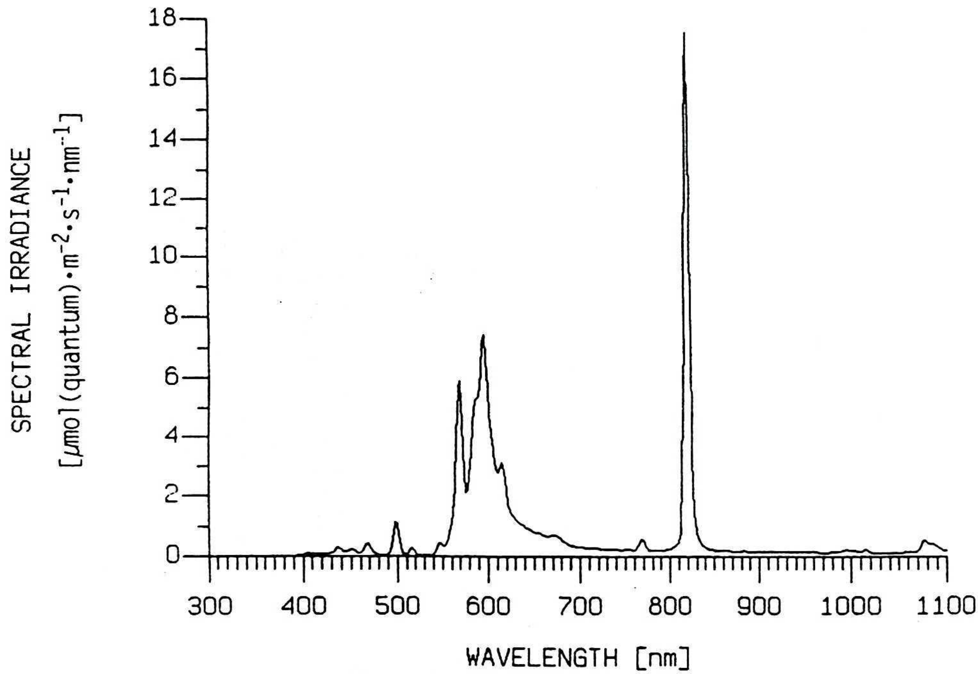


Fig. 3. Spectral irradiance in the range of 300–1100 nm inside the exposure chamber (measurement at 2 nm intervals with LI-1800 LI-COR USA) provided by Philips SOD-4 Agro 400W lamps

Spektralne natężenie napromieniowania w zakresie 300-1100 nm wewnątrz komory ekspozycyjnej (lampy SOD-4 Agro 400W firmy Philips; pomiar w interwałach co 2 nm za pomocą spektroradiometru LI-1800 LI-COR USA)

at the vertical level (about 8%), in irradiation intensity were observed. The phytotron air-conditioned chamber also ensures temperature control in the range of 4°C–30°C. Irradiation and air conditioning of both experimental chambers by means of one system allow the differences between control- and exposure-chambers to be minimised during the experiments. Also in the case of any incidental events the control and the exposed material are treated in a similar way.

Air exchange is guaranteed by an axial-flow fan (type TD-160/100 Venture Industries Poland), of continuous performance control, which permits a 1-fold exchange of atmosphere per minute in the chambers. The air velocity is great enough to secure a relatively homogeneous atmosphere inside the experimental chambers. This velocity is also great enough to destroy the boundary leaf layer resistance and to reach the leaf cells in most plants. The air is sucked in through flexible teflon pipes of 100 mm diameter simultaneously from both chambers. Such a system ensures a low partial pressure, which prevents the escape of ozone from the exposure chamber. Non filtered air is used in experiments (mean ambient air ozone concentration is relatively low – 6.2+1.3 ppb – Fig. 4A inside). An Ultrasonic Humidifier type KUH-IR15H (Taiwan) with a humidity meter type FIR 201M (Shinko, Japan) and a sensor and feeder type PWW-14 (KFAP, Poland), enable the pre-set humidity in the range from 25 to 60% to be maintained.

Ozone is supplied into the experimental chamber through an inlet channel suitably mixed with the air. Gas is obtained from a Fisher type 500M ozone generator. The amount of ozone supplied to the chamber can be regulated in two ways: by regulating the O_2-flow through the ozone generator or (and) by regulating the ozone-producing effectiveness of the ozone generator.

Ozone concentrations in the experimental chambers are controlled by a 49C UV Photometric O_3 Analyser, produced by Thermo Environmental Instruments Inc. USA, provided with a self-calibrating system [1]. The samples of air for measurements are withdrawn from the central point in the exposure and the control chambers. With the maximum airflow in the system the ozone concentration up to about 5000 ppb can be obtained. The installed computer provides the automatic control of the ozone level and data collection. Using computer software (instead of the data logger), makes it possible to register even very high concentrations of O_3 [2]. Representative examples of the day course ozone concentration in the chamber are shown in Fig. 4A (at lower concentration) and Fig. 4B (at higher concentration). The amplitude of the variations in the gas concentration when fumigated with about 110 ppb does not exceed 10 ppb and with about 450 ppb does not exceed 22 ppb, i.e. 9% or 5%, respectively (Figs 4A and 4B). Similarly, for very high ozone concentrations (about 4700 ppb) the observed deviations in these gas concentrations during fumigation reached nearly 10% (data not shown). Expected ozone concentrations are achieved during about fifteen minutes after switching on the ozone generator.

The described fumigation chambers were constructed especially for the fumigation of plants with ozone, but this equipment permits fumigation also of such experimental material as fungi, small animals, or inanimate material.

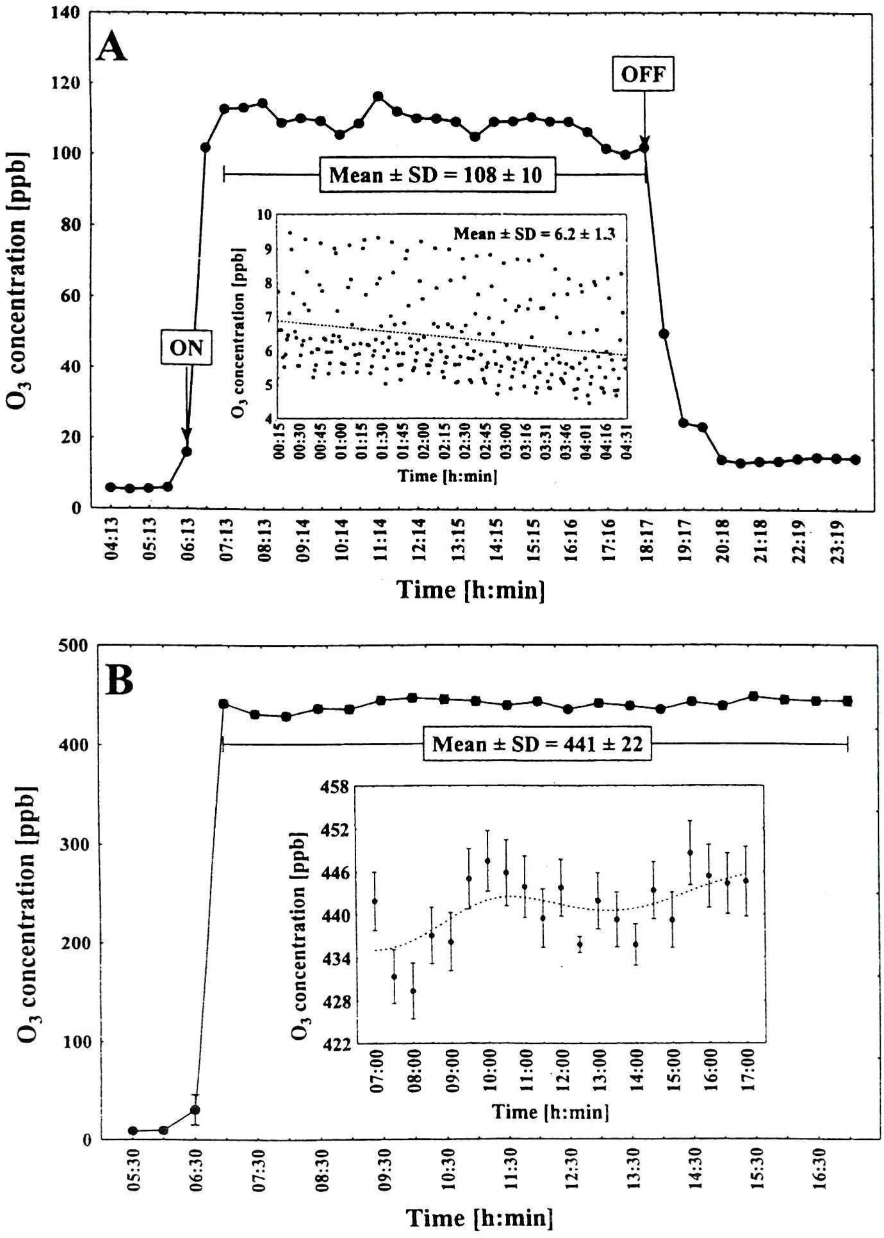


Fig. 4. An example of the dial O_3 concentration in the exposure chamber (each point presents mean value from 30 estimations): A – at O_3 concentration 110 ppb (inside – changes in O_3 concentration in external air); B – at O_3 concentration 450 ppb (inside – fluctuation of O_3 during the fumigation in enlargement)

Przykładowe wykresy dziennych zmian stężenia O_3 w komorze fumigacyjnej (każdy punkt stanowi wartość średnią z 30 pomiarów): A – przy stężeniu O_3 110 ppb (w środku – zmiany stężenia O_3 w powietrzu zewnętrznym); B – przy stężeniu O_3 450 ppb (w środku – przebieg zmian stężenia O_3 podczas fumigacji w powiększeniu)

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