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A device to study the effect of space radiation on photosynthetic organisms

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Abstract

This research concerns the study of the effects of ionising space radiation on the oxygen-evolving activity of algae and cyanobacteria, focusing our attention on Photosystem II (PS-II), the oxygen-evolving complex. These microorganisms as higher plants, can use light energy to split water molecules and evolve oxygen in a process that produce storable energy-rich products from atmospheric carbon dioxide. Algae and cyanobacteria which can grow in the presence of nutrients and carbonate are expected to be utilised to maintain an oxygen-atmosphere and to constitute biomass in space shuttles.

Irradiation was performed in gamma ^{60}Co-sources of different activities; fluorescence techniques *in vivo* and SDS-PAGE analysis *in vitro* were used to determine PS-II efficiency during radiation stress. We determined the radiation target on PS-II by immunoblot. We built a miniaturised growth box that preserves constant pressure and temperature to measure automatically photosynthetic activity by a fluorescence sensor, directly in space during a mission in an ASI balloon.

KEYWORDS: Ionizing radiation, oxygen-evolution activity, space stress.

1. Introduction

Algae, cyanobacteria and higher plants are unique in the biosphere since they can use light energy to split water molecules and evolve oxygen in a process that produce storable energy-rich products from atmospheric carbon dioxide. These events are vital for maintaining the present levels of biomass on our planet and for sustaining an oxygenic atmosphere [1, 2].

Algae and cyanobacteria that can grow in the presence of nutrients and carbonate are expected to be utilised to maintain an oxygen-atmosphere and to constitute biomass in space shuttles. However, space is permeated by ionising radiation that damages the photosynthetic apparatus and reduce its oxygen-evolution efficiency [3]. The mechanism of radiation stress induced damage to the components of the photosynthetic apparatus is not well understood. Mainly the Photosystem II (PS-II) apparatus is affected by stress. Damage on PS-II is primarily localised at the D1 protein where electron transfer between the primary electron donor, Tyr Z, and the secondary plastoquinone acceptor, Q_B occurs [4]. It is known that the inhibition of PSII activity is greatly increased when stress is imposed under relatively high light leading to a photoinhibitory process [5]. Therefore, we concentrate our studies on the response of PS-II activity to radiation stress in different light regimes [6].

We built a miniaturised growth device for the photosynthetic microorganisms to measure automatically PS-II activity as fluorescence. This device will be sent to the biosphere inside a balloon in order to study the effect of ionising space radiation.

2. Material and methods

For our experiments we used different photosynthetic microorganisms: the green algae *Chlorella Sorokiniana* and the cyanobacteria *Spirulina platensis* and *Synechococcus elongatus*.

The algae and cyanobacteria, kept in various glass tubes, were placed inside a box tested for vacuum resistance, atmospheric pressure, temperature of $29° \pm 3°$. A correct growth of the algae and cyanobacteria was guaranteed by insufflating air continuously inside the tubes.

We used a FMS 2-HANSATECH Fluorimeter to detect fluorescence parameters in the photosynthetic microorganisms.

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3. Results and discussion

Our preliminary experiments on irradiation of isolated PS-II particles by gamma rays, show that at first the oxygen-evolving complex is relocated into the lumen and later a depletion of D1/D2 proteins occurs (Fig. 1). Similar effects are observed when the PS-II apparatus is submitted to either high light intensities or additional stress with relatively high light [2].

We observed that the photosynthetic activity is greatly reduced after exposition to gamma radiations in a ^{60}Co-source of 5.87 kGy/h, that can be assimilated to energy which is consistent with the energies and fluxes given by space radiation. In particular cyanobacteria *Spirulina platensis* activity is reduced by 40% after 6h exposition (Fig. 2).

The experiment consists in measuring the variation of photosynthetic microorganism activity respect to the absorbed ionising radiation directly in

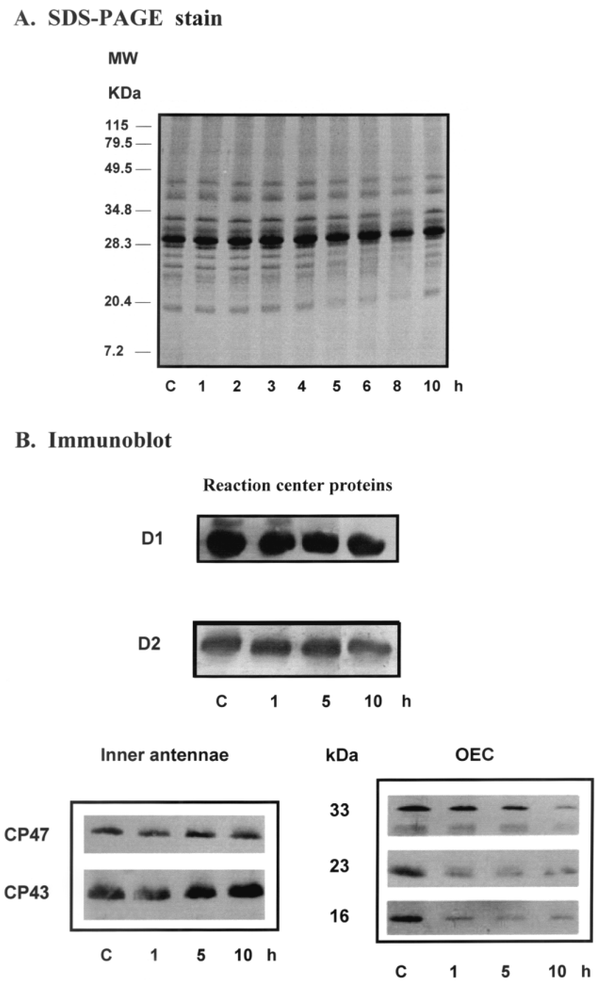

Fig. 1 – SDS-PAGE and immunoblot of PS-II particles after radiation stress.

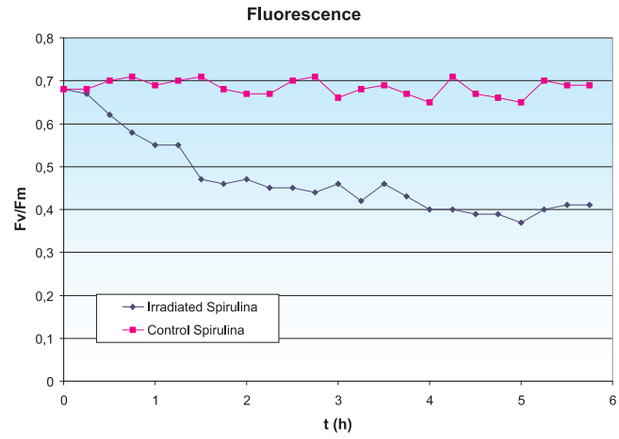

Fig. 2 – *Spirulina platensis* activity during gamma radiation exposition to gamma ^{60}Co-source of 5,87 kGy/h.

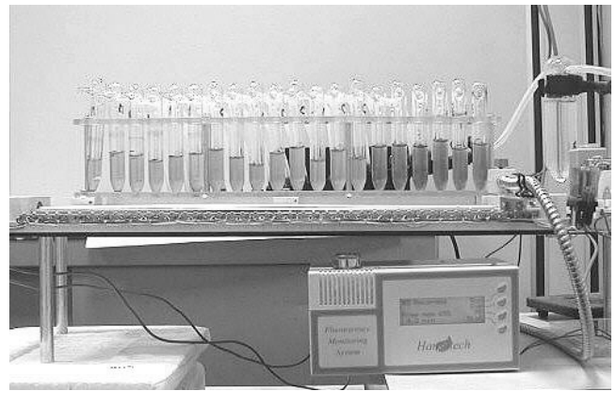

Fig. 3 – Automatic device to measure the fluorescence of microorganisms. A sensor with optical fibre moves along a mechanical rail.

space. For this purpose we built an automatic device to measure the PS-II activity by fluorescence. In this device an optic fibre coil connects a fluorescence sensor to 20 vials; a computer captures the signals and then processes the data. The optical fibre moves along a mechanical rail made of 22 switches and the fluorescence is measured automatically. Figure 3 shows a photo of the device.

4. Conclusions

These studies allowed us to i) increase knowledge on the effect of space radiation on the physiology of oxygen-evolving organisms; ii) to identify Photosystem II target to space stress.

With the built device we will determine, during the ASI balloon flight, the light conditions able to maximise the evolution of oxygen from microorganism cultures in space conditions.

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