Inhibition of Energy Transfer Reactions in Cyanobacteria by Different Ultraviolet Radiation

G. KULANDAIVELU, V. GHEETHA AND S. PERIYANAN

School of Biological Sciences
Madurai Kamaraj University
Madurai 625 021, INDIA

Summary

When Anacystis nidulans cells were irradiated with ultraviolet-C (UV-C, 254 nm), UV-B (285–325 nm) or UV-A (320–400 nm) radiation, the overall photosynthetic rate decreased progressively with time of treatment. Since a decrease in the rate of photosynthesis could be either due to a loss of excitation energy transfer from phycobilisomes (PBS) to chlorophyll and/or inhibition of various electron transfer reactions, both the fluorescence spectra and electron transfer reactions (rate of \( O_2 \) evolution) were measured in UV irradiated cells. UV irradiation brings about drastic changes in the excitation and emission spectra of Anacystis cells. A comparative investigation on the nature of action of these different UV wavelengths indicates strong action by UV-C radiation on both PBS to Chl \( a \) energy transfer and Chl \( a \)-mediated electron transport reactions than that of UV-B and UV-A. UV-C radiation brings about drastic loss of phycobilins, as evidenced from absorption and fluorescence excitation spectra. In contrast to this, UV-B and UV-A treatment resulted in loss of energy transfer from allophycocyanin (APC) to Chl \( a \). This was indicated by increased fluorescence emission from phycobilins with concomittant decrease in chlorophyll fluorescence.

Introduction

In the past three decades, several workers have made a number of investigations on the mechanism of inhibition of photosynthetic electron transport by ultraviolet (UV) radiation. Many (Bishop 1961; Yamashita and Butler 1968; Erixon and Butler 1971; Katoh and Kimimura 1974) have investigated in great detail the action of short wavelength UV radiation, namely UV-C (< 280 nm). Attention has also been focused on long wavelength UV, particularly UV-B (285–325 nm), as this radiation constitutes a part of solar radiation, and the level of which at the earth’s surface is regulated by atmospheric ozone density (Berner 1972; Green \( et \) al. 1974). The action of UV-C and UV-B on photosynthetic electron transport has been compared and shown to be quite distinct (Kulandaivelu and Noorudeen 1983). Recently we have found that long wavelength
blue-UV radiation (UV-A, 320–400 nm), which forms a major part of UV radiation in sunlight, inhibits the photosynthetic reaction specifically at the water oxidation site.

Among the lower algae, cyanobacteria are used extensively for studies on photochemical energy transfer reactions as they have phycobilisomes (PBS) as the major light harvesting complex. Besides, the unicellular forms are easy to manage, unlike the red and brown algae. The PBS, being protein chromophores, are likely to undergo denaturation on absorption of UV radiation. Hence, the present investigation has been undertaken to study in detail the nature of structural and photochemical changes occurring in PBS and energy transfer from PBS to chlorophyll upon treatment with different UV radiations in a typical unicellular cyanobacterium, *Anacystis nidulans*.

**Materials and Methods**

**Algal cultures:** Cultures of *Anacystis nidulans* were developed photoautotrophically in 500 ml culture tubes at 25°C. The cultures were aerated with filtered air. For all experiments, cells were harvested at the mid-log phase by centrifugation, washed once, and suspended in fresh culture medium.

**UV treatment:** Cell suspension at a chlorophyll concentration of 0.5 mg/ml was transferred to thermostated irradiation vessel (3 cm diameter × 3 mm depth) as a thin layer (approx. 1 mm thick) for UV treatment. UV radiation of different wavebands was obtained using either a Philips fluorescent black light lamp, type 05 (UV-A, λ emission max. 365 nm) or Philips sun lamp, type 12 (UV B, λ emission max. 315 nm) or Philips germicidal lamp (UV-C, λ emission max. 254 nm). Temperature during the treatment was maintained at 20°C. To avoid sedimentation of cells, the irradiation vessel was vibrated, using a motor at a speed of 5 Hz. Fluence rate was 5 W.m⁻². Control samples were covered with a plastic filter to remove all radiation below 400 nm. UV radiance was measured using a IL 700A radiometer (International Light, Inc. USA).

**Photosynthetic measurement:** The rate of photosynthetic O₂ evolution was measured in a Hansatech O₂ electrode under saturating white light at 25°C. White light at a radiance of 100 W.m⁻² was provided by a slide projector. Radiance level was measured using a Li-cor 188 quantum/radiometer (Li-cor, Inc., USA). Chl-a content was determined by the method of Myers and Kratz (1955).

**Absorption and fluorescence spectra:** Room temperature absorption spectra of cells were measured using a Hitachi 557 spectrophotometer. Fluorescence excitation and emission spectra were measured in a Hitachi MPF 4 spectrofluorimeter. Spectra presented here are not corrected for the differences in emission characteristics of the monochromator and