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Influence of substituted 1,4-anthraquinones on the chlorophyll fluorescence and photochemical activity of pea thylakoid membranes

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Abstract

The effect of substituted 1,4-anthraquinones on the photochemical activity and chlorophyll fluorescence of thylakoid membranes was examined. Both the fluorescence and the photochemical activity depend on the 1,4-anthraquinone substituent. Stronger quinone-induced quenching of the chlorophyll fluorescence than quinone-induced changes in the activity of photosystem II is observed. The type (Cl or Br) and the position (Cl) of the chalogen atom strongly influence the degree of inhibition of PSII electron transport and the quenching of chlorophyll fluorescence. The data suggest that the quenching of chlorophyll fluorescence is due rather to the interaction of the 1,4-anthraquinones and chlorophyll molecules than to an indirect effect caused by stimulation of the photochemistry.

Keywords: Chlorophyll fluorescence quenching; Thylakoid membranes; 1,4-Anthraquinones; Photochemical activity

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Changes in the energy distribution between chlorophyll–protein complexes of thylakoid membranes from pea mutants with modified pigment content I. Changes due to the modified pigment content

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Abstract

The low-temperature (77 K) emission and excitation chlorophyll fluorescence spectra in thylakoid membranes isolated from pea mutants were investigated. The mutants have modified pigment content, structural organization, different surface electric properties and functions [Dobrikova et al., Photosynth. Res. 65 (2000) 165]. The emission spectra of thylakoid membranes were decomposed into bands belonging to the main pigment protein complexes. By an integration of the areas under them, the changes in the energy distribution between the two photosystems as well as within each one of them were estimated. It was shown that the excitation energy flow to the light harvesting, core antenna and RC complexes of photosystem II increases with the total amount of pigments in the mutants, relative to the that to photosystem I complexes. A reduction of the fluorescence ratio between aggregated trimers of LHC II and its trimeric and monomeric forms with the increase of the pigment content (chlorophyll *a*, chlorophyll *b*, and lutein) was observed. This implies that the closer packing in the complexes with a higher extent of aggregation regulates the energy distribution to the PS II core antenna and reaction centers complexes. Based on the reduced energy flow to PS II, i.e., the relative increased energy flow to PS I, we hypothesize that aggregation of LHC II switches the energy flow toward LHC I. These results suggest an additive regulatory mechanism, which redistributes the excitation energy between the two photosystems and operates at non-excess light intensities but at reduced pigment content.

Keywords: 77 K chlorophyll fluorescence; Energy distribution; Thylakoid membranes; Pigment–protein complexes; Pea mutants

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Resonance Raman Spectroscopy of Xanthophylls in Pigment Mutant Thylakoid Membranes of Pea

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Abstract: *Low-temperature resonance Raman spectroscopy was used to study the changes in the molecular structure and configuration of the major xanthophylls in thylakoid membranes isolated from mutants of pea with modified pigment content and altered structural organization of their pigment–protein complexes. The Raman spectra contained four known groups of bands, ν_1–ν_4, which could be assigned to originate mainly from the long wavelength absorbing lutein and neoxanthin upon 514.5 nm and at 488 nm excitations, respectively. The overall configuration of these bound xanthophyll molecules in the mutants appeared to be similar to the wild type, and the configuration in the wild type was almost identical with that in the isolated main chlorophyll a/b light harvesting protein complex of photosystem II (LHCII). Significant differences were found mainly in the region of ν_4 (around 960 cm^{-1}), which suggest that the macroorganization of PS II–LHCII supercomplexes and/or of the LHCII-only domains are modified in the mutants compared to the wild type.* © 2004 Wiley Periodicals, Inc. Biopolymers 00: 000–000, 2004

Keywords: *resonance Raman spectroscopy; xanthophylls; thylakoid membranes; pigment mutants; light harvesting complex photosystem II*

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Role of LHCII organization in the interaction of substituted 1,4-anthraquinones with thylakoid membranes

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Abstract

The chlorophyll fluorescence, photochemical activity and surface electric properties of thylakoid membranes with different stoichiometry of pigment–protein complexes and organization of the light-harvesting chlorophyll *a*/*b* protein complex of photosystem II (LHCII) were studied in the presence of substituted 1,4-anthraquinones. Data show strong dependence of the quenching of the chlorophyll fluorescence on the structural organization of LHCII. The increase of the LHCII oligomerization, which is associated with significant reduction of the transmembrane electric charge asymmetry and electric polarizability of the membrane, correlates with enhanced quenching effect of substituted 1,4-athraquinones. Crucial for the large quinone-induced changes in the membrane electric dipole moments is the structure of the quinone molecule. The strongest reduction in the values of the dipole moments is observed after interaction of thylakoids with 3-chloro-9-hydroxy-1,4-anthraquinone (TF33) which has the highest quenching efficiency. The quinone induced changes in the photochemical activity of photosystem II (PSII) correlate with the total amount of the supramolecular LHCII–PSII complex and depend on the number of substituents in the 1,4-anthraquinone molecule.

Keywords: Chlorophyll fluorescence; Thylakoid membranes; Light-harvesting chlorophyll *a*/*b* protein complex; 1,4-Anthraquinones; Photochemical activity; Surface electric properties

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[redacted]

Oligomerization State of LHCII Modulates the Redox Properties of the Acceptor Side of Photosystem II in *Costata-2/133* Mutant of Pea

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***In vivo* photosynthetic characterization of the phenotypic *Costata 2/133* mutant of pea (*Pisum sativum* L.) revealed that the photochemical efficiency of photosystem II (PSII) does not differ from the wild type (WT). However, the yield of electron transport over PSII (F_e) and the photochemical quenching coefficient (qP) were decreased to 73% and 77.6% respectively, while non-photochemical quenching (qN) was slightly increased (109%) compared to the values in WT. Characterization of the chlorophyll-protein complexes in thylakoid membranes revealed lower (3.34) relative ratio of oligomeric ($LHCII^1$) to monomeric ($LHCII^3$) forms of the light-harvesting Chl *a/b* complex (LHCII) of PSII in *2/133* mutant than in WT (4.57), although only minor differences in the abundance of LHCII polypeptides were observed. This was accompanied by a considerable reduction of all photosynthetic pigments, especially the xanthophylls involved in the xanthophyll cycle in *2/133* mutant. Thermoluminescence (TL) measurements of PSII revealed that $S_2/S_3Q_B^-$ recombinations were shifted to lower temperatures in *2/133* mutant compared to WT plants. Concomitant with this, *2/133* mutant demonstrated a significant shift of $S_2Q_A^-$ characteristic TL peak to higher temperatures, thus narrowing the redox potential gap between $S_2Q_B^-$ and $S_2Q_A^-$, which might result in increased possibility for reaction centre quenching of excess light in *2/133* mutant. The role of LHCII structural alterations in modulating the probability for alternative non-radiative charge recombination pathways is discussed.**

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Changes in the energy distribution in mutant thylakoid membranes of pea with modified pigment content. II. Changes due to magnesium ions concentration

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Abstract

Low-temperature (77 K) steady-state chlorophyll fluorescence emission spectra, room temperature fluorescence and light scattering of thylakoid membranes isolated from pea mutants were studied as a function of Mg^{2+} concentration. The mutants have modified pigment content and altered structural organization of the pigment-protein complexes, distinct surface electric properties and functions. The analysis of the 77 K emission spectra revealed that Mg^{2+}-depletion of the medium caused not only an increased energy flow toward photosystem I in all investigated membranes but also changes in the quenching of the fluorescence, most probably by internal conversion. The results indicated that the macroorganization of the photosynthetic apparatus of mutants at supramolecular level (distribution and segregation of two photosystems in thylakoid membranes) and at supermolecular level (stacking of photosystem II supercomplexes) required different Mg ion concentrations. The data confirmed that the segregation of photosystems and the stacking of thylakoid membranes are two distinct phenomena and elucidated some features of their mechanisms. The segregation is initiated by changes in the lateral microorganization of light harvesting complexes II, their migration (repulsion from photosystem I) and subsequent separation of the two photosystems. Most likely 3D aggregation and formation of macrodomains, containing only photosystem II antenna complexes, play a certain precursory role for the increasing degree of the membrane stacking and the energy coupling between the light harvesting complexes II and the core complexes of photosystem II in the frame of photosystem II supercomplexes.

Keywords: Energy distribution; Thylakoid membranes; Pigment-protein complexes; Pea mutants; Mg ions; Stacking; Separation of PS I and PS II

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Relationship between the organization of the PSII supercomplex and the functions of the photosynthetic apparatus

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Abstract

The chlorophyll fluorescence and the photosynthetic oxygen evolution (flash-induced oxygen yield patterns and oxygen bursts under continuous irradiation) were investigated in the thylakoid membranes with different stoichiometry and organization of the chlorophyll-protein complexes. Data show that the alteration in the organization of the photosystem II (PSII) supercomplex, i.e. the amount and the organization of the light-harvesting chlorophyll *a*/*b* protein complex (LHCII), which strongly modifies the electric properties of the membranes, influences both the energy redistribution between the two photosystems and the oxygen production reaction. The decrease of surface electric parameters (charge density and dipole moments), associated with increased degree of LHCII oligomerization, correlates with the strong reduction of the energy transfer from PSII to PSI. In the studied pea thylakoid membranes (wild types Borec, Auralia and their mutants *Coeruleovireus 2/16*, *Costata2/133*, *Chlorotica XV/1422*) with enhanced degree of oligomerization of LHCII was observed: (i) an increase of the S_0 populations of PSII in darkness; (ii) an increase of the misses; (iii) an alteration of the decay kinetics of the oxygen bursts under continuous irradiation. There is a strict correlation between the degree of LHCII oligomerization in the investigated pea mutants and the ratio of functionally active PSIIα to PSIIβ centers, while in thylakoid membranes without oligomeric structure of LHCII (*Chlorina f2* barley mutant) the PSIIα centers are not registered.

Keywords: Light-harvesting chlorophyll *a*/*b* protein complex of photosystem II; Chlorophyll fluorescence; Photosynthetic oxygen evolution; Pea mutant thylakoid membranes

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ORIGINAL PAPER

Sensitivity of the photosynthetic apparatus to UV-A radiation: role of light-harvesting complex II–photosystem II supercomplex organization

Pavlina I. Ivanova · Anelia G. Dobrikova · Stefka G. Taneva · Emilia L. Apostolova

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Abstract In this work we study the effect of UV-A radiation on the function of the photosynthetic apparatus in thylakoid membranes with different organization of the light-harvesting complex II–photosystem II (LHCII–PSII) supercomplex. Leaves and isolated thylakoid membranes from a number of previously characterized pea species with different LHCII size and organization were subjected to UV-A treatment. A relationship was found between the molecular organization of the LHCII (ratio of the oligomeric to monomeric forms of LHCII) and UV-A-induced changes both in the energy transfer from PSII to PSI and between the chlorophyll–protein complexes within the LHCII–PSII supercomplex. Dependence on the organization of the LHCII was also found with regard to the degree of inhibition of the photosynthetic oxygen evolution. The susceptibility of energy transfer and oxygen evolution to UV-A radiation decreased with increasing LHCII oligomerization when the UV-A treatment was performed on isolated thylakoid membranes, in contrast to the effect observed in thylakoid membranes isolated from pre-irradiated pea leaves. The data suggest that UV-A radiation leads mainly to damage of the PSIIα centers. Comparison of membranes with different organization of their LHCII–PSII supercomplex shows that the oligomeric forms of LHCII play a key role for sensitivity to UV-A radiation of the photosynthetic apparatus.

Abbreviations

A	Initial oxygen burst
BQ	1,4-Benzoquinone
Chl	Chlorophyll
LHCII	Light-harvesting chlorophyll *a/b* protein complex of photosystem II
LHCIIo/m	Oligomeric to monomeric forms of LHCII
OEC	Oxygen evolving complex
PSI	Photosystem I
PSII	Photosystem II
Q_A	Primary quinone electron acceptor of PSII
Q_B	Secondary quinone electron acceptor of PSII
S_i	Redox state *i* of the water oxidizing system
wt	Wild type
Y_3	Amplitude of the oxygen flash yields after third flash

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Effect of phosphatidylglycerol depletion on the surface electric properties and the fluorescence emission of thylakoid membranes

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Abstract

To explore the possible effect of phosphatidylglycerol (PG) on the surface electric properties and chlorophyll fluorescence characteristics we used electric light scattering technique and 77 K chlorophyll fluorescence of thylakoid membranes from a cyanobacterium, *Synechocystis* PCC6803 (wild type) and its *pgsA* mutant defective in PG synthesis. We found a strong decrease in the permanent and induced electric dipole moments of the mutant thylakoids, following long-term PG depletion parallel with a decrease of the emission peak from PSI and an increase of the emission peak from PSII. Partial recovery of the electric state of thylakoid membranes was observed at re-addition of PG to the mutant cells depleted of PG for 21days. This change in the electric dipole moments is probably due to a decrease in PG content and progressive structural alterations in the macroorganization of the photosynthetic complexes induced by PG deprivation.

Our results suggest that the depletion of a lipid, which carries a negative charge, despite its small contribution to the overall lipid content, significantly perturbs the surface charge of the membranes. These changes are related with the chlorophyll fluorescence emission ratios of two photosystems and may partly explain our earlier results concerning the PG requirement for the function and assembly of photosystems I and II reaction centers.

Keywords: Phosphatidylglycerol; *Synechocystis* PCC6803; *pgsA* mutant; Thylakoid membranes; Electric light scattering; Chlorophyll fluorescence

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Relationship between the degree of carotenoid depletion and function of the photosynthetic apparatus

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ABSTRACT

Fluridone, an inhibitor of the carotenoid biosynthesis, was used to study the relationship between the degree of carotenoid depletion and the function of the photosynthetic apparatus. The data reveal that, at a small reduction of the carotenoid content (25% decrease of the total carotenoids), the PSII and PSI (oxidation of P700 by far-red light) photochemistry is not influenced, while the oxygen evolution is strongly inhibited. Further reduction of the total carotenoid content (more than 40%) leads to decrease of the chlorophyll content and inhibition of the functions of both photosystems as the effect on the photosynthetic oxygen evolution and primary photochemistry is stronger than the effect on P700 oxidation. The analysis of the oxygen production under continuous illumination and flash oxygen yields suggests that the inhibition of the oxygen evolution is caused mainly by the damage of PSIIα centers.

Доклади на Българската академия на науките
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BIOLOGIE
Biophysique

ASSESSMENT OF CHLOROPHYLL FLUORESCENCE AND PHOTOSYNTHETIC OXYGEN EVOLUTION PARAMETERS IN DEVELOPMENT OF BIOSENSORS FOR DETECTION OF Q_B BINDING HERBICIDES

Radka Vladkova, Pavlina Ivanova, Vassilena Krasteva, Amarendra N. Misra*, Emilia Apostolova

(*Submitted by Academician K. Kumanov on December 23, 2008*)

Abstract

Thylakoid membranes isolated from pea leaves were used for comparing the sensitivity of the parameters of Pulse-Amplitude-Modulation (PAM) chlorophyll fluorescence and photosynthetic oxygen evolution to elaborate a biosensor for detection of Q_B binding herbicide, atrazine. Non-photochemical quenching parameters (qN and NPQ) and flash oxygen evolution (estimated as the amplitude of the oxygen evolution after third flash, Y3) are the most suitable parameters for monitoring the effect of atrazine.

Key words: thylakoid membrane, atrazine, non-photochemical quenching, oxygen evolution, biosensor

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BIOLOGIE
Biophysique

ASSESSMENT OF SENSITIVITY OF PHOTOSYNTHETIC OXYGEN EVOLUTION AND CHLOROPHYLL FLUORESCENCE PARAMETERS TO COPPER FOR APPLICATION IN BIOSENSORS

Anelia Dobrikova, Radka Vladkova, Georgy Rashkov, Mira Busheva, Amarendra N. Misra*, Emilia Apostolova

(*Submitted by Academician K. Kumanov on March 12, 2009*)

Abstract

The effects of copper ions on the parameters of the photosynthetic oxygen evolution measured by polarographic oxygen rate electrode and Pulse-Amplitude-Modulation (PAM) chlorophyll fluorescence of pea thylakoid membranes are compared. Data reveal that the non-photochemical quenching parameters and flash-induced oxygen evolution are suitable for detection of copper in solutions.

Key words: thylakoid membranes, photosystem II, copper, oxygen evolution, PAM fluorometry

Доклади на Българската академия на науките
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BIOLOGIE
Biophysique

THE ROLE OF ANIONIC LIPIDS IN LHCII ORGANIZATION AND IN PHOTOINHIBITION OF PHOTOSYNTHETIC APPARATUS

Kolyo Dankov, Anelia Dobrikova, Balázs Bogos*, Zoltan Gombos*, Emilia Apostolova

(*Submitted by Corresponding Member A. Kosev on April 6, 2009*)

Abstract

Pea mutants are characterized by chlorophyll fluorescence detected with a Pulse-Amplitude-Modulated fluorometer, photosynthetic oxygen evolution measured with polarographic oxygen rate electrode and lipid composition of thylakoid membranes measured by thin layer and gas chromatography. The results suggested a specific role of anionic lipids in protection of photosynthetic apparatus to photoinhibition. Data revealed that the decrease in the anionic lipids, which correlates with an increase in the oligomeric forms of light-harvesting complexes of photosystem II (LHCII), lead to lower sensitivity of photosynthetic apparatus to high-light treatment.

Key words: thylakoid membrane, photoinhibition, anionic lipids, photosynthetic apparatus

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BIOLOGIE
Biochimie

FREEZE-THAW DAMAGE OF PHOTOSYNTHETIC APPARATUS. EFFECT OF THE ORGANIZATION OF LHCII-PSII SUPERCOMPLEX

Kolyo Dankov, Stefka Taneva*, Emilia L. Apostolova

(*Submitted by Academician K. Kumanov on April 30, 2009*)

Abstract

The effect of freeze-thaw treatment on the energy transfer and photosynthetic oxygen evolution of pea mutant thylakoid membranes in the presence of cryotoxic (NaCl) and cryoprotector (sucrose) substances was investigated. Data reveal that freeze-thaw induced changes in the acceptor side of PSII, which depend on the organization of LHCII-PSII supercomplex, influence on the interaction of Q_B with exogenous electron acceptors and with plastoquinone. The increase of the oligomerization of LHCII preserves the capacity for oxidation of Q_B from artificial electron acceptors and plastoquinone during freezing.

Key words: thylakoid membrane, freezing damage, LHCII-PSII supercomplex

Доклади на Българската академия на науките
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BIOLOGIE

Biophysique

DIFFERENTIAL RESPONSE OF THE PHOTOSYNTHETIC APPARATUS OF ANTARCTIC ALGAE *SYNECHOCYSTIS SALINA* (CYANOPHYTA) AND *CHLORELLA VULGARIS* (CHLOROPHYTA) TO UV-B RADIATION

Emilia Apostolova, Irina Pouneva*, Irena Grigorova*, Kaledona Minkova*, Nezabravka Nikolaeva, Georgi Rashkov

(*Submitted by Academician K. Kumanov on March 16, 2010*)

Abstract

The sensitivity of the photosynthetic apparatus of Antarctic *Synechocystis salina* and *Chlorella vulgaris* after UV-B irradiation was compared. Our results clearly demonstrate that UV-B induced changes in the energy transfer between chlorophyll-protein complexes, primary photochemistry of photosystem II and photosynthetic oxygen evolution, are stronger influenced in the cyanobacterium *Synechocystis salina* than that in the green alga *Chlorella vulgaris*.

Key words: UV-B, photosynthetic apparatus, photosynthetic oxygen evolution, *Synechocystis salina*, *Chlorella vulgaris*

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Biophysique

DIFFERENTIAL RESPONSE OF THE PHOTOSYNTHETIC APPARATUS OF ANTARCTIC ALGAE *SYNECHOCYSTIS SALINA* (CYANOPHYTA) AND *CHLORELLA VULGARIS* (CHLOROPHYTA) TO UV-B RADIATION

Emilia Apostolova, Irina Pouneva*, Irena Grigorova*, Kaledona Minkova*, Nezabravka Nikolaeva, Georgi Rashkov

(*Submitted by Academician K. Kumanov on March 16, 2010*)

Abstract

The sensitivity of the photosynthetic apparatus of Antarctic *Synechocystis salina* and *Chlorella vulgaris* after UV-B irradiation was compared. Our results clearly demonstrate that UV-B induced changes in the energy transfer between chlorophyll-protein complexes, primary photochemistry of photosystem II and photosynthetic oxygen evolution, are stronger influenced in the cyanobacterium *Synechocystis salina* than that in the green alga *Chlorella vulgaris*.

Key words: UV-B, photosynthetic apparatus, photosynthetic oxygen evolution, *Synechocystis salina*, *Chlorella vulgaris*

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Photoelectron transport ability of chloroplast thylakoid membranes treated with NO donor SNP: Changes in flash oxygen evolution and chlorophyll fluorescence

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ABSTRACT

The nitric oxide (NO) donor sodium nitroprusside (SNP) is frequently used in plant science *in vivo*. The present *in vitro* study reveals its effects on the photosynthetic oxygen evolution and the chlorophyll fluorescence directly on isolated pea thylakoid membranes. It was found that even at very low amounts of SNP (chlorophyll/SNP molar ratio ~ 67:1), the SNP-donated NO stimulates with more than 50% the overall photosystem II electron transport rate and diminishes the evolution of molecular oxygen. It was also found that the target site for SNP-donated NO is the donor side of photosystem II. Compared with other NO-donors used in plant science, SNP seems to be the only one exhibiting stimulation of electron transport through photosystem II.

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REGULAR PAPER

Identification of thylakoid membrane thermal transitions in *Synechocystis* sp. PCC6803 photosynthetic mutants

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Abstract We used differential scanning calorimetry (DSC) as a technique capable of identifying photosynthetic complexes on the basis of their calorimetric transitions. Annotation of thermal transitions was carried out with thylakoid membranes isolated from various photosynthetic mutants of *Synechocystis* sp. PCC6803. The thylakoid membranes exhibited seven major DSC bands between 40 and 85°C. The heat sorption curves were analyzed both by mathematical deconvolution of the overall endotherms and by a subsequent annealing procedure. The successive annealing procedure proved to be more reliable technique than mathematical deconvolution in assigning thermal transitions. The main DSC band, around 47°C, resulting from the high enthalpy change that corresponds to non-interacting complex of PSII, was assigned using the PSI-less/*apcE*$^-$ mutant cells. Another band around 68–70°C relates to the denaturation of PSII surrounded by other proteins of the photosynthetic complexes in wild type and PSI-less/*apcE*$^-$ cells. A further major transition found at 82–84°C corresponds to the PSI core complex of wild type and PSII-deficient BE cells. Other transition bands between 50–67 and 65–75°C are believed to relate to ATP synthase and cytochrome b_6f, respectively. These thermal transitions were obtained with thylakoids isolated from PSI$^-$/PSII$^-$ mutant cells. Some minor bands determined at 59 and 83–84°C correspond to an unknown complex and NADH dehydrogenase, respectively. These annotations were done by PSI-less/*apcE*$^-$ and PSI$^-$/PSII$^-$ mutants.

Keywords Differential scanning calorimetry · Cyanobacterium · Photosynthesis · Thylakoid membrane · Protein complex · Endotherm assignation

Abbreviations

2D-BN/SDS-PAGE	Two-dimensional blue native/SDS polyacrylamide gel electrophoresis
BE	Phycobilisome-less and PSII-less mutant of *Synechocystis* PCC6803
CC	Core complex
DSC	Differential scanning calorimetry
NDH	NADH dehydrogenase
PSI	Photosystem I
PSII	Photosystem II
RC47	PSII CC without CP43 subunit

Introduction

Protein complexes provide structural basis for the activity of the photosynthetic apparatus. The protein subunits are organized in macro aggregates, which are necessary for photosynthetic activity. The formation of photosynthetic complexes can be studied by various biophysical

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Research article

LHCII organization and thylakoid lipids affect the sensitivity of the photosynthetic apparatus to high-light treatment

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ABSTRACT

Pulse-amplitude-modulated (PAM) chlorophyll fluorescence and photosynthetic oxygen evolution were used to investigate the role of the different amount and organization of light-harvesting complexes of photosystem II (LHCII) in four pea species on the susceptibility of the photosynthetic apparatus to high-light treatment. In this work we analyzed the thylakoid membrane lipid composition of the studied pea plants. A relationship between the structural organization of LHCII proteins, the amount of the main lipid classes and the sensitivity of the photosynthetic apparatus to high-light treatment was found. The results reveal that the photosynthetic apparatus, enriched in oligomeric forms of LHCII concomitant with decreased amount of anionic lipids and increased content of the monogalactosyldiacylglycerol (MGDG), is less sensitive to high light. Our data also suggest that the degree of LHCII oligomerization, as well as the lipid composition do not influence the degree of recovery of the PSII photochemistry after excess light exposure.

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Prolonged sensitivity of immobilized thylakoid membranes in cross-linked matrix to atrazine

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ABSTRACT

Freshly prepared pea thylakoid membranes were immobilized in bovine serum albumin–glutaraldehyde cross-linked matrix (BSA–GA matrix) and their stability under long term storage was analyzed by Pulse-Amplitude-Modulated (PAM) chlorophyll fluorescence and photosynthetic oxygen evolution measured by oxygen rate electrode. The thylakoid membranes stored at 4 °C showed prolonged stability in BSA–GA matrix and additional adsorption on nitrocellulose membrane filters gave them more stability. The sensitivity of the parameters of the oxygen evolution of thylakoid membranes to atrazine increased with immobilization. The half-inhibition time for oxygen evolution and quantum efficiency of photosynthesis could be prolonged to more than 15 days. These results suggest that the immobilized thylakoid membranes in BSA–GA matrix can be used as biological receptor in biosensors for a long period of time (up to 25 days) applying the proposed new method for atrazine detection by using polarographic oxygen rate electrode. This method is more sensitive, faster and easier to use than other methods for detection of herbicides based on determination of the photochemical activity of photosystem II.

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Sensitivity of *Chlorella vulgaris* to herbicides. Possibility of using it as a biological receptor in biosensors

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ABSTRACT

In the present study the sensitivity of *Chlorella vulgaris* to herbicides was investigated using polarographic oxygen rate electrode and the Pulse-Amplitude-Modulated (PAM) chlorophyll fluorescence measurements. Data reveal: (i) higher sensitivity of parameters of photosynthetic oxygen evolution (flash induced oxygen yields and oxygen burst under continuous illumination) in comparison to the widely used parameters of the chlorophyll fluorescence; (ii) higher sensitivity of oxygen evolution parameters of *Chlorella* cells to Q_B-binding herbicides in comparison to the pea thylakoid membranes; (iii) similar sensitivity of the PAM parameters to herbicides for both *Chlorella* cells and thylakoid membranes from higher plants. The relationship between the herbicide sensitivity and the kinetic parameters of the oxygen evolution of green algae and higher plants are discussed.

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ROLE OF ORGANIZATION OF PHOTOSYNTHETIC APPARATUS FOR ITS SENSITIVITY TO ATRAZINE

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Abstract

In the current study was investigated the sensitivity of the photosynthetic oxygen evolution of pea thylakoid membranes with different organization of photosystem II complex to atrazine. Our results revealed that atrazine-induced inhibition of the oxygen evolution increases with the decrease of the oligomeric form of light-harvesting complex of photosystem II, which correlates with increase of the number of the thylakoid membranes in grana.

Key words: atrazine, thylakoid membranes, pea mutants, photosynthetic oxygen evolution

Introduction. The wide use of herbicides in modern agriculture has led to serious environmental problems. In the last years triazines herbicides are used in large quantities. One widely used herbicide from this group is atrazine, which targets the quinone binding site Q_B and inhibits photosystem II (PSII) [1, 2]. The chlorophyll-protein complex of PSII has a key role in the energy-conversing mechanisms of higher plants. This complex drives electrons from water to plastoquinone to produce molecular oxygen and protons using energy derived from

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Effect of partial or complete elimination of light-harvesting complexes on the surface electric properties and the functions of cyanobacterial photosynthetic membranes

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Influence of the modification of the cyanobacterial light-harvesting complex [i.e. phycobilisomes (PBS)] on the surface electric properties and the functions of photosynthetic membranes was investigated. We used four PBS mutant strains of *Synechocystis* sp. PCC6803 as follows: PAL (PBS-less), CK (phycocyanin-less), BE (PSII-PBS-less) and PSI-less/*apcE*$^{-}$ (PSI-less with detached PBS). Modifications of the PBS content lead to changes in the cell morphology and surface electric properties of the thylakoid membranes as well as in their functions, such as photosynthetic oxygen-evolving activity, P700 kinetics and energy transfer between the pigment–protein complexes. Data reveal that the complete elimination of PBS in the PAL mutant causes a slight decrease in the electric dipole moments of the thylakoid membranes, whereas significant perturbations of the surface charges were registered in the membranes without assembled PBS–PSII macrocomplex (BE mutant) or PSI complex (PSI-less mutant). These observations correlate with the detected alterations in the membrane structural organization. Using a polarographic oxygen rate electrode, we showed that the ratio of the fast to the slow oxygen-evolving PSII centers depends on the partial or complete elimination of light-harvesting complexes, as the slow operating PSII centers dominate in the PBS-less mutant and in the mutant with detached PBS.