Heat-Induced Changes in the Photochemical Centres and the Protein Secondary Structures of Photosystem II Studied by Variable Fluorescence and Difference FT-IR Spectroscopy

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Variable fluorescence (F_v), i.e., $F_v = F_m - F_o$ where F_o is the minimal fluorescence and F_m the maximum fluorescence, and difference Fourier transform infrared (FT-IR) spectroscopy were used to study the effect of heat stress in the 25–55 °C range on photosystem II (PSII) structure and function. First, the F_v intensity reflects accurately the changes in the number of open photochemical centers in PSII. Secondly, the use of F_v in combination with FT-IR spectroscopy can disclose structure-function correlations in the heat inactivation of the PSII complex. Analysis of the midpoint temperatures of thermal denaturation, i.e., 50% inactivation, reported so far in investigations of the thylakoid membrane components has revealed that most of the thermal transitions attributed to PSII are in the 39–46 °C range. In this work, it is shown specifically that the midpoint temperature of PSII inactivation is at about 40 °C. Moreover, it was clearly demonstrated that the heat-induced changes above 40 °C are the result of a marked decrease in the number of open photochemical centers in PSII. It was also seen that above this same temperature the loss of photochemical centers has its structural counterpart in overall modifications of the secondary structures of the PSII proteins resulting from the decrease in the α-helix content concomitant with the increase in extended chain (β-strand) conformations. In brief, a novel finding reported here is that the number of open photochemical centers in PSII is dependent on a dynamic equilibrium between the contents of the PSII proteins in α-helix and extended chains (β-strands), but not in β-sheets and β-turn structures except for the antiparallel-β-sheet conformations. This therefore associates the thermal inactivation of the photochemical centers in photosystem II with distinct conformational changes in the proteins of the PSII supramolecular complex. In the particular context of the present study, these findings constitute a significant contribution to the investigation of structure-function correlations in the photosynthetic membrane. In a broader context, this information might be essential for the comprehension of the molecular arrangements or local structure order that are involved directly or indirectly in biological catalysis.

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