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Abstract

Chloroplast Control Mechanisms by Molecular Electronic Device †

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The aim of this research is to study the light phase of photosynthesis based on X-ray diffraction data from photosystems I and II (PS-I and PS-II), as well as the molecular structures of solar energy conversion and electron flow control systems.

The structural analysis of PS-II showed that the manganese cluster $Mn_4O_5Ca(H_2O)_4$ is an electron generator, where solar energy breaks the chemical bonds of water, accompanied by H_2O_2 formation. The electrochemical oxidation of H_2O_2 by Mn^{4+} ion leads to the formation of oxygen and two protons $H_2O_2 - 2e^- \rightarrow O_2\uparrow + 2H^+ + 23.5$ kcal, while Mn^{4+} is reduced to Mn^{2+}. Mn^{4+} regeneration occurs by donating two electrons to PS-I to NADPH·H.

The uncontrolled generation of electrons in chloroplasts leads to the appearance of free radicals that destroy cellular structures. In this regard, chloroplasts have protective mechanisms to remove excess electrons. X-ray diffraction studies of PS-I and PS-II showed that the active centers P680 and P700 have formed photoelectrolysis systems in which chlorophyll molecules act as electrodes (cathode and anode). Electronic circuits P680 and P700 close iron–sulfur trigger clusters that control the flow of electrons. Triggers switch electron flows to reduce NADPH·H or send excess electrons to electrolyzers to oxidize water at the anode: $2H_2O \rightarrow O_2\uparrow + 4H^+ + 4e^-$ and reduce protons at the cathode: $2H^+ + 2e^- \rightarrow \uparrow H_2$.

Conclusions. Based on the results of X-ray diffraction studies of H_2O-plastoquinone oxidoreductase (PS-II), the mechanism of electron generation of $Mn_4O_5Ca(H_2O)_4$ is considered. Photoelectrolysis systems in the P680 PS-II and P700 PS-I structures have been identified, and the principle of their operation is described. A natural molecular electronic device that controls and monitors the processes occurring in the ETC of the light phase of photosynthesis is considered.

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