*IOSR Journal of Pharmacy and Biological Sciences (IOSR-JPBS)*
*e-ISSN:2278-3008, p-ISSN:2319-7676. Volume 12, Issue 6 Ver. II (Nov. – Dec. 2017), PP 65-67*
*www.iosrjournals.org*

# Chemical Scheme of Water-Splitting Process during Photosynthesis by the Way of Experimental Analysis

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***Abstract:*** *Different water oxidation schemes during photosynthesis are developed from different view-point by analysis of different experimental data. In this paper, an approach will be done to create a symmetrical opinion among all of the opinions of water oxidation by perfect analysis of experimental data. However it is an important guide-line to explain the chemical changes in S-state mechanism during water oxidation process.*

***Keywords:*** *S-state Mechanism, Bonding Chemistry, Photochemical Effect, Oxide Reaction.*

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Date of Submission: 07-11-2017 Date of acceptance: 21-11-2017

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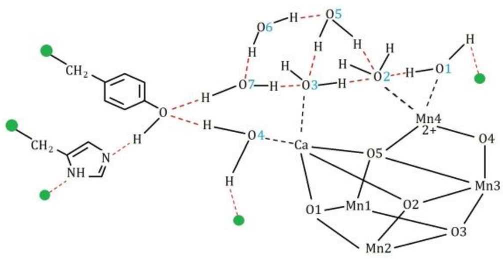
## I. Introduction

It is already known that the arrangement of hydrogen-bonding network among oxygen-evolving complex (OEC), water molecules ($H_2O$), tyrosine D1-Y161 and D1-His190 in PS II can play an important role in water oxidation process during photosynthesis. The hydrogen-bonding network which is placed at normal situation of water-splitting procedure in PS II is denoted by red dot lines below:



Water-splitting is occurred obviously in between the first and second water molecules (marked as blue numbers in the above figure) attached with $Ca^{2+}$ and $Mn4^{2+}$ of $Mn_4CaO_5$ cluster by coordinate covalent bonding (shown as black dot lines above). The reaction of water oxidation is proceeded through absorption of photon (hv) by Mn4 whose oxidation states ranging from +2 to +3 & +4 and finally rearrangement of hydrogen-bonding network will be happened by accepting two water molecules ($2H_2O$) from outside to comeback at normal situation (preliminary figure) of water-splitting procedure.

## II. Water-Splitting

At first in the water oxidation process, $Mn4^{2+}$ absorbs a photon (hv) from light and releases an active electron (e) which attacks tyrosine D1- Y161 to produce phenoxide ion of D1-Y161, $H^+$ and an electron (e). This electron can stabilize photoactive ionized accessory-chlorophyll ($P_A^+$) into stable accessory-chlorophyll ($P_A$) [1]. $H^+$ is accepted by D1-His190 to form ionized D1-His190. As a result, the metallo-oxo cluster ($Mn_4CaO_5$) is transferred into a state of ionized metallo-oxo cluster ($[Mn_4CaO_5]^+$).

To stabilize the ionized cluster, $H^+$ ion will be released from second water molecule and a new bond will be formed in between oxygen atom of the water molecule and Mn4 atom (now its oxidation state is +3). That $H^+$ can be accepted by phenoxide ion of D1-Y161 to generate normal D1-Y161 again. In this situation, ionized D1-His190 can release its previous accepted $H^+$ to develop normal D1-His190. Here stable metallo-oxo cluster will be created with hydroxide formation from second water molecule at period-one in S-state mechanism [2].

In this way, stable metallo-oxo cluster with peroxide, super oxide and dioxygen [3] (also intermediate S-states [4]) will be formed at period-two, period-three and period-four [5] respectively in S-state mechanism. As well as the oxidation states of Mn4 (+2 in preliminary state) are transferred into +3, (+4 to +2), +3 & (+4 to

+2) respectively in the all periods of S-state mechanism. At final level, two new water molecules ($2H_2O$) are accepted to regenerate normal metollo-oxo cluster with its preliminary form.

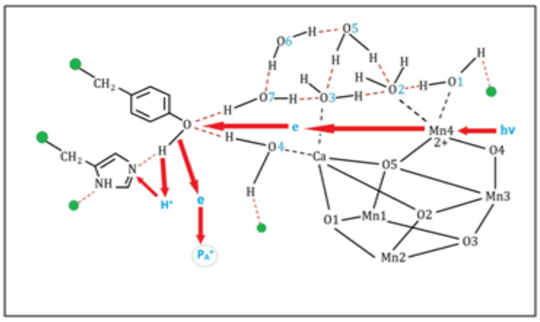


**Figure- 1: $S_0$ (monoxide)**

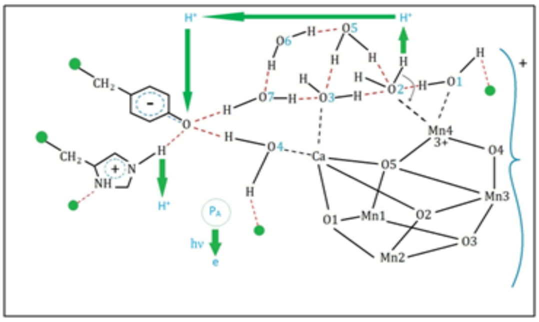


**Figure- 2: $S_0$*([$Y_zS_0$])**

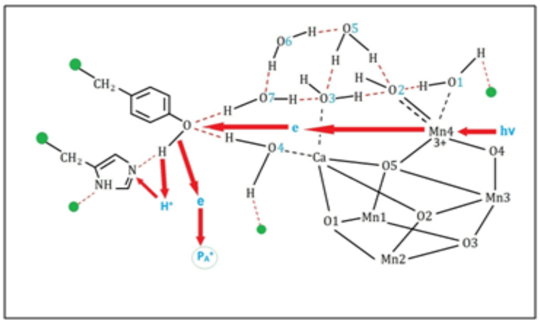


**Figure- 3: $S_1$ (hydroxide)**

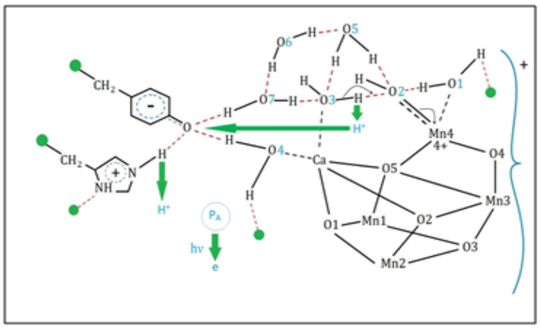


**Figure- 4: $S_1$* ([$Y_zS_1$])**

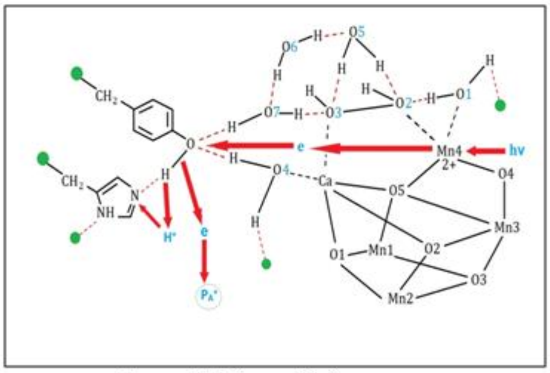


**Figure- 5: $S_2$ (peroxide)**

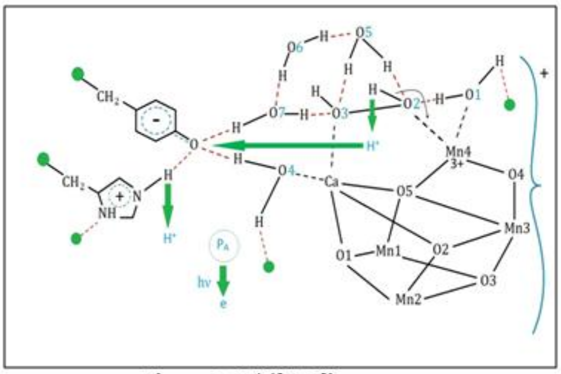


**Figure- 6: $S_2$* ([$Y_zS_2$])**

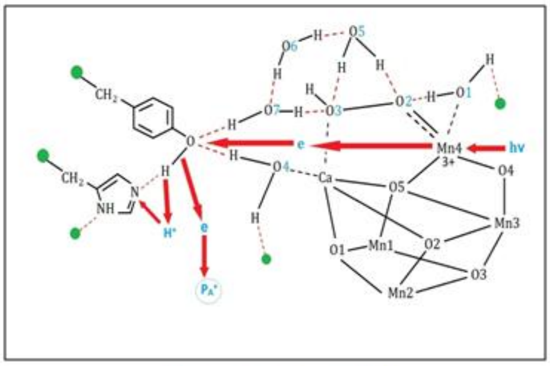


**Figure- 7: $S_3$ (super oxide)**

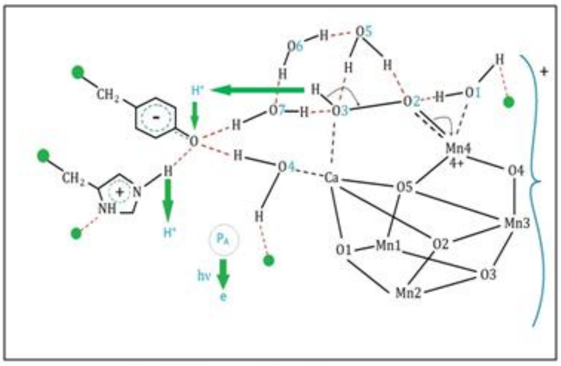


**Figure- 8: $S_3$* ([$Y_zS_3$])**

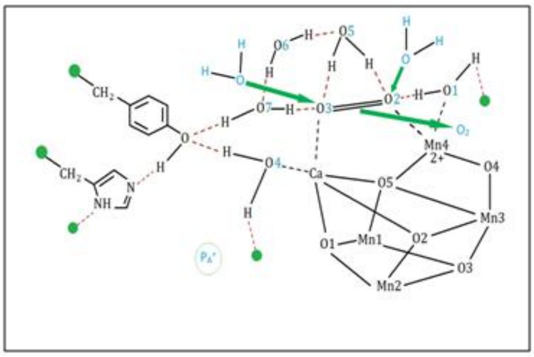



Figure- 9: $S_4$ (di-oxygen)

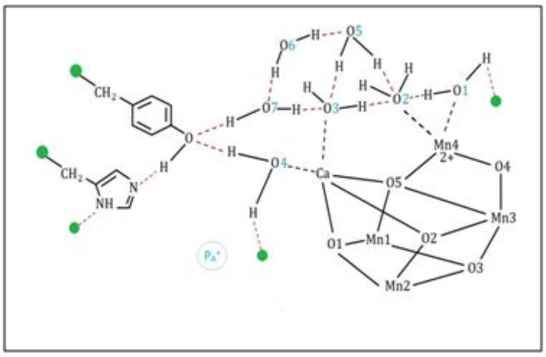



Figure- 10: $S_0$ (monoxide)

The above figures are considered according to modern introduced S-states ($S_0$, $S_1$, $S_2$ & $S_3$) and intermediate S-states ($S_0$*, $S_1$*, $S_2$*, $S_3$* & $S_4$) [3, 4]. However the discussed scheme successfully explains actual nature of all S-states and the reality of chemical changes in S-state mechanism side by side.

## III. Summary

The period-one, two, three and four of S-state mechanism are expressed in figures: 1-3, 3-5, 5-7 & 7-10 respectively. Here the figures of reaction to split water ($H_2O$) during photosynthesis are developed by perfect analysis of experimental data. All of the possible ways from the data are maintained as a sufficient manner of accuracy (data not shown).

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