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Thermoluminescence

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Abstract

Thermoluminescence is the simple technique very useful for studying electron transfer reactions on the photosystem II (standard thermoluminescence) or the level of lipid peroxidation in the membranes (high temperature thermoluminescence) in photosynthetic organisms. Both techniques were availed to investigate the effects produced on Chlorella vulgaris cells by the six compounds: the chemical intermediates bromobenzene and diethanolamine, the antioxidant propyl gallate, the semiconductors indium nitrate, the pesticides sodium monofluoroacetate and the antimalarial drug chloroquine.

Keywords*: - Thermoluminescence, photosystem II, bromobenzene, lipid peroxidation, electron transfer*

INTRODUCTION

Electron transfer activity of the photosystem II significantly decreased after the exposure of the Chlorella cells to all the six chemicals availed. Lipid peroxidation was slightly reduced by the antioxidant propyl gallate, not changed by indium nitrate and very potently simulated by diethanolamine, chloroquine, sodium monofluoroacetate and the bromobenzene. For five of the chemicals studied (not bromobenzene) there is the very good correlation between the cytotoxic effects in Chlorella cells measured by the algal growth inhibition test, and also the inhibition of photosystem II activity (Chapman et al., 1991). The results suggest that one very key effect of these chemicals in the Chlorella cells is the inhibition of photosynthetic metabolism by the blocking of the

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monofluoroacetate, diethanolamine and the chloroquine this inhibition seems to be related with the induction of high level of the lipid peroxidation in cells that may alter the stability of photosystem II(Clegg et al.,2010). The results obtained by the both techniques supply information that can be used as a supplement to the growth inhibition tests and allows a more complete assessment of the effects of the chemical in photosynthetic organisms of aquatic ecosystems (Dalla Chiesa et al.,1997).

PHOTOSYNTHETIC THERMOLUMINESENCE

A fundamental discovery of the photosynthetis research in the 1950s was the detection of thermally stimulated light emission from the preilluminated photosynthetic material [Arnold W and Sherwood H (1957) ProcNatlAcadSci USA 43: 105-114]. This phenomenon, termed thermoluminescence (TL), is the characteristic of a wide range of materials (minerals, semiconductors, inorganic and the organic crystals, and complex biological systems), which share the ability of the storing radiant energy in thermally stabilized trap states (Burnap et al.,1992). The original discovery of TL in the dried chloroplasts later proved to be a phenomenon common to all the photosynthetic organisms: photosynthetic bacteria, cyanobacteria, algae and the higher plants, which can be observed in isolated membrane particles, intact chloroplasts and the unicellular organisms, and whole leaves. Following the initial observations mainly considerable effort has been devoted to the identification and characterization of the photosynthetic TL components. The major application of thermoluminesence can be in agricultural genomics(Sreeremya,2018).This work has firmly established the participation of the various oxidation states of the water-oxidizing complex, the redox-active tyrosines, and the quinone electron acceptors of the Photosystem II (PS II) in the generation of photosynthetic glow curves. Since TL characteristics are very much sensitive to subtle changes in the redox properties of the involved electron transport components, the specific TL method has become the powerful tool in probing a wide range of PS II redox reactions and their modifications by the environmental stress effects. Here, the main milestones of research in the photosynthetic TL are covered until the present day (Bohne et al., 1986).

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Thermoluminescence photosynthetic membranes are cooled and then it is heated in the dark from the low temperature, they emit light at distinct temperatures yielding what is known as the glow curve(s) or the TL. The TL observed in photosynthetic membranes was initially explained on the basis of the mechanism in semiconductors (Briantais et al, 1992). However, it became apparent that the TL in photosynthetic membranes occurs as a result of a recombination between the oxidized donors and the reduced acceptors produced in the preceding light exposure. Moreover, there are several recombination events that are involved in generating the ramified glow curves since several peaks are produced that are susceptible to the electron transport inhibitors, modifiers of the water-oxidizing complex or compounds that it interfere with the light-induced electron transport(Arnold et al.,1957).

OVERVIEW

The discovery of the delayed light emission (DLE) by photosynthetic organisms that later led to the study and assessment of TL was, in a way, a chance event (Bhatnagar et al., 2002). When some researchers were attempting to mainly demonstrate the photosynthetic formation of the energy rich phosphate (ATP) (adenosine tri phosphate) using a firefly luminescent assay, they observed that the light was given off by the chloroplasts even in the absence of the firefly extract. They studied different characteristics of this light emission and then concluded that this DLE was the reflection of the reversibility of certain early reactions of photosynthesis. Several intriguing observations were made and they were subsequently confirmed and extended by other studies and investigations (Arnold et al., 1968). These included, e.g., the effect of the inhibitors of photosynthesis, the action spectra and its dark decay. Some researchers discovered TL in the dried chloroplasts and had used the term glow curve. Few scientists also showed that there are multiple components of DLE decaying with different half lives. Furthermore, they also showed the TL from dried chloroplasts yielding two peaks, one between 50°C and 60°C and another between 140°C and 160°C. A mechanism involving the recombination of holes and the electrons trapped. In subsequent studies, some researchers reported TL glow curves in the green algal species belonging to the genera Chlorella and Scenedesmus, encompassing Scenedesmus mutants. However, the first

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well resolved glow curves were published by in the year (1968).It was clear that not only are there several bands that mainly appear at different temperatures but also that most of these originated in PS II. Moreover, there were indications that the TL and DLE are related to each other. These important observations were mainly confirmed and further elaborated in the 1970s .These and the subsequent studies during the 1980s by several research groups demonstrated the potential of the TL technique in probing the PS II (Arnold,1966). In more recent years the bands that mainly appear at somewhat higher temperatures have also been characterized. We now know that TL can be availed not only to probe PS II but in addition it can provide information on the several other physiological aspects. Several excellent reviews have mainly appeared on these aspects. Researchers has also provided an account of the history of photosynthetic TL that also encompasses photographs of the many researchers in the field of TL in photosynthetic systems (Arnold, 1965).

CONCLUSION

The characteristics of some materials which have mainly accumulated energy over a long period of mainly becoming luminescent when pretreated and typically subjected to high temperatures, availed as the means of dating ancient ceramics and other artefacts. The major aspects of thermoluminesence are discussed in this paper.

REFERENCES

I. Arnold W (1965) an electron-hole picture of photosynthesis. J Phys Chem 69: 188–791
II. Arnold W (1966) Light reaction in green plant photo-synthesis: A method of study. Science 154: 1046–1049
III. Arnold WA and Azzi JR (1968) Chlorophyll energy levels and electron flow in photosynthesis. ProcNatlAcadSci USA 61: 29–35
IV. S. Sreeremya, 2018. Journal of Research in Pharmacognosy and Natural Medicinal Products, Application of Agricultural Genomics,. Vol (1):2,1-11.
V. Arnold WA and Sherwood HK (1957) Are chloroplasts semiconductors? ProcNatlAcadSci USA 43: 105–114
VI. Bhatnagar R, Saxena P, Vora HS, Dubey VK, Sarangpani KK, Shirke ND and Bhattacharjee SK (2002) Design and performance of a

Page 63-67 © MANTECH PUBLICATIONS 2020. All Rights

versatile, computer controlled instrument for studying low temperature thermoluminescence from biological samples. MeasSciTechnol 13: 2017–2026

VII. Bohne C, Campa A, Cilento G, Nassi L and Villablanca M (1986) Chlorophyll: an efficient detector of electronically excited species in biochemical systems. Anal Biochem 155: 1–9

VIII. Briantais JM, Ducruet JM, Hodges M and Krause GH (1992) The effects of low temperature acclimation and photoinhibitory treatments on photosystem 2 studied by thermoluminescence and fluorescence decay kinetics. Photosynth Res 31: 1–10

IX. Burnap RL, Shen J-R, Jursinic PA, Inoue Y and Sherman LA (1992) Oxygen yield and thermoluminescence characteristics of a cyanobacterium lacking the manganese-stabilizing protein of photosystem II. Biochemistry 31: 7404–7410

X. Chapman DJ, Vass I and Barber J (1991) Secondary electron transfer reactions of the isolated photosystem II reaction centre after reconstitution with plastoquinone-9 and dia-cylglycerolipids. Biochim BiophysActa 1057: 391–398

XI. Clegg RM, Sener M and Govindjee (2010) From FörsterResonance Energy Transfer (FRET) to Coherent Resonance Energy Transfer (CRET) and Back --A wheeno' micklesmak's a muckle. In: Alfano RA (ed) Optical Biopsy VII, Proceedings of SPIE, Vol. 7561. SPIE, Bellingham (paper number: 7561–12; article CID number: 75610.

XII. Dalla Chiesa M, Friso G, Deak Z, Vass I, Barber J and Nixon PJ (1997) Reduced turnover of the D1 polypeptide and photoactivation of electron transfer in novel herbicide resistant mutants of Synechocystis sp. PCC 6803. EurJ Biochem 248: 731–740

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