REVIEW ARTICLE

A Review on Bioluminescent fungi: A Torch of Curiosity

Kushwaha Vinodkumar and Hajirnis Sarita

Department of Botany, Satish Pradhan Dnyanasadhana College of Arts, Science and Commerce, Thane (W), India
Email: kushwahavinod30@gmail.com

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ABSTRACT

Fungi are one of the world's least studied life forms and there are presumably hundreds of species remaining to be found in the form of bioluminescence. Bioluminescence is a natural light emitting phenomenon that is emitted by several living organism, verified in 71 of 100,000 described species in the kingdom fungi. Bioluminescence results when energy from a chemical reaction is released as light, this occurs when an enzyme, such as luciferase catalyzes the oxidation of an organic molecule luciferin. These bioluminescent fungi are applied for biotechnological applications such as Luciferase systems in genetic engineering as reporter genes, environment monitoring, heavy metal extraction and many more. The aim of this review is to address the current studies on bioluminescent fungi and their future applications.

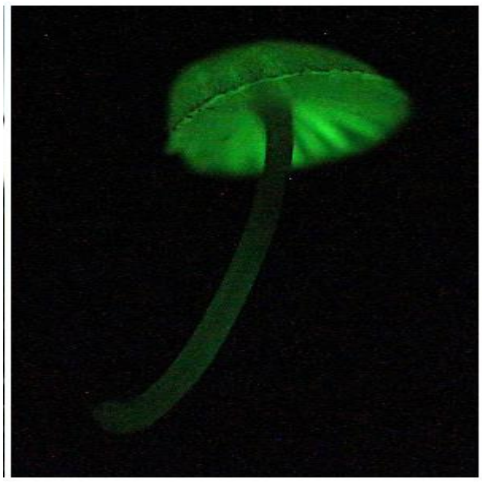
Keywords: Fungi, Bioluminescence, luciferin, luciferase

INTRODUCTION

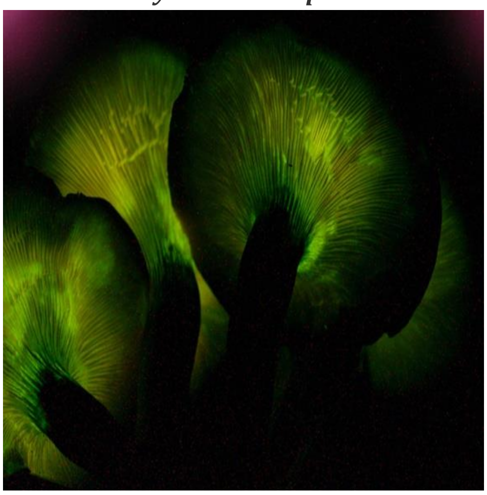
Bioluminescent organisms have attracted the attention of mankind since ancient world. Aristotle(382BC) and the Roman scholar Pliny the Elder observed the effect of fungal bioluminescence when they described the glowing light of the cold "fire" of damp wood, this probably later became known as "foxfire" cause in old French "*fois*" means "false". The next mention of luminous wood in the literature occurred in 1667 by Robert Boyle who noticed glowing earth and noted that heat was absent from light. As quoted Johnsons and Yata, 1966 and Newton 1952, many early scientists such as Conrad Gesner, Francis Bacon and Thomas Bartolin observed and made notation of luminous earth. The first mention that the light of luminous wood was due to fungi occurred from a study of luminous timbers used as supports in mines by Bishoff in 1823. Fabre established the basic parameters of bioluminescence fungi, that is, (1) Light without heat. (2) Light ceased in a vacuum, in hydrogen, and carbon dioxide (3) The light was independent of humidity, temperature, and did not burn any brighter in pure oxygen. A Dutch consul in 1700 reported that Indonesian people used fungal fruits to illuminate forest pathways. The phenomenon of bioluminescence is most common in marine environments and a number of theories have been put forward to account for its selective advantage in the dark of Deep Ocean. From the 1850's to the early part of the 20th century the identification of the majority of fungal species exhibiting bioluminescent traits was completed. The research of bioluminescent fungi stagnated from the 1920's till 1950's (Newton, 1952 and Herring, 1978). After which extensive research began involving the mechanisms of bioluminescence and is being still carried out. Amongst fungi the majority of bioluminescence occurs in the Basidiomycetes and only one observation has been made involving the Ascomycetes; specifically in the Ascomycete genus *Xylaria* (Harvey 1952). At present there are 42 confirmed bioluminescent Basidiomycetes that occur worldwide and share no resemblance to each other visually, other than the ability to be bioluminescent. Of these 42 species that have been confirmed 24 of these have been identified just in the past 20 years and as such many more species may exhibit this trait but are yet to be found. Luminescence may not confer a significant selective advantages as there are both luminescent and non-luminescent strains of the same species and species that only have luminescent mycelium. (Herring,1994). The two main genera that display bioluminescence are *Pleurotus* which has at present 12 species which occur in continents of Europe and Asia and genus *Mycena* which has 19 species identified to date with a worldwide distribution range. In North America only 5 species of bioluminescent basiodiomycetes have been reported. These include the Honey mushroom *Armillaria mellea*, the common Mycena -*Mycena galericulata* , the Jack O'Latern - *Omphalotus olearius, Panellus stipticus* and *Clitocybe illudens*.

Panellus stipticus

Mycena chlorophos



Mycena singeri



Omphalotus olearius

PHYSIOLOGY OF BIOLUMINESCENCE

Bioluminescence in fungi is an oxygen-dependent reaction involving substrates generically termed luciferans, which are catalyzed by one or more of an assortment of unrelated enzymes referred to as luciferases. In fungi, both the luciferans and luciferases involved remain largely unidentified. During the luciferans- luciferase reaction, unstable chemical intermediates are produced which when decompose excess energy is released as light emission, causing the tissues in which this reaction occurs to glow or luminesce. Although the older literature reports some fungal species as producing white or blue light, all recent studies and observations indicate that bioluminescent fungi emit a greenish light with a maximum of 520-530nm.

Fungal Bioluminescence (Airth & Foerster, 1962)

$$L + NAD\ (P) + H^{+} \xrightarrow{\text{reductase}} LH_2 + NAD\ (P)^{+}$$

$$LH_2 + O_2 \xrightarrow{\text{Luciferease}} LO + H_2O + hv$$

L-Luciferin, **LH$_2$**-reduced luciferin, **LO**-oxyluciferin

ROLE OF LUMINESCENCE IN FUNGI

Bioluminesce fungi offer many advantages like,

1) Attracting insects for dispersal of fungal spores. This hypothesis is supported by the presence of luminescence more strongly in the gills (*P. stipticus*) or in the spores region (*Mycena rorida var. lamprospora*). (Bermudes et al., 1992).

2) Functions as predators of fungivores,

3) repulsion of negative phototropic fungivores and

4) as a warning signal to nocturnal fungivores. (Sivinski 1981). Another hypothesis suggests that bioluminescence is a by-product of a biochemical reaction and has no ecological value. For example, a relationship of biolumenescenc to lignin degradation has been suggested where it may act to detoxify peroxides that are formed during lignolysis. (Bermudes et al., 1992; Lingle, 1993).

CURRENT RESEARCH APPLICATIONS

Luminescence is the only biochemical process that has a visible indicator than can be measured. Luminometer is a device used to measure luminescence which can detect small amounts of light given off in the bioluminescent reaction. It is used in scientific research involving biological process applications. E.g.

Biosensors

The property of bioluminescence can be used as biosensors in Bioremediation for detection of heavy metal ions like mercury and aluminium. This can be achieved by using bacteria with light genes fused to their ion resistant regulons.

For example, if a bacteria that is resistant to Hg is in the presence of Hg, the genes coding for its Hg resistance will be activated which in turn will activate the luciferase gene fused to it, so the bacteria will produce luciferase whenever Hg is present. Adding luciferin and testing for light production with a luminometer reveals the presence of the metal ion in the solution. This technique is especially useful in testing for pollutants in the water supply when concentrations are too low to detect by conventional means (Herring 1978, and Patel 1997).

Biosensors also has application in *Tuberculosis Test*. Testing for tuberculosis has long been a problem because of the long time it takes for the species (mycobacterium) to grow to a size that is detectable by modern medicine. By the use of bioluminescence in the TB test has found to sharply reduced the diagnosis time to as two days. The technique involves inserting the gene through a viral vectors that codes for luciferase into the genome of the TB bacterial culture taken from the patient. The bacteria now start producing luciferase. When luciferins are added the amount of light produced needed to code for enough luciferase to produce a detectable amount of light, is reduced to only 2-3 days. By reducing the time needed to prescribe the correct drugs for treatment, this application of bioluminescence will someday be ready to save some of the 3 million killed each year by tuberculosis (Patel 1997).

Other applications

Fungal luciferin chemically differs from other known luciferins because it exhibits a different mechanism of light emission. This attribute of it is used in photochemistry, biochemistry and evolution. Bioluminescence is also used in scientific research including evolution, ecology, histology, physiology, biochemistry, biomedical applications, cytology and taxonomy.

FUTURE SCOPE

1. Creation of an autonomously luminescent plant

Scientists may now be able to explain not only why certain fungi glow in the dark, but how. Unlike the other luciferins, fungal luciferin is compatible with plant biochemistry, hopefully this will eventually allow Plant to biosynthesize luciferins by itself. So, they are nearer to creating glowing trees as a novel form of street lighting, replace electricity-draining conventional streetlights, lit- up road signs and interior lighting. The trees would come "on" at night and go "off" during the day. The trees would need only air, water, and soil nutrients to maintain their urban lighting duties.

2. Agricultural Signs.

When crops need water or nutrients, they will be able to tell farmers. Plants could even go to red, yellow or green "alert" to give farmers early warning about disease and invasions by harvest- destroying pests. Bioluminescence will provide a new dimension of Lighting, Healthcare and Food industry. Adoption of these technologies will lead to a massive growth of Bioluminescence.

CONCLUSION

When technology matures and becomes economically feasible, it will definitely offers a superior value proposition.

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