Bioluminescence of Beetles: Chemistry, Biology, and Technology

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Bioluminescence (BL) - visible and coldlight emission by living organisms - is a worldwidephenomenon, bright and multicolored, described in terrestrial and marine environments since ancient times.It has appeared discontinuously along evolution over 30 times as an adaptive response against oxygen toxicity and has been appropriated for sexual attraction, predation, and camouflage. In all cases, BL results from the oxidation of a substrate (luciferin) by O_2catalyzed by a luciferase yielding the product (oxyluciferin) in its singlet state, fluorescent, which decays to the ground state by photon emission.In the late 80s,the isolation and expression of firefly luciferase gene (*luc*)in mammalian cellsand plants catapulted the development of molecular biology. We will focus here on luminescent beetles (Coleoptera) belonging to three main families - Lampyridae (fireflies), Elateridae (click-beetles), and Phengodidae (railroad worms)-, of which the chemical mechanism, luciferase-modulated colors, cooperative roles of luciferase and superoxide dismutase (SOD) against O_2toxicity, and BL technology will be discussed.The luciferins of all luminescent beetles were found to be the same, although eliciting distinct color emissions (from green to red) due to subtle amino acid changes in the luciferase structures. Regarding the BL biological functions, the electroretinogram of adult click-beetle *Pyrophoruspunctatissimus* matches its BL spectrum, necessary for communication in mating. Conversely, the green light emitted by hundreds of *Pyrearinyustermitilluminans* larvae in the surface of the “luminous termite mounds” of Central Brazil attracts flying preys. *Phrixothrix*phengodids are unique BL insects due tosimultaneously emanating two colors: red from a cephalic lantern and yellow-green by eleven pairs oflanterns along the abdomen. Their two luciferases were cloned in *E.coli*, whose luminescence spectraperfectly match the insect BL colors. As expected, larval *P. termitilluminans* hypoxia triggers concomitant induction of luciferase and SOD. In an attempt to evaluate the fraction of O_2spent for light emission by these larvae,*in vivo*EPR oximetry in the presence of lithium phthalocyaninewas conducted, revealing ~20% oxygen consumption.Finally, we emphasize the biotechnological potential of beetle BL, for example, by harnessing the elsewhere published construction of luciferase-bound quantum nanorods (Bioluminescence Resonant Energy Transfer) for intracellular ATP measurements.Financial Support: FAPESP, CNPq, and INCT Redoxome.

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