Firefly bioluminescence: What's hot, and what's not?

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Among thousands of bioluminescence organisms, the sequence of chemical reactions underlying the emission of light in fireflies and other bioluminescent beetles is one of the most thoroughly studied processes by a variety of experimental and computational methods. Despite these remarkable efforts, contrasting arguments and fierce academic debates continue around even some of the most fundamental aspects of the bioluminescence mechanism. In an attempt to reach a consensus on specific aspects of its chemistry, here we made an exhaustive search and compiled the key discoveries on bioluminescence [1], fluorescence and chemiluminescence of firefly oxyluciferin and its chemical variants reported over the past 50+ years. The individual and synergistic factors that affect the light emission, including specific and non-specific intermolecular interactions, solvent polarity, and electronic effects were analyzed in the context of both the reaction mechanism and the different colors of light emitted naturally by different beetles or mutant luciferases. The collective data aided in disentangling these factors and point toward a combined emission of multiple chemical forms of oxyluciferin as the most probable explanation for the variation in color of the emitted light. We also highlight realistic research directions to eventually address some of the remaining questions related to firefly bioluminescence. It is our hope that this extensive compilation of data and detailed analysis will not only consolidate the existing body of knowledge on this important bioluminescence reaction, but will also aid in reaching a wider consensus.

References

1 C. Carrasco-López, N. M. Lui, S. Schramm and P. Naumov, Nat. Rev. Chem., 2021, 5, 4.