深紫外光子灭活技术

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深紫外光（DUV）辐照能够直接破坏致病菌的遗传物质或阻止遗传物质的有效复制，是抑制致病菌传播的一种快速、有效的方式。在新型冠状病毒（SARS-CoV-2）肺炎疫情发生以来，紫外光消毒技术已被运用在空气、表面消毒。然而，病毒变异株（Delta 与 Omicron）和低温条件对 DUV 病毒灭杀效果的影响仍然未知。

厦门大学康俊勇教授、尹君副教授课题组根据致病菌中遗传物质、蛋白质的紫外光吸收特性，开发了一种由 275-nm 氮化物 LED 组成的大功率（3.2 W）且辐照均匀的平面光源，能够在 1 秒内完成对新冠病毒、H1N1 流感病毒、金黄色葡萄球菌的有效杀灭（常温下，≥99.99%）。同时，研究团队使用该固态平面光源，探究病毒变异株、低温环境等未知因素对 DUV 消毒效果的影响。经研究发现，冷冻环境下（如零下 50 摄氏度），需要显著更高的紫外辐射剂量才能达到室温下相同的致死率。研究团队首次建立了生物光电效应的大弛豫负 U 模型，以阐述温度因素的影响。指出在低温环境下，DUV 激发的电子被活性遗传分子重新捕获回到初始光离子化位置的可能性更高。值得关注的是，由于遗传物质与蛋白质的特性，Omicron 需要显著更高的 DUV 剂量才能达到其它毒株相同的灭杀效果。

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Deep-ultraviolet photonics for the disinfection of SARS-CoV-2 and its variants (Delta and Omicron) in the cryogenic environment

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Deep ultraviolet (DUV) irradiation is a fast and effective way to inhibit the spread of pathogenic microorganisms, because it can directly destroy the genetic materials of microorganisms or prevent the effective replication of genetic material. Since the outbreak of COVID-19 (elicited by SARS-CoV-2), ultraviolet technology has been used for air and surface disinfection.

The research group from Xiamen University developed a high light output (3.2 W) and uniform planar light source comprised of 275-nm light-emitting diodes (LEDs) based on the germicidal effectiveness curve. This light source could kill the SARS-CoV-2, H1N1, and staphylococcus aureus (≥99.99% at room temperature) within 1 second.

Meanwhile, the research gaps were filled regarding the influences of viral variants (Delta and Omicron) and low temperatures on the DUV virucidal efficacy. The lethal effect of DUV was reduced by the cryogenic environment, for instance, the DUV dose needed to be doubled at −50 ℃ to achieve the same inactivation performance compared to the room temperature for the variant of Omicron. This was mainly elicited by the different thermal energy and the chance of capture in the negative-U large-relaxation model. Besides, the inactivation of Omicron required a significantly higher DUV dose compared to other viral strains, which was theoretically due to its genetic and proteinic characteristics. They also investigated the relationship between the DUV dose and the virucidal efficacy of SARS-CoV-2 at different temperatures.

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