細胞の深紫外共鳴ラマンイメージングにおける試料光劣化の抑制

Deep-UV resonance Raman imaging of a cell by lanthanide ion molecular protection

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In Raman spectroscopy, deep-UV (DUV) excitation can enhance signals of organic molecules such as aromatic amino acids and nucleotide bases, due to the resonance effect. DUV resonance Raman spectroscopy has enabled label-free distribution imaging of nucleotide bases in a cell. To date, however, a practical use of DUV resonance Raman imaging has been restricted due to sample photodegradation that occurs under DUV exposure.

Here we present a method to suppress molecular photodegradation of cells during DUV Raman imaging[3,4]. The trivalent ions of lanthanide elements (i.e. Tb^{3+}, Eu^{3+}, Tm^{3+}) have suppressed molecular photodegradation of cells under DUV (λ = 257 nm) exposure. The morphology of cells immersed in the solution containing the lanthanide ions were not significantly destroyed by DUV irradiation while the cells in the solution without lanthanide ions disappeared after DUV exposure. The suppression of the cellular photodegradation can be confirmed by DUV resonance Raman imaging. The cells treated with lanthanide ions provided a larger Raman signal of adenine and guanine than the cells without the lanthanide ions treatment because of the molecular protection. The molecular protection has also enabled repetitive DUV resonance Raman imaging of nucleotide bases distribution in cells.

Underlying mechanisms of the photodegradation suppression can be explained according to energy transfer from the excited DUV-absorptive molecules in cells to the lanthanide ions. Excitation relaxation of the DUV-absorptive molecules due to the energy transfer can suppress ionization, generation of reactive oxygen species, and reactions with surrounding molecules.

This approach, directly removing excited energy at the fundamental origin of cellular photodegradation, indicates an important first step towards the practical use of DUV resonance Raman imaging in a variety of biological applications.

References

1. Y. Kumamoto, et al., *J. Biomed. Opt.* **17**, 076001 (2012).
2. Y. Kumamoto, et al., *Biomed. Opt. Express* **2**, 927-936 (2011).
3. Y. Kumamoto, et al., *Biomed. Opt. Express* **7**, 158-170 (2016).
4. S. Kawata, et al., *Chem. Rev.* **117**, 4983-5001 (2017).