First investigation of energy transfer in quantum dots with ^{211}At

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Quantum Dot (QD) is a useful tool for biological imaging with its controllability of emission wavelength depending on the size and widely used in the cell imaging. However, for utilizing the emission photon, the excitation photon is required and it limits the usage or QD only in the surface imaging. The excitation free luminescence will be preferable

In previous researches, the energy transfer has been reported with the principle of Cherenkov light (CRET Cherenkov resonance energy transfer) and/or direct excitation by radiation with some nuclides.[1] However, there is no report on the interaction between ^{211}At and QD. ^{211}At is one of the most promising alpha-emitting nuclides for radio-theranostics applications and has a relatively short half-life (7.2 h) compared with ^{225}Ac and attracts attention.[2,3] In this study, we have investigated the energy transfer between ^{211}At and QD by observing the emission photon (610 nm) of QD via a fluorescence imaging device. Indium Phosphide (InP) based quantum dot (InP-QD) is fabricated and used for the experiment. InP-QD is a promising QD because it is free from cadmium, which can be toxic for human. ^{211}At was produced in the ^{209}Bi$(\alpha, 2n)^{211}$At reaction at the RIKEN AVF cyclotron and was purified by a dry distillation.[4]

We prepared four samples, (1) Water (1 mL), (2) InP-QD (1 μM), (3) ^{211}At solution (11.1 MBq, 1 mL), and (4) Mixture of InP-QD and ^{211}At (1 μM, 11.1 MBq, 1 mL) for comparison. The 4 liquid samples are contained in the black 24-well plate. The samples are observed with Clairvivo OPT imaging device (Shimadzu). No excitation light is used for the observation and the exposure time is 2 mins. The emission filter with the wavelength of 532, 605, 664, 719, and 849 nm is used.

Figure 1 shows the imaging results of the four samples. Although the difference is small, light emission is observed in mixture and InP-QD in the center part of circles. No emission is observed in ^{211}At and water in the center part of circles. The luminescence in the outer circle with green color is atributed to the leak light with imperfect shielding. This result indicates that the energy transfer from ^{211}At to InP-QD and InP-QD emits the photons. One of the possible way to transfer the energy from ^{211}At to InP-QD will be the direct excitation of InP-QD by alpha particle emitted from ^{211}At.

Figure 2 shows the observed luminescence intensity based on the filter wavelength for four samples through

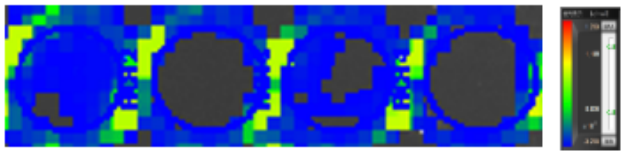

Fig. 1. The measured luminescence by Clairvivo optical imaging of mixture (InP-QD-^{211}At), RI(^{211}At), and QD(InP-QD) and Water from left to right.

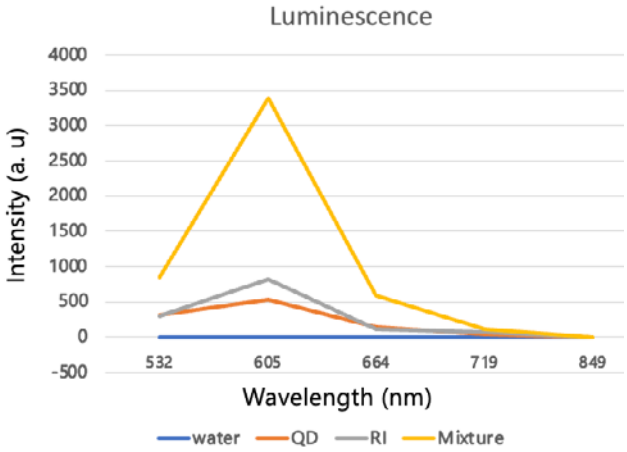

Fig. 2. The measured luminescence intensity depending on the filter wavelength for four samples.

outer circle ROI analysis. Mixture sample shows more than three times higher intensity at 605 nm filter case. RI(^{211}At) and QD(InP-QD) also show the small intensity until 664 nm, however, those results are strongly affected by the luminescence at the edge of circles caused by light leakage. The luminescence in RI(^{211}At) can be caused by an energy transfer from RI to QD and that in QD(InP-QD) is an emission caused by background excitation because of the imperfect shielding in the measurement. Although further investigation is necessary to reveal the mechanism of energy transfer, we have successfully observed the energy transfer between ^{211}At and InP-QD for the first time via luminescence of InP-QD. The visualization of ^{211}At via QD also indicates the possibility of localization of alpha-emitting nuclides through optical imaging technology, which will be useful for the identification of ^{211}At distribution in the cell.

References

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