Quantum Dots for Imaging Applications

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A few imaging applications using quantum dots (QDs) will be introduced, which will cover from visible to infrared(IR) for the wavelengths and from cellular super-resolution to whole body in vivo imaging for the object scale. (1) QDs were conjugated to tumor-specific antibodies(Abs) with zwitterionic surface coating to reduce nonspecific bindings. The Ab-QD probes were used to diagnose tumors for sectioned mouse tissues, fresh mouse colons stained ex vivo and in vivo, and also for fresh human colon adenoma tissues. The probes successfully detected not only cancers that are readily discernible by bare eyes but also hyperplasia and adenoma regions. Multiplexed QD, spray-and-wash, and endoscopy approach provided a significant advantage for detecting small or flat tumors that may be missed by conventional endoscopic examinations. QD-Ab probe was also used in conjunction with a ratiometric fluorescent molecular probe, cresyl violet–glutamic acid derivative, that ratiometrically switches between two fluorescent colors in response to the enzyme activity of λ-glutamyltranspeptidase. Co-application of the two kinds of probes, QD-Abs and the ratiometric molecular probe, afforded accurate visualization of carcinomas, hyperplasia and adenoma regions. (2) Amphiphilic polyethyleneimine derivatives (amPEIs) were synthesized and used to encapsulate dozens of QDs. The QD-amPEI showed very efficient QD cellular fluorescent labeling. Co-encapsulation of QDs and oxygen sensing phosphorescence Ru dyes allowed accurate and reversible oxygen sensing capability by the ratiometric signals, which was successfully applied to cellular and spheroid models. (3) Photo-modulating QDs were designed by conjugating crystal violets (CVs) on QD surface. The QD CV conjugates (QD-CVs) shows a single cycle of emission burst as go through the stage of initially quenched off to photo-activated on and back to photo-darkened off stage. The QD-CV probes were introduced into cells, and the visible light excitation yielded photo-modulation nearly ten folds in intracellular environment. Exploiting the stochastic PL burst of QD-CVs and multiplexing capability of QDs, simultaneous multi-color super-resolution localizations were demonstrated. (4) Recent technological advances have expanded fluorescence imaging into the second near-infrared region (NIR-II; wavelength = 1000–1700 nm), providing high spatial resolution through deep tissues. However, bright and compact fluorophores are rare in this region, and sophisticated control over NIR-II probes has not been achieved yet. We showcase an enzyme-activatable NIR-II probe that exhibits turn-on fluorescence upon matrix metalloprotease activity in tumor microenvironment.

Reference

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