Literature Report

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Article

Amine-Reactive Activated Esters of *meso*-CarboxyBODIPY: Fluorogenic Assays and Labeling of Amines, Amino Acids, and Proteins

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(1) Chemosensors—Design, synthesis and chemical/biological applications of novel sensory materials based on mechanism of fluorescence off/on switching and spectral shift of fluorescent molecules (i.e. conjugated polymers, organic dyes, nanoparticles, quantum dots

(2) Molecular Imaging Materials—Rational Design and synthesis of far red or near-IR molecular imaging probes for diagnostic, therapeutic and biotechnological applications

(3) Photosensitizing Materials for Photodynamic Therapy (PDT)—Design and synthesis of novel PDT agents with increased selectivity and low side-effects

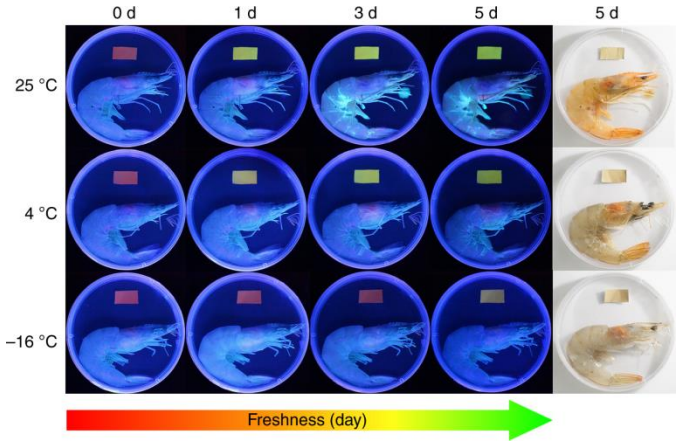
(4) Molecular Electronics Devices—Development and application of molecular electronic device materials such as LEDs, field effect transistors, and photovoltaic devices

(1) Organic synthesis—exploit the properties of elements from the entire periodic table to design molecular solutions that address unsolved problems in synthetic chemistry.

(2) Unusual or exotic chemical species (e.g. rare structures or topologies, stabilized reactive intermediates) – to the design, synthesis and processing of functional organic materials and nanomaterials.

胺的比色或荧光检测的重要应用

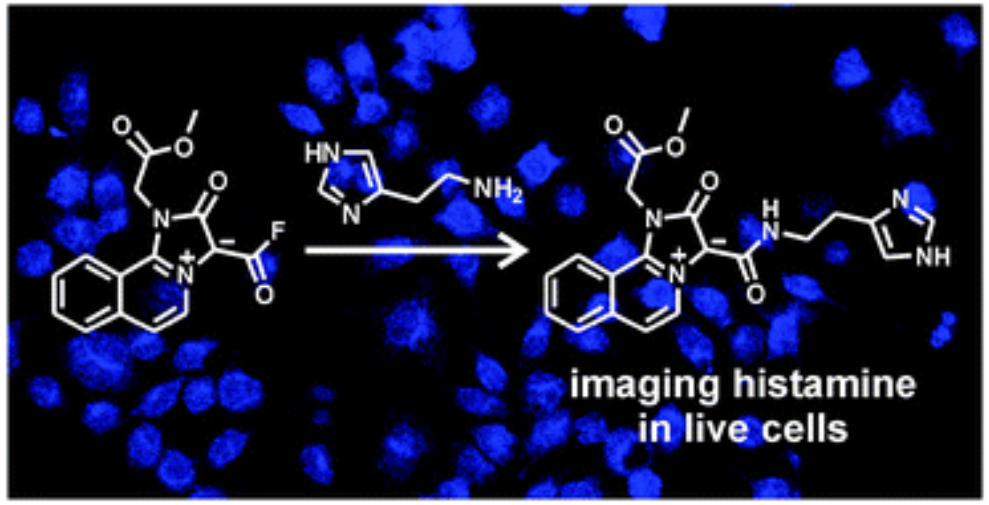
Indicators for food spoilage



Nat. Comm. **2019**, *10*, 795.

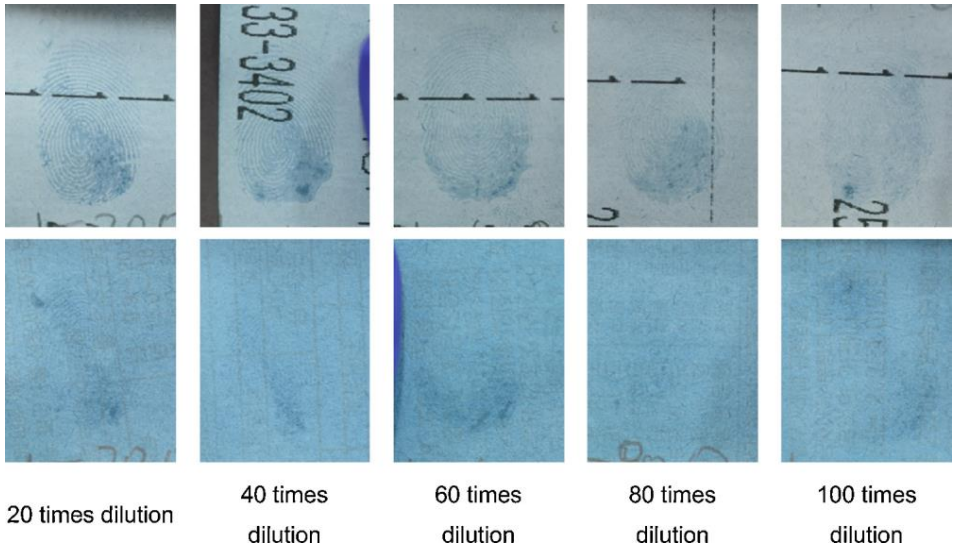
Total protein staining for loading control in Western blots

Tracking biomolecules by imaging microscopy



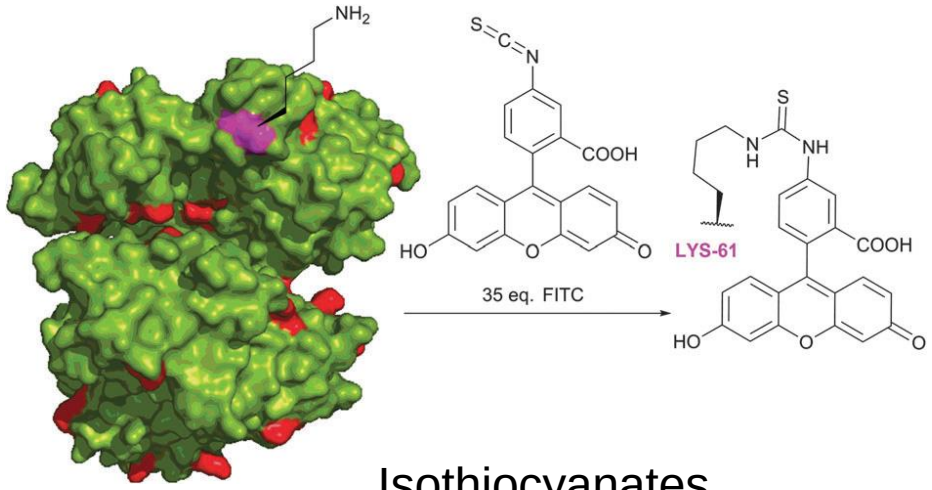
Chem. Commun. **2012**, *48*, 7401–7403.

Chemical enhancement of latent bloody fingerprints

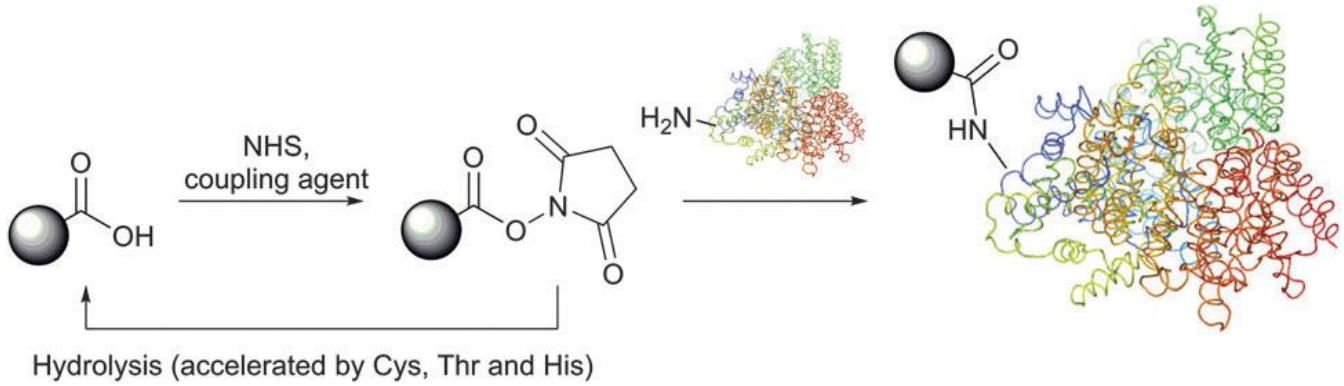


Forensic Sci. Int. **2015**, *257*, 379–384.

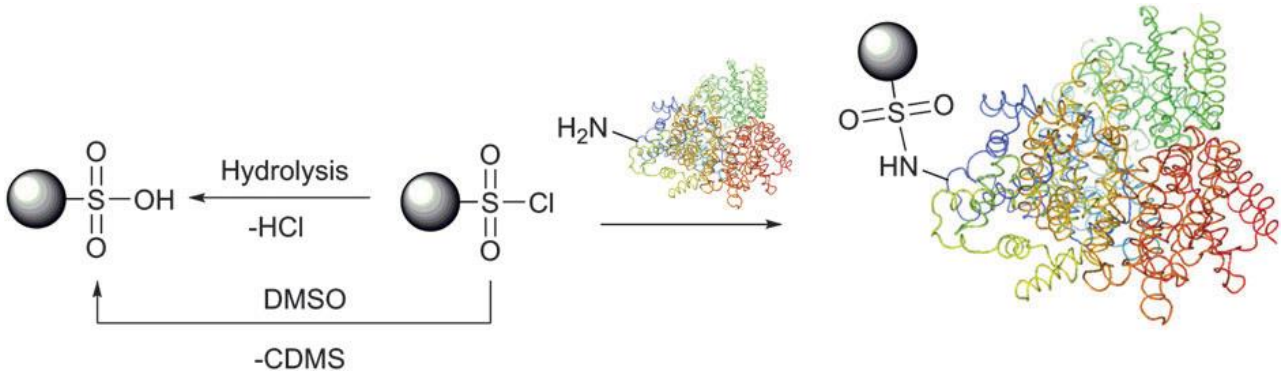
常见的胺的荧光 标记方式



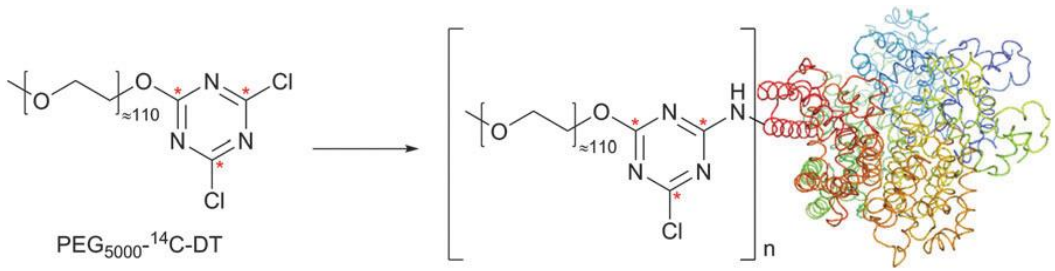
Isothiocyanates



Activated esters



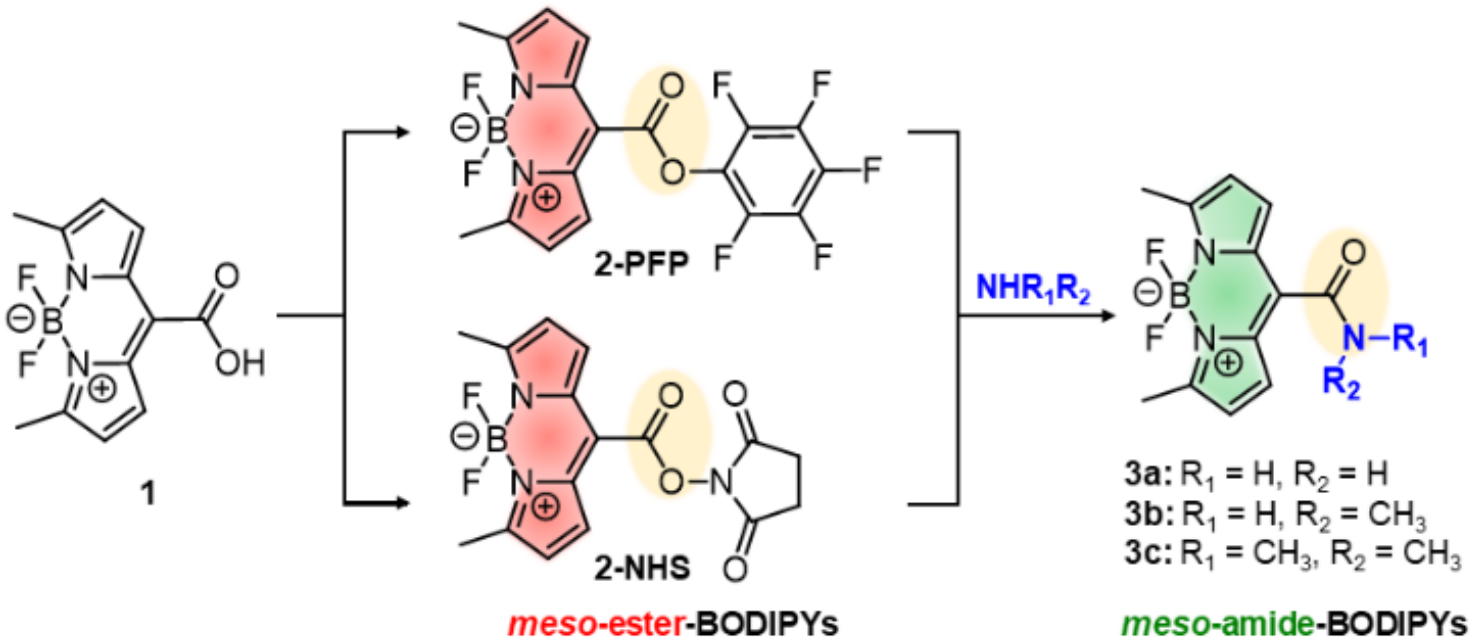
Sulfonyl halides



Dichlorotriazine derivatives

Chem. Soc. Rev., **2015**, 44, 5495--5551

meso-active-ester-BODIPYs 和 meso-amide-BODIPYs



Scheme 1. Schematic representation of the synthesis of *meso*-active-ester-BODIPYs (2-PFP and 2-NHS) and their fluorogenic conversion to *meso*-amide-BODIPY products (e.g., 3a-3c) upon reaction with amines.

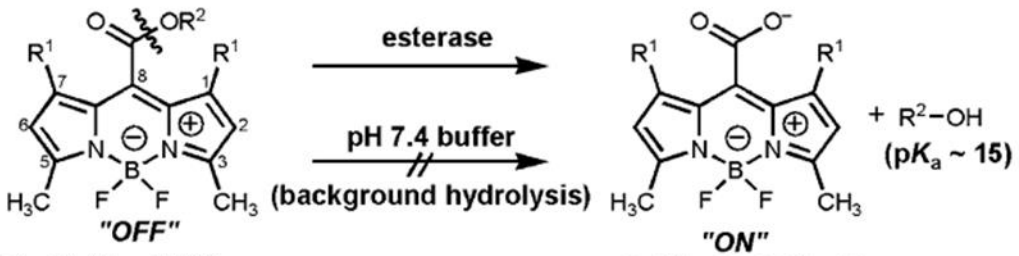
Table 1. Photophysical Properties of Compounds in CH_3CN (A), and in PBS Buffer (10 mM, pH 7.4, 1% CH_3CN, B).

Compound	λ_{abs} [nm]	ε [$M^{-1}\,cm^{-1}$]	λ_{em} [nm]	Φ_{FL}[a]
2-PFP (A)	541	42 000	615	0.31
2-PFP (B)	565 (644)[b]	38 000	618	0.001
2-NHS (A)	534	56 000	615	0.45
2-NHS (B)	622	42 000	648	0.001
3a (A)	514	79 000	551	0.80
3a (B)	519	77 000	558	0.67
3b (A)	515	79 000	546	0.85
3b (B)	519	78 000	549	0.83
3c (A)	512	82 000	535	0.98
3c (B)	517	76 000	540	0.97
1 (A)	492	35 000	591	0.04
1 (B)	505	62 000	554	0.78

[a]Quantum yields relative to fluorescein in 0.1 N NaOH (Φ_{FL} = 0.95) for **3a-3c** and **1**, and relative to Rhodamine-6G in EtOH (Φ_{FL} = 0.94) for **2-PFP** and **2-NHS**.[b]Parenthesis: aggregation band.

(c) This Work: 'Carboxylate-side' fluorogenic esterase probe

1a: R^1 = H, R^2 = Me
1b: R^1 = H, R^2 = Bn
1c: R^1 = H, R^2 = *t*-Bu
2a: R^1 = Me, R^2 = Me
2b: R^1 = Me, R^2 = Bn
2c: R^1 = Me, R^2 = *t*-Bu



3: R^1 = H; **4** R^1 = Me

Chem. Eur. J. 2015, 21, 9645 – 9649

Compd.	$\lambda_{abs.max}$ [nm][c]	ε [$M^{-1}\,cm^{-1}$]	$\lambda_{em.max}$ [nm][d]	Φ_{FL}[e]
1 a[a]	534	41500	597	0.22
1 b[a]	537	28500	600	0.12
1 c[a]	525	45800	594	0.19
2 a[a]	511	94500	526	0.019
2 b[b]	512	92400	529	0.018
2 c[b]	512	85300	530	0.013
3[a]	505	53400	550	0.55
4[a]	496	49600	511	0.58

2-PFP对甲胺的传感响应以及对不同胺的反应性和选择性

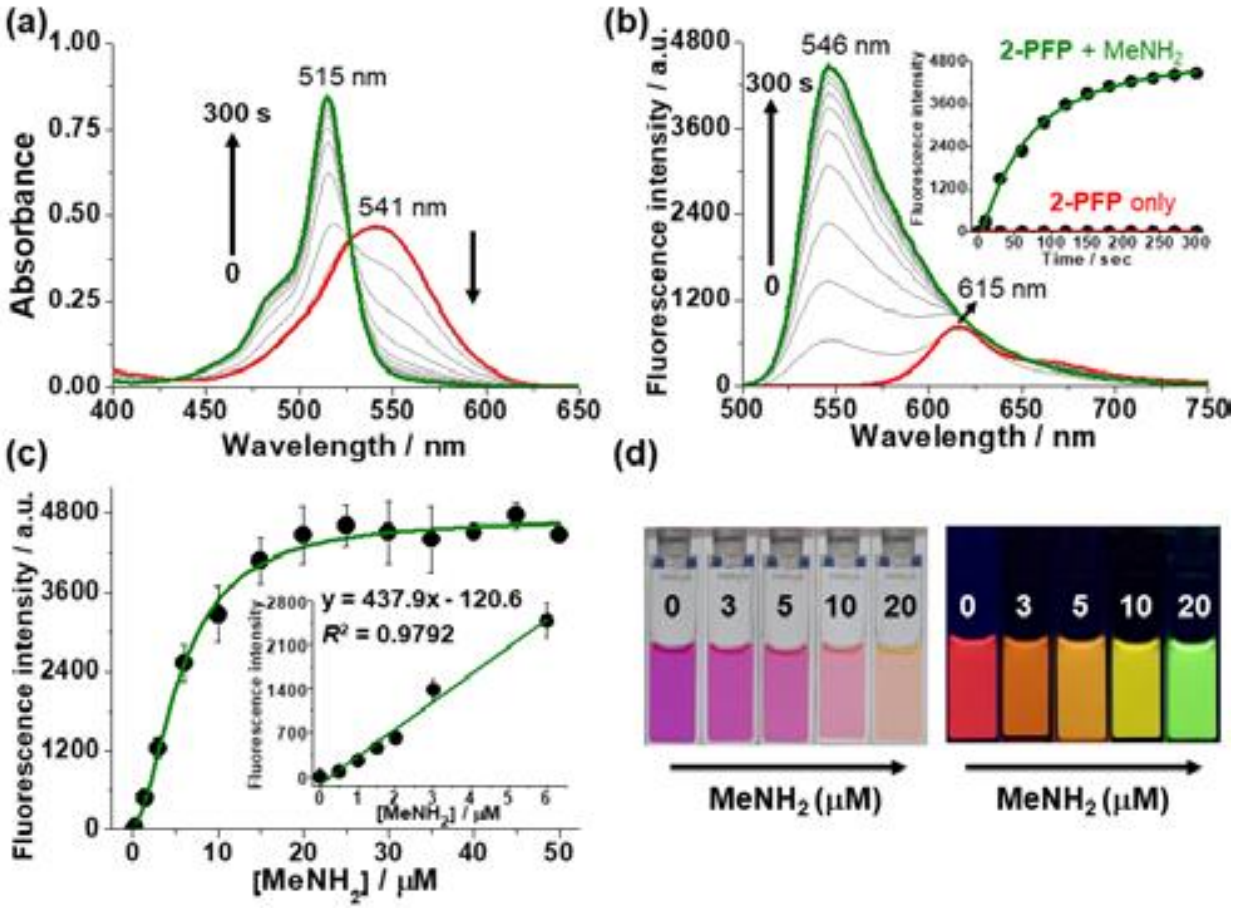


Figure 1. Absorption (a) and emission (b) spectra of 2-PFP (c) Relative fluorescence intensity at 546 nm as a function of [MeNH2] (0–50 μM). (d) Photographs of 2-PFP (20μM) upon addition of MeNH2 under ambient light (left) and 365 nm UV irradiation (right).

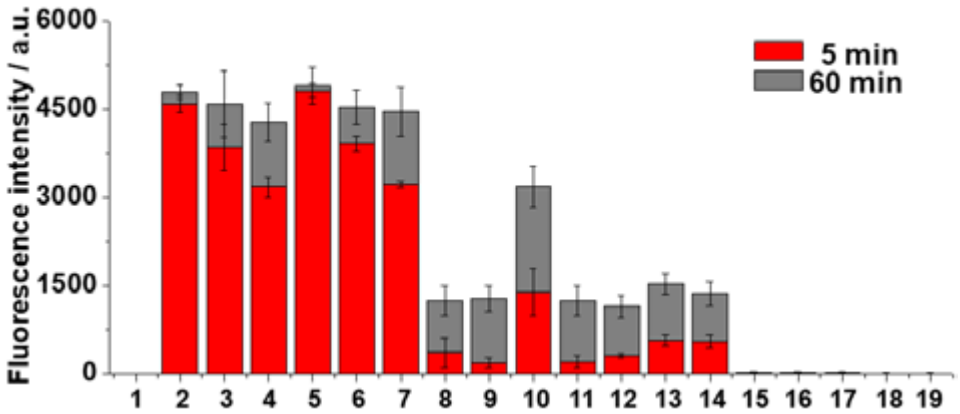


Figure 2. Fluorescence response of **2-PFP** toward various amines. Spectra were obtained 5 min (red) or 60 min (grey) after addition of the amine analyte (20 μM) to **2-PFP** (10 μM) in CH3CN at 25°C. Relative fluorescence intensities at 546 nm (528 nm for 13 and 14) were recorded (λex = 470 nm). Amines are as follow: (1) **2-PFP** only as a control, (2) methylamine, (3) 1-butanamine, (4) 1-hexanamine, (5) 1,3-diaminopropane, (6) 1,4-diaminobutane, (7) 1,5-diaminopentane, (8) isobutylamine, (9) cyclohexylamine, (10) histamine, (11) benzylamine, (12) tyramine (13) dimethylamine, (14) piperidine, (15) diisopropylamine, (16) *t*-butylamine, (17) trimethylamine, (18) pyridine (19) aniline. The experiments were performed in triplicate, and results are expressed as mean ± SD (*n*=3).

2-PFP作为固态指示剂的应用

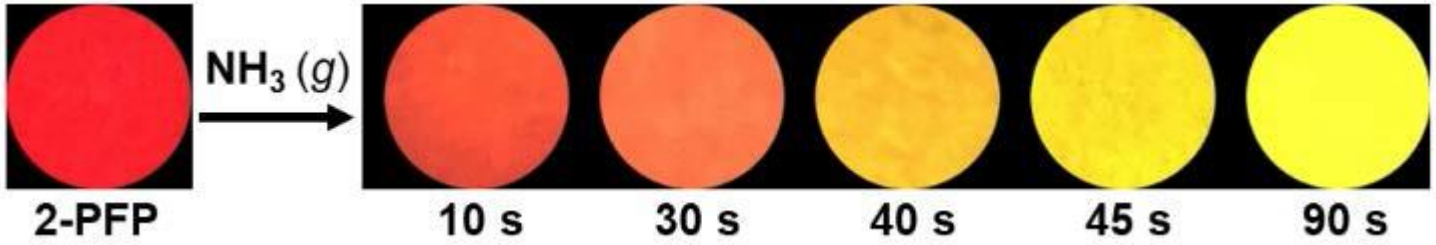


Figure 3. Photographs of fluorescence responses of the filterpaper embedded with 2-PFP/PEGDME upon exposure to a flow of ammonia gas (flow rate = 150 cm3·min-1) as a function of exposure time (left to right: 0−90 s) at 25 ° C. Photographs of the fluorescence response were taken under UV irradiation (365 nm).

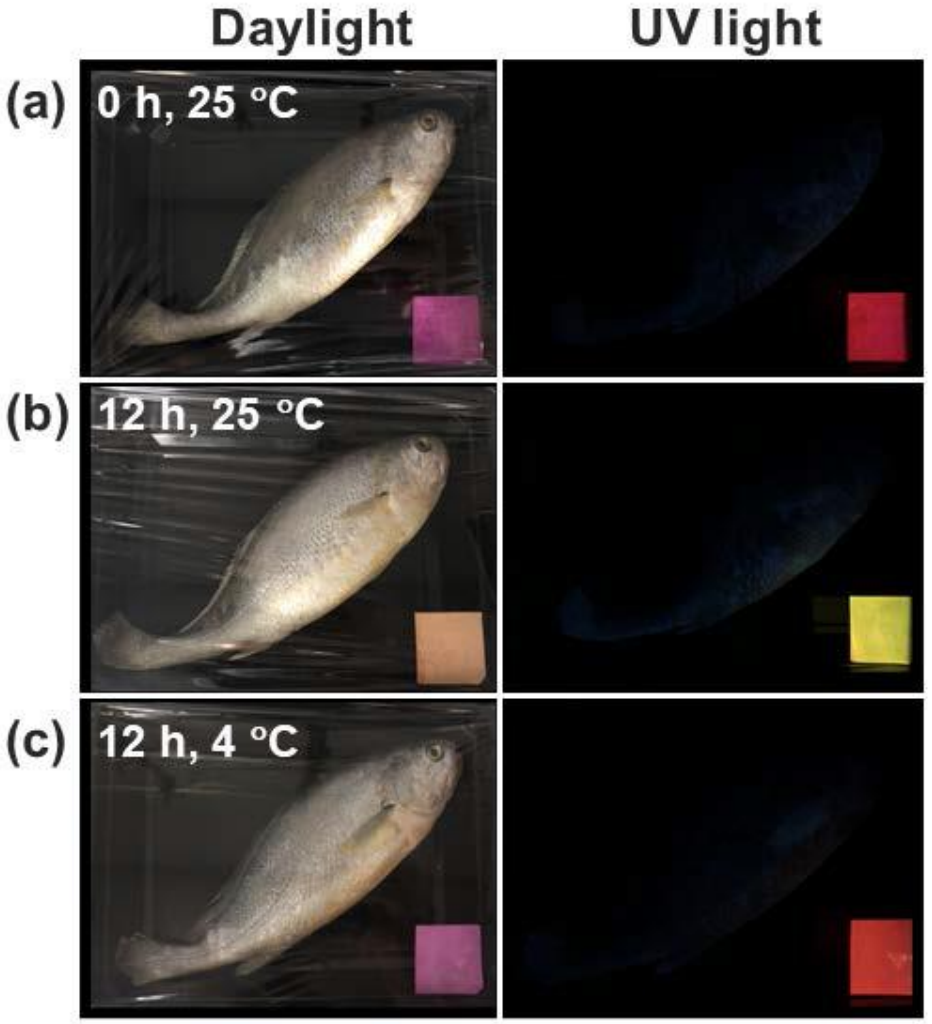


Figure 4. Monitoring of fish freshness using 2-PFP.

2-NHS与氨基酸在水缓冲液中的反应

Compound	λ_{abs} [nm]	ε [M^{-1} cm^{-1}]	λ_{em} [nm]	Φ_{FL}[a]
2-NHS (A)	534	56 000	615	0.45
2-NHS (B)	622	42 000	648	0.001
3a (A)	514	79 000	551	0.80
3a (B)	519	77 000	558	0.67
3b (A)	515	79 000	546	0.85
3b (B)	519	78 000	549	0.83
3c (A)	512	82 000	535	0.98
3c (B)	517	76 000	540	0.97
1 (A)	492	35 000	591	0.04
1 (B)	505	62 000	554	0.78

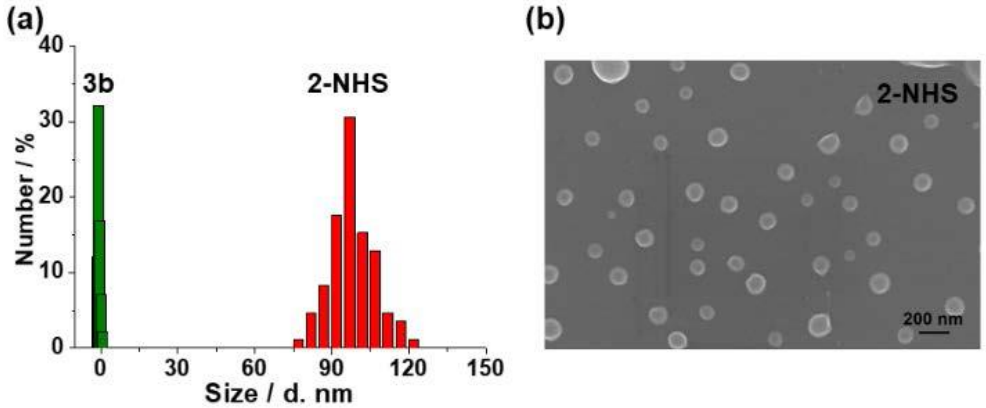


Figure 5. (a) Size distribution of aggregates of 2-NHS (red) and 3b (green) by DLS (2-NHS: 95 ± 15 nm; 3b 1.2 ± 0.3 nm). (b) SEM images (110 ± 25 nm) of aggregates of 2-NHS.

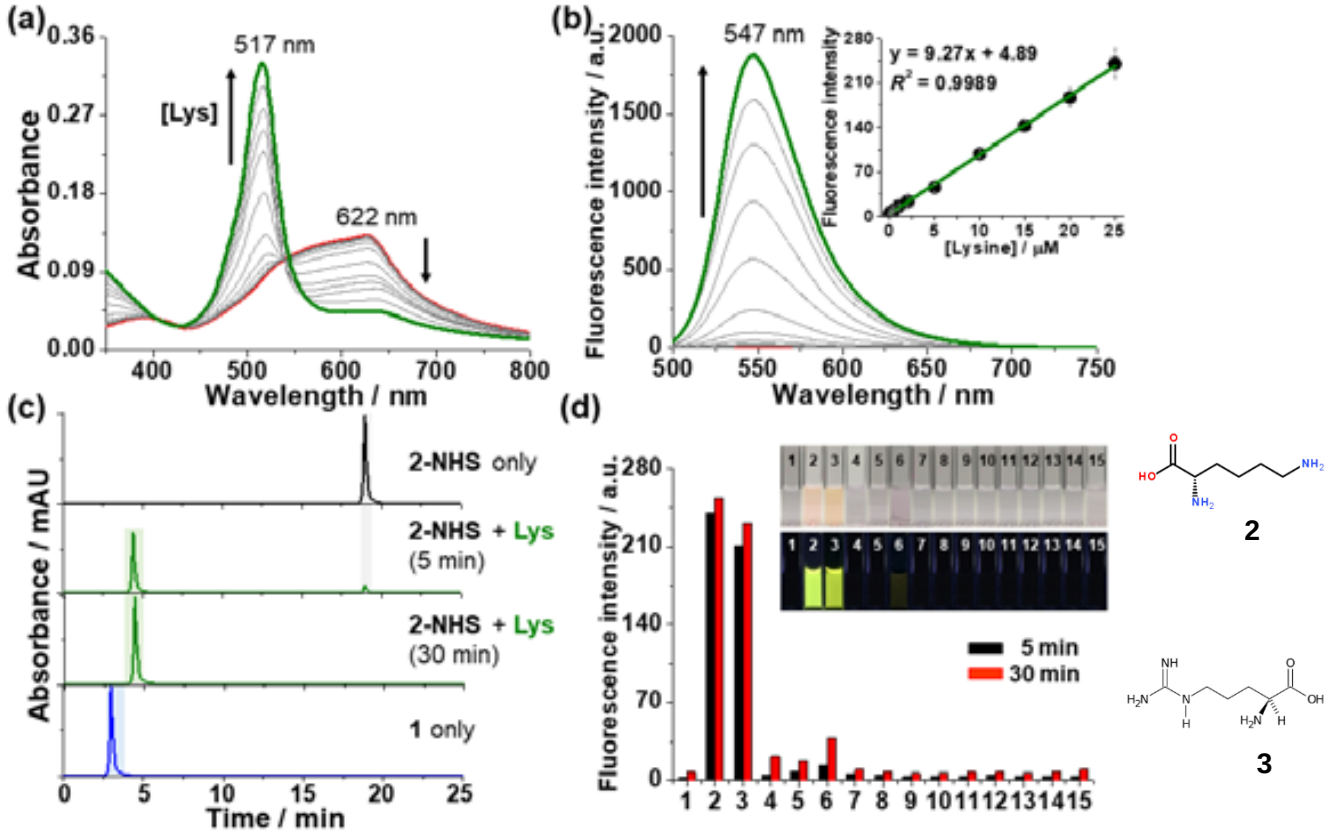


Figure 6. Absorption (a) and fluorescence (b) spectra of 2-NHS (5 μM) upon the addition of lysine at various concentrations(c) HPLC chromatograms of 2-NHS (5 μM) before (top) and after the reaction with lysine (5 equiv) for 5 min and 30 min, respectively (middle) and compound 1 only (bottom). (d) Fluorescence responses of 2-NHS (5 μM) to various amino acids (5 equiv); (1) 2-NHS only (control), (2) **lysine**, (3) **arginine**, (4) proline, (5) histidine, (6) cysteine, (7) serine, (8) tyrosine, (9) threonine, (10) alanine, (11) aspartic acid, (12) phenyl alanine, (13) leucine, (14) tryptophan, (15) glycine.

电泳凝胶上蛋白的荧光检测

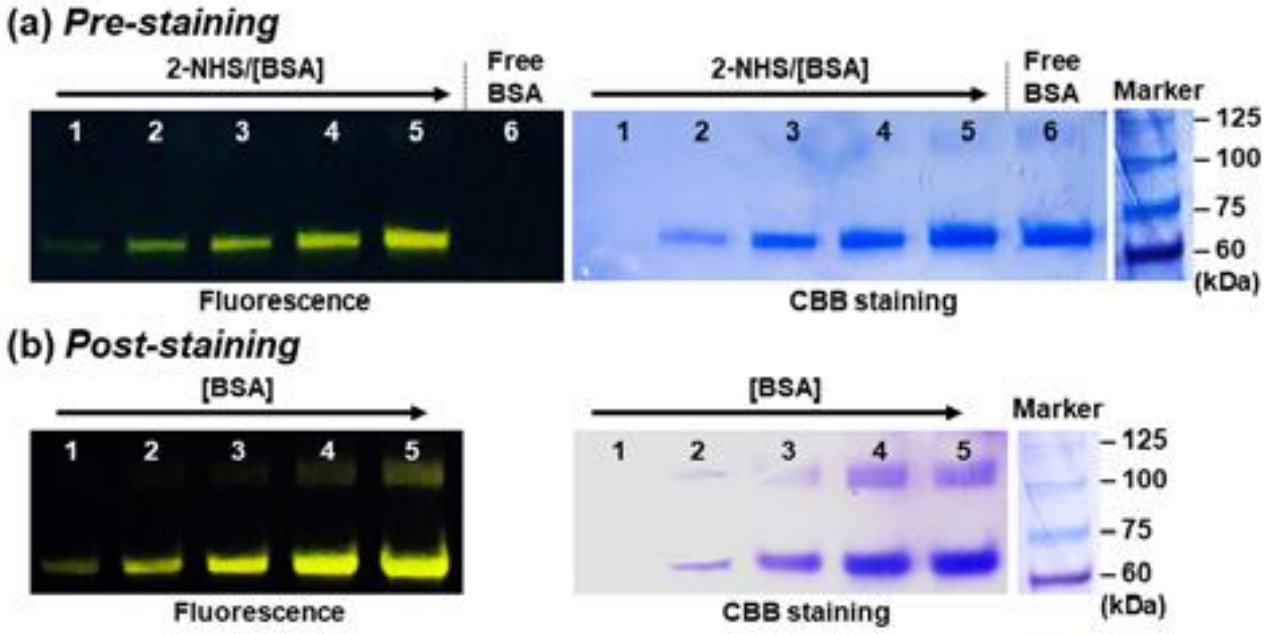


Figure 7. SDS-PAGE gel electrophoresis of free BSA and BSA/2-NHS conjugates. SDS-PAGE fluorescence images (left) of BSA at different amounts (lanes 1-5: 0.01, 0.05, 0.1, 0.25, 0.5 μg; lane 6: pure BSA 1.0 μg) pre-stained (a) and post-stained (b) with 2-NHS, and images of the same gel re-stained with CBB R250 (right). Fluorescent gel images were obtained without a washing step, under UV (365 nm) irradiation. Protein size markers are shown on Marker lane.

水溶液中蛋白/抗体的定量检测

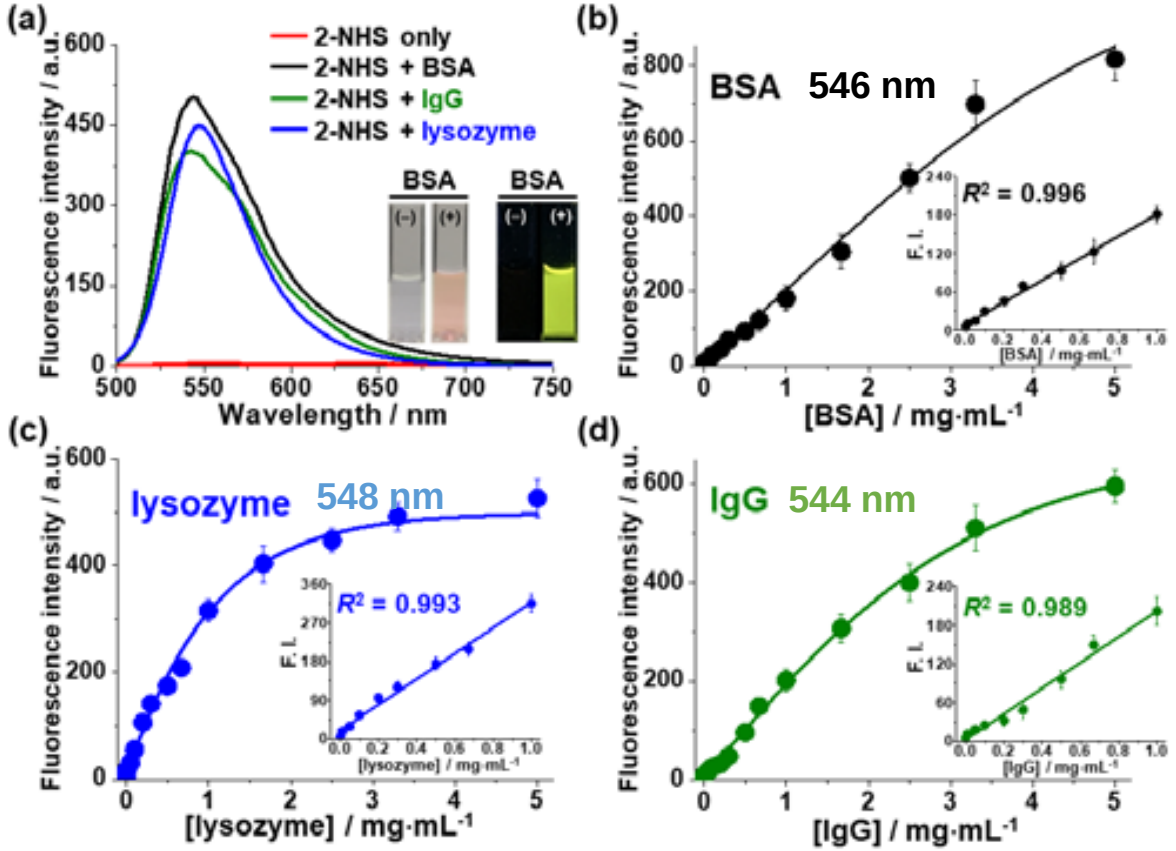


Figure 8. (a) Fluorescence emission spectra of 2-NHS (red) and its reaction with BSA (black), IgG (green), and lysozyme (blue), respectively, in PBS buffer (10 mM, pH 7.4, 1% CH3CN) at 25 ° C. (b, c, d) Relative fluorescence intensity of the green emission band as a function of [protein] (0−5 mg/mL).

活细胞中的蛋白标记

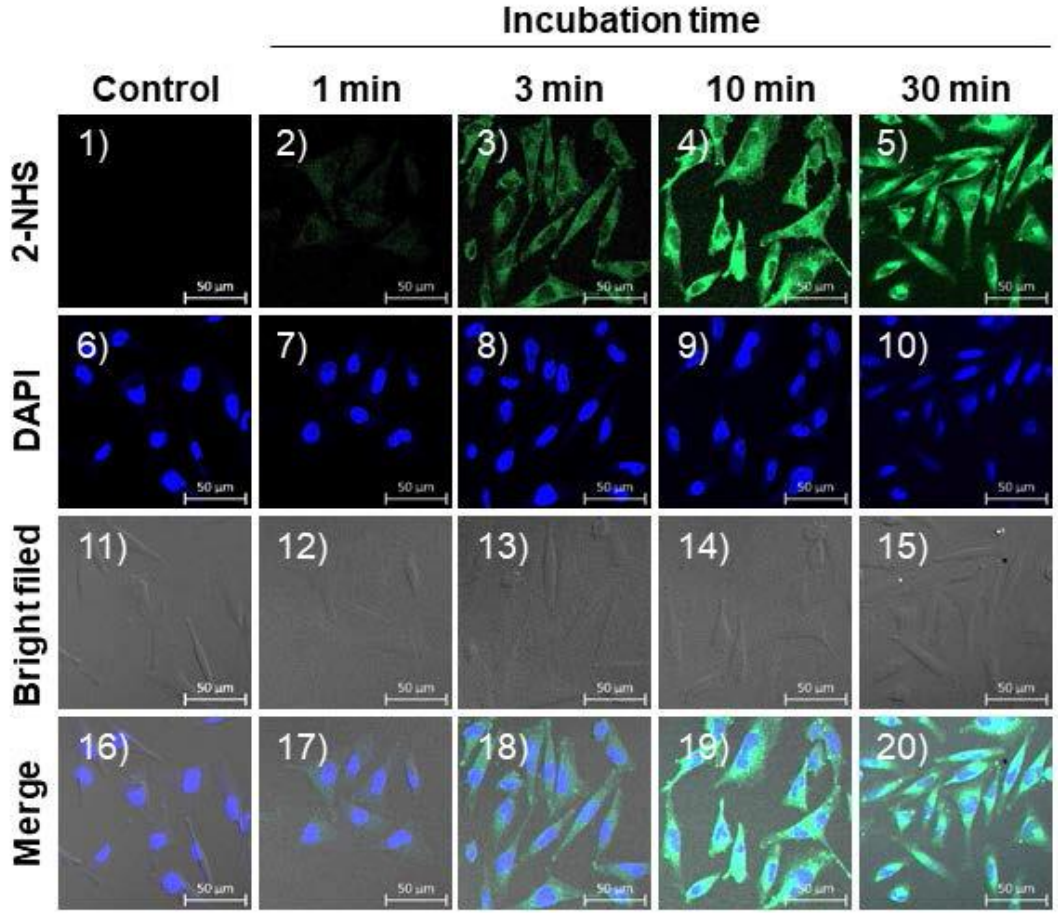


Figure 9. Application of 2-NHS to protein labeling in living cells. Confocal fluorescence images of A2058 human melanoma cells incubated with 2-NHS (10 μM) for the indicated time (0, 1, 3, 10 or 30 min) at 37° C. The cells were co-stained with the blue fluorescent DNA-binding dye DAPI.

靶向不同细胞器的荧光显微成像

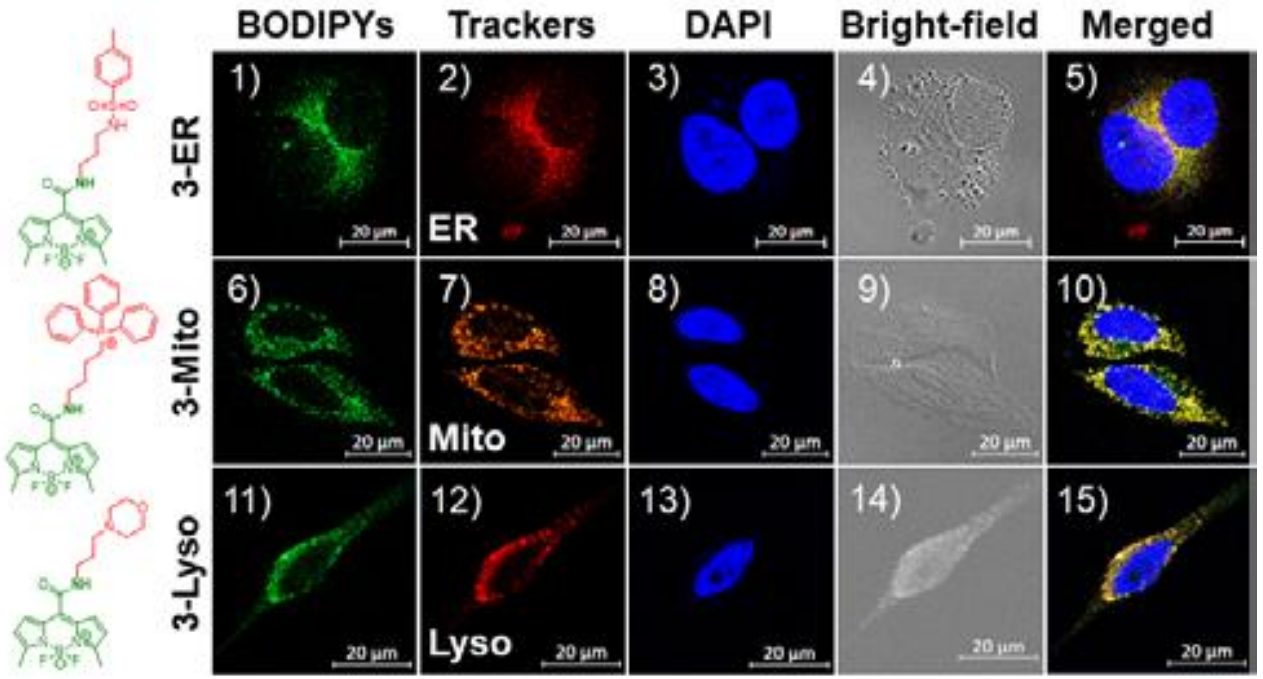


Figure 10. (left) Chemical structures of organelle-specific mesoamide-BODIPY dyes 3-ER, 3-Mito and 3-Lyso, (right) Confocal fluorescence images of living HeLa cells co-stained with (1–5) 3-ER (10 μM, 2 h), and then ER-Tracker Red (1 μM, 30 min), (6–10) 3-Mito (10 μM, 2 h), and then MitoTracker Orange (0.1 μM, 30 min), (11–15) 3-Lyso (10 μM, 2 h), and then LysoTracker Red (0.5 μM, 30 min).