Supporting information

Biocompatible Fluorescent Nanodiamonds as Multifunctional Optical Probes for Latent Fingerprint Detection

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Table S1. Zeta-potential of FND and FND@PVP. All particles were dispersed in deionized water. The solution including particles was injected into a folded capillary cell (DTS1060). After the cell was placed into the Zetasizer and equilibrated at 25 □C, measurements were performed 3 times. The reported error corresponds to the standard deviation.

Sample	Size[a] (nm)	Potential (mV)
FND	136 ± 41	–51 ± 1
FND@PVP	82 ± 13	–46 ± 2

[a] Size was determined by DLS

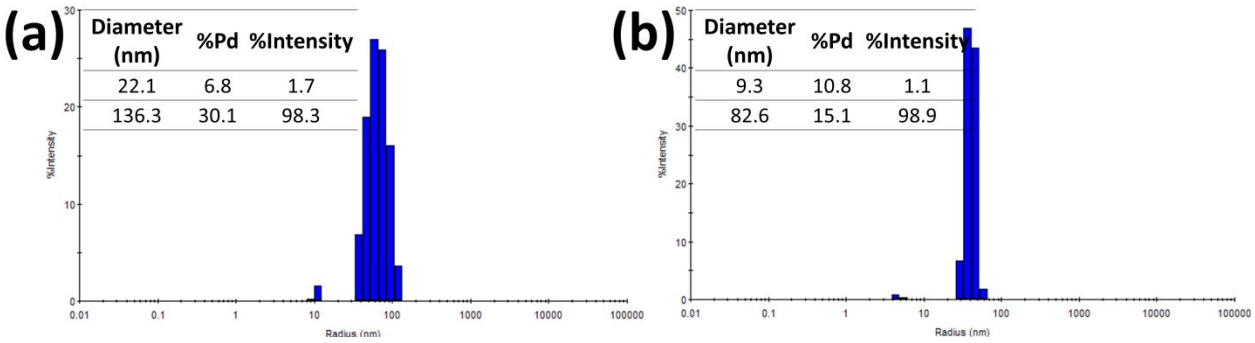
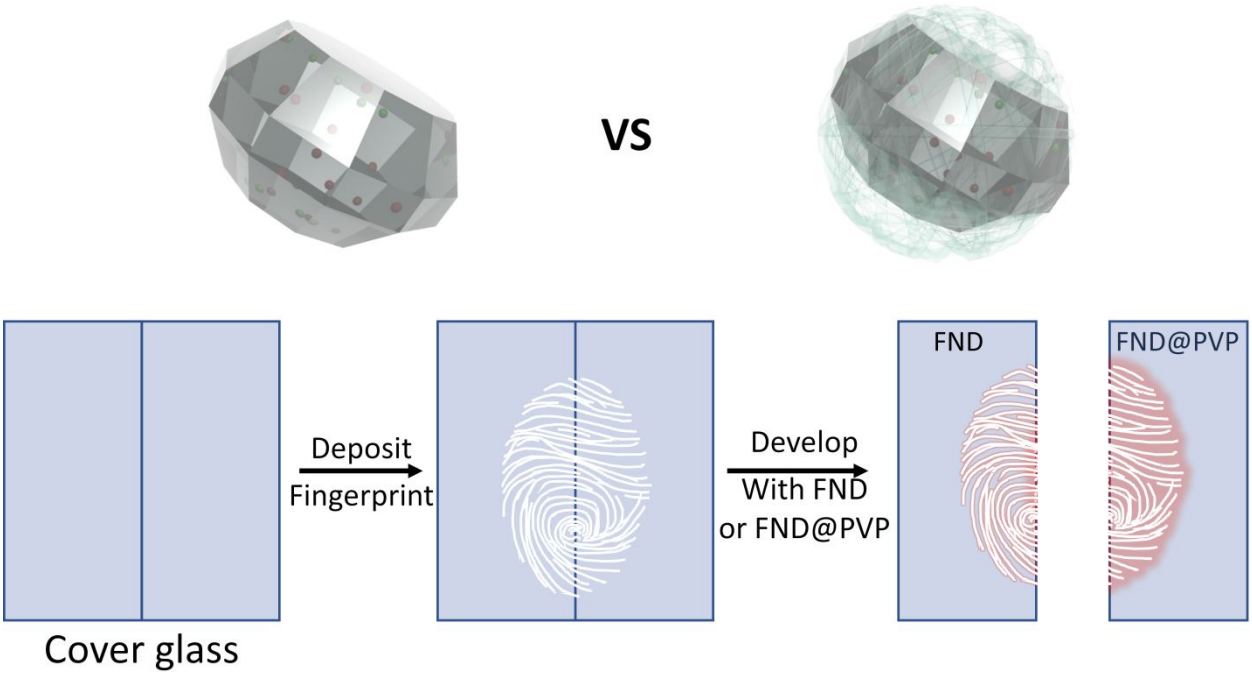


Figure S1. DLS measurements of hydrodynamic diameter of (a) unmodified 50 nm FND and (b) PVP-coated FND in water. The curves represent the distribution of mass weighted particle sizes and the reported diameters correspond the mean of each peak. DLS measurements and analysis are described in the Methods section of the main text.



Scheme S1. Comparison of LFP detection with FND and FND@PVP. A fingerprint was deposited on split pair of cover slips. Each half fingerprint was treated with FND or FND@PVP. Bright-field optical images of developed LFPs taken with a Nikon D80 camera with an AF-Micro Nikkor 105mm 1:2.8 lens under room light. Developed fingerprints were imaged with 525 nm excitation, a 30 s exposure, and an Ethidium Bromide (570~640 nm) emission filter using UVP BioSpectrum Imaging System equipped with a BioLite MultiSpectral Light Source.

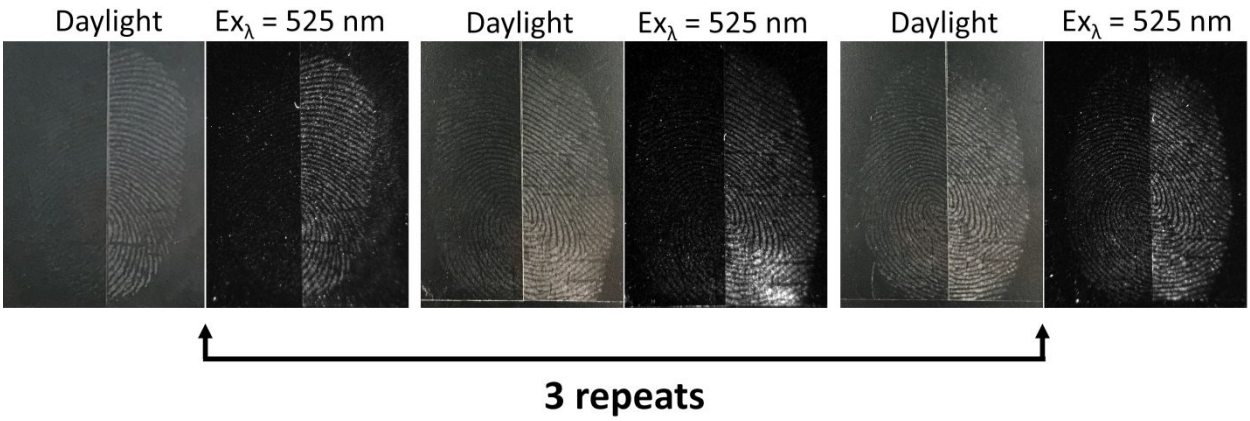


Figure S2. Adhesion efficiency comparison between unmodified FND and FND@PVP. The left half of the fingerprint in each set was developed with bare FNDs whereas the right half of the fingerprint was developed using FND@PVP. The comparison between FND and FND@PVP was repeated three times with the same print from a single donor to confirm reproducibility.

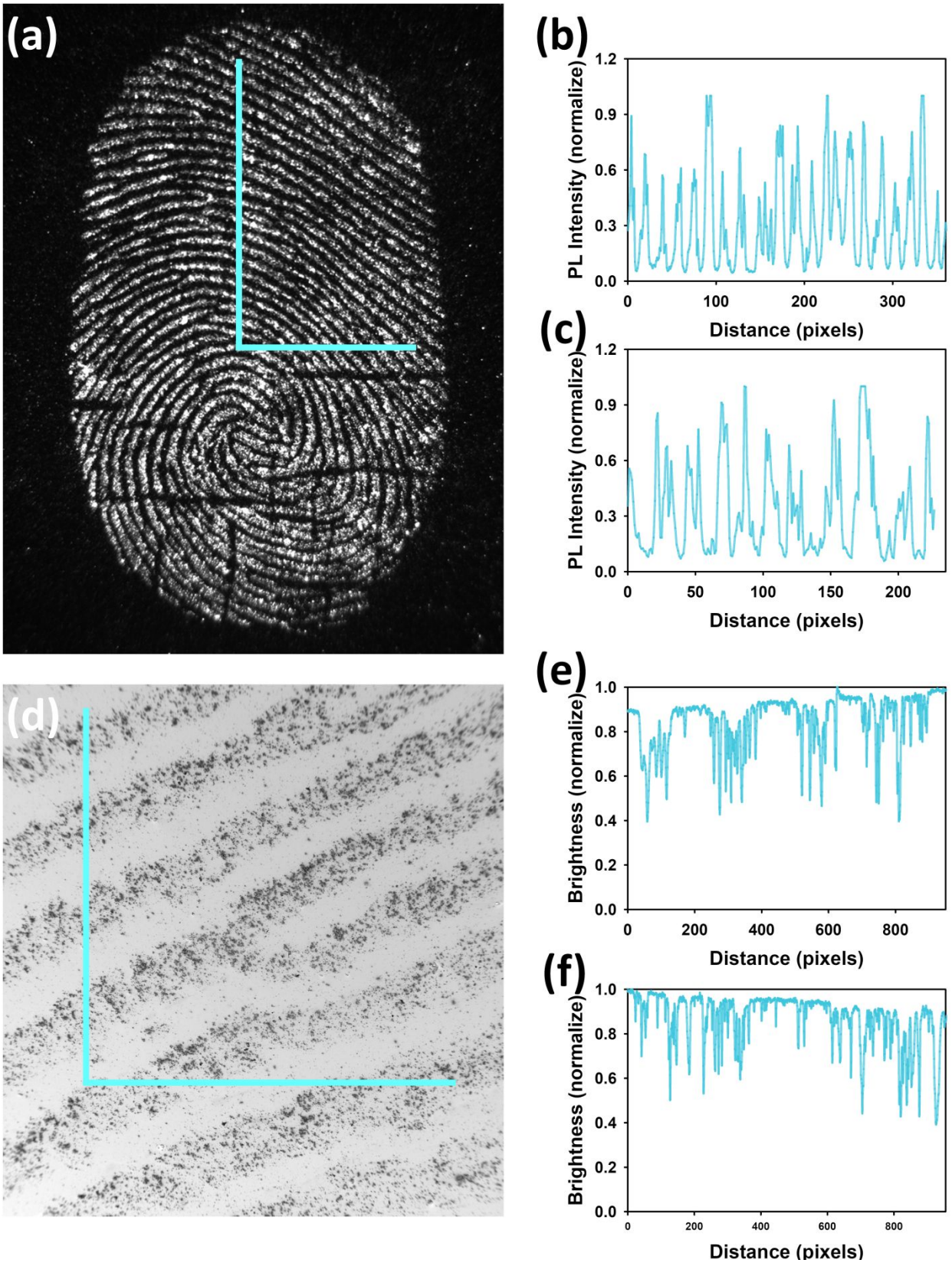

(a)
(b)
PL Intensity (normalize)
1.2
0.9
0.6
0.3
0.0
0
100
200
300
Distance (pixels)
(c)
PL Intensity (normalize)
1.2
0.9
0.6
0.3
0.0
0
50
100
150
200
Distance (pixels)
(d)
(e)
Brightness (normalize)
1.0
0.8
0.6
0.4
0.2
0.0
0
200
400
600
800
Distance (pixels)
(f)
Brightness (normalize)
1.0
0.8
0.6
0.4
0.2
0.0
0
200
400
600
800
Distance (pixels)

Figure S3. High resolution fluorescence and SEM image of FND@PVP labeled LFPs. (a) fluorescence image of fingerprint and normalized PL intensity along two orthogonal lines in (a): (b) vertical axis from top to bottom and (c) horizontal axis from left to right. (d) SEM image and normalized brightness along two orthogonal lines in (d): (e) vertical axis from top to bottom and (f) horizontal axis from left to right. The PL intensity in fluorescence images represents an increase above background, therefore the PL line scans exhibit positive peaks. Conversely, the contrast in SEM images represents a decrease in intensity below background, so the SEM line scans exhibit negative peaks due to the contrast of the FND.

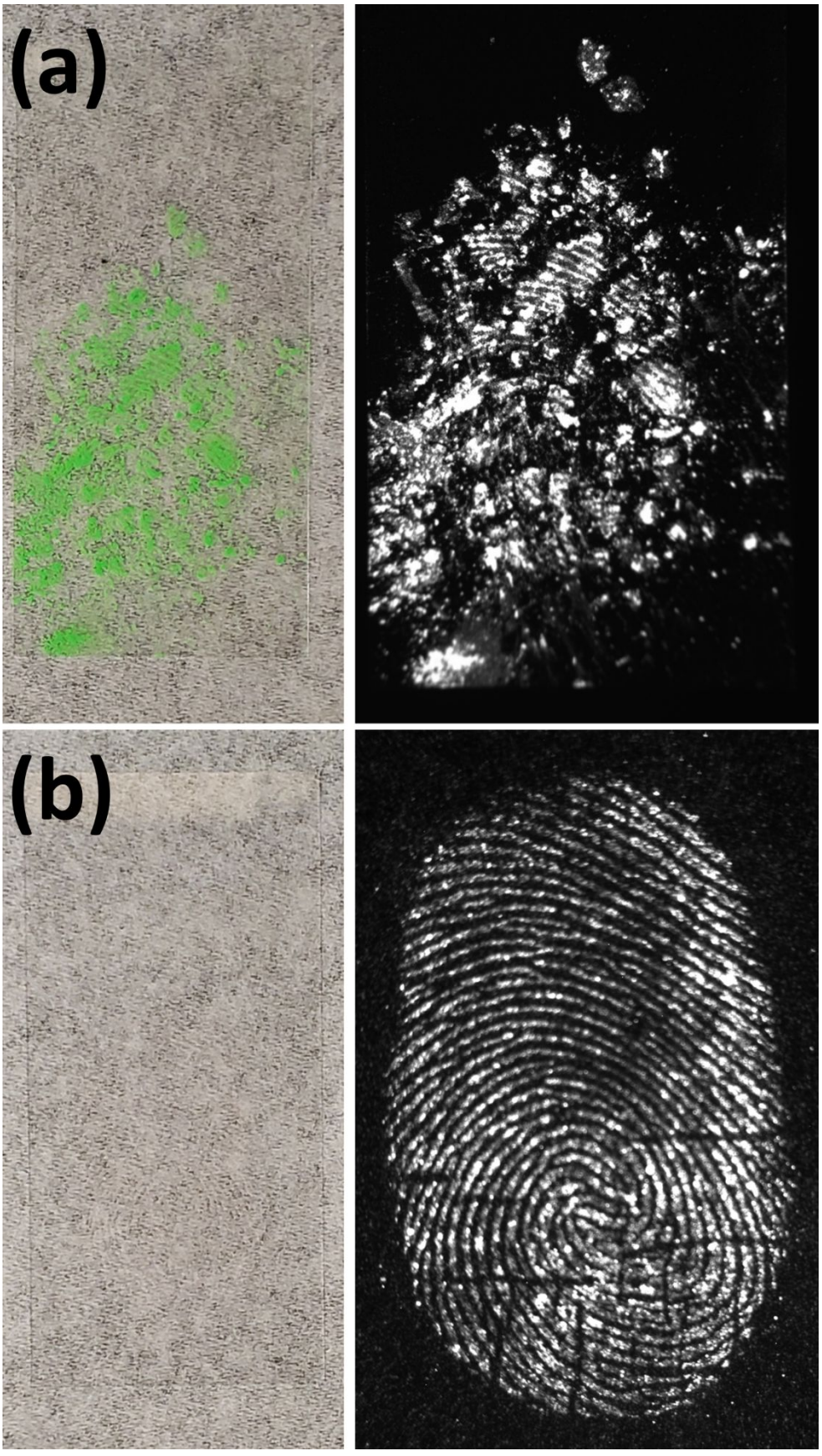

(a)
(b)

Figure S4. Bright-field and fluorescence images of a fingerprint developed with (a) conventional fluorescent powder (green powder) and (b) FND@PVP. The conventional fluorescent powder treated fingerprint was imaged with 365 nm excitation, a 15 s exposure, and a SYBR Green (515~570 nm) emission filter. The FND@PVP treated fingerprint was imaged with 525 nm excitation, a 30 s exposure, and an Ethidium Bromide (570~640 nm) emission filter.

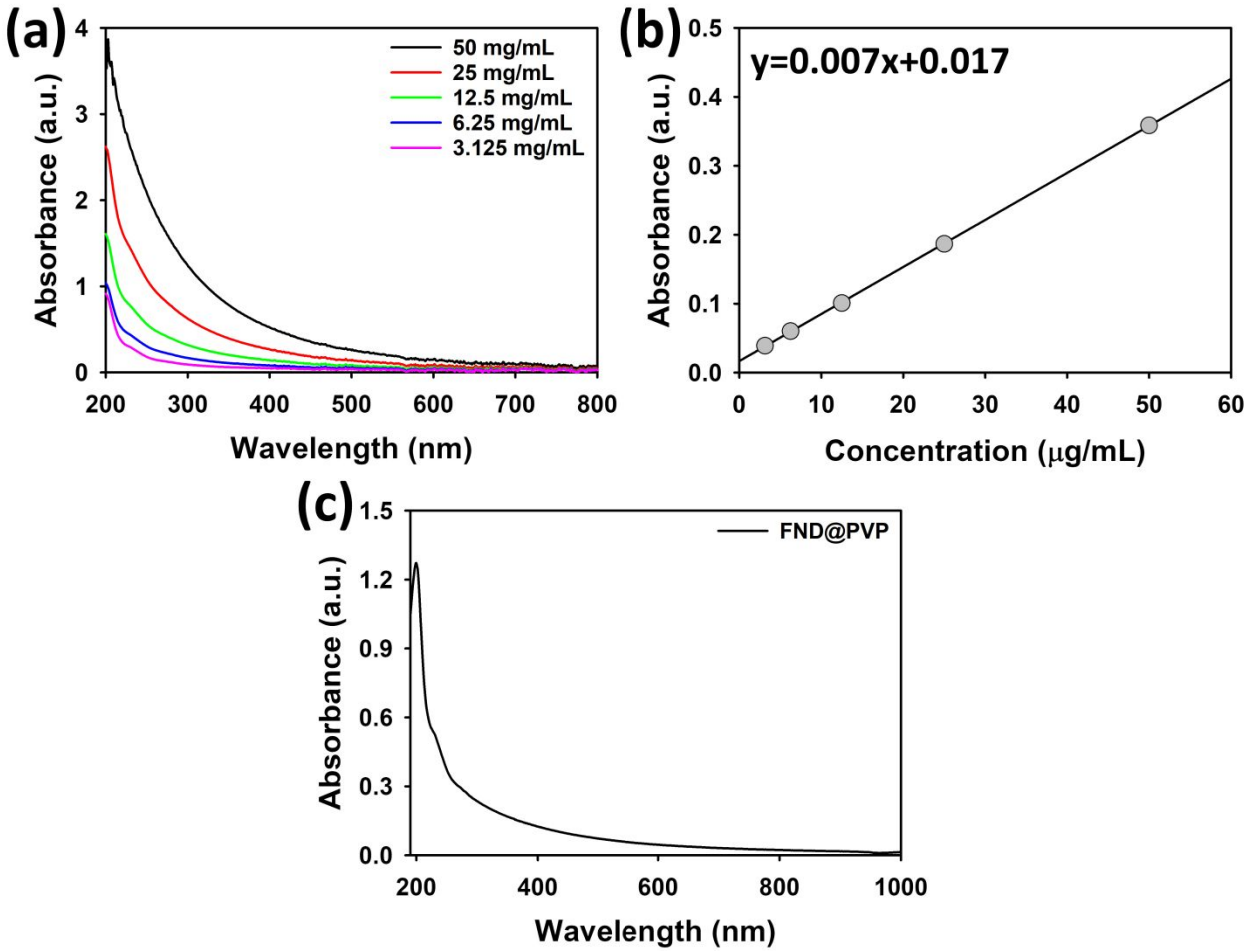


Figure S5. Determination of the amount of FND@PVP deposited to develop a LFP. (a) UV–Vis absorption spectra of FND@PVP as function of concentration, (b) calibration curve of the absorption at 450 nm as a function of FND@PVP concentration, and (c) 10 fold dilution of the FND@PVP released from a developed LPF, corresponding to a concentration of 110 µg/mL in a total volume of 1 mL for a total of 110 µg of FND@PVP.

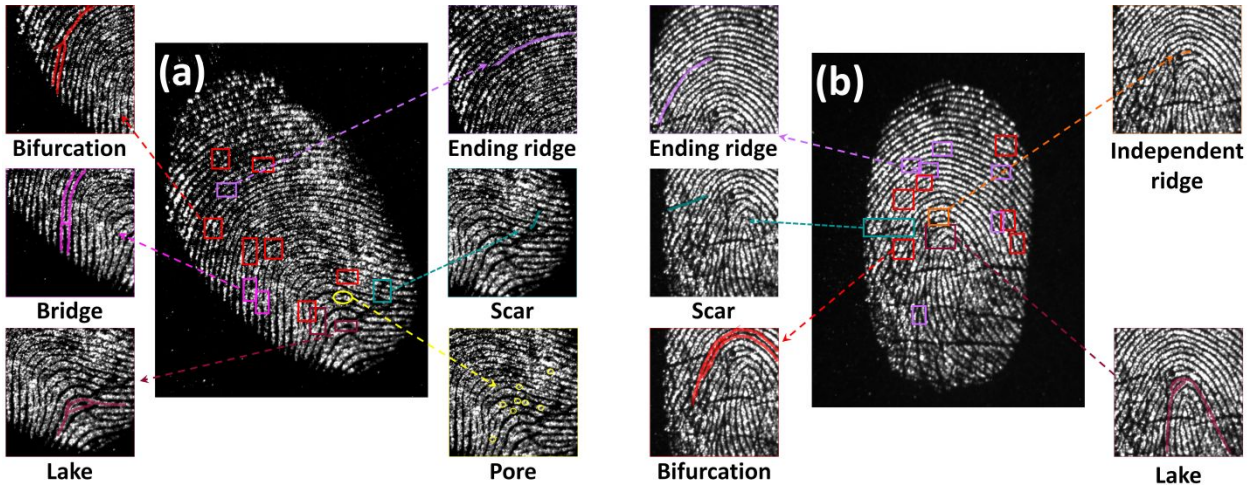


Figure S6. High resolution fluorescence images and magnified regions of fluorescence images of FND@PVP labeled fingerprints from two different donors. The fluorescence images were obtained with 525 nm excitation, a 30 s exposure, and an Ethidium Bromide (570~640 nm) emission filter. (a) donor 1 fingerprint and (b) donor 2 fingerprint. The level 1 (overall shape), 2 (bifurcation, bridge, lake, ending ridge, and independent ridge) and 3 features (pore and scar) are indicated in the magnified regions of the fluorescence images of the two fingerprints.

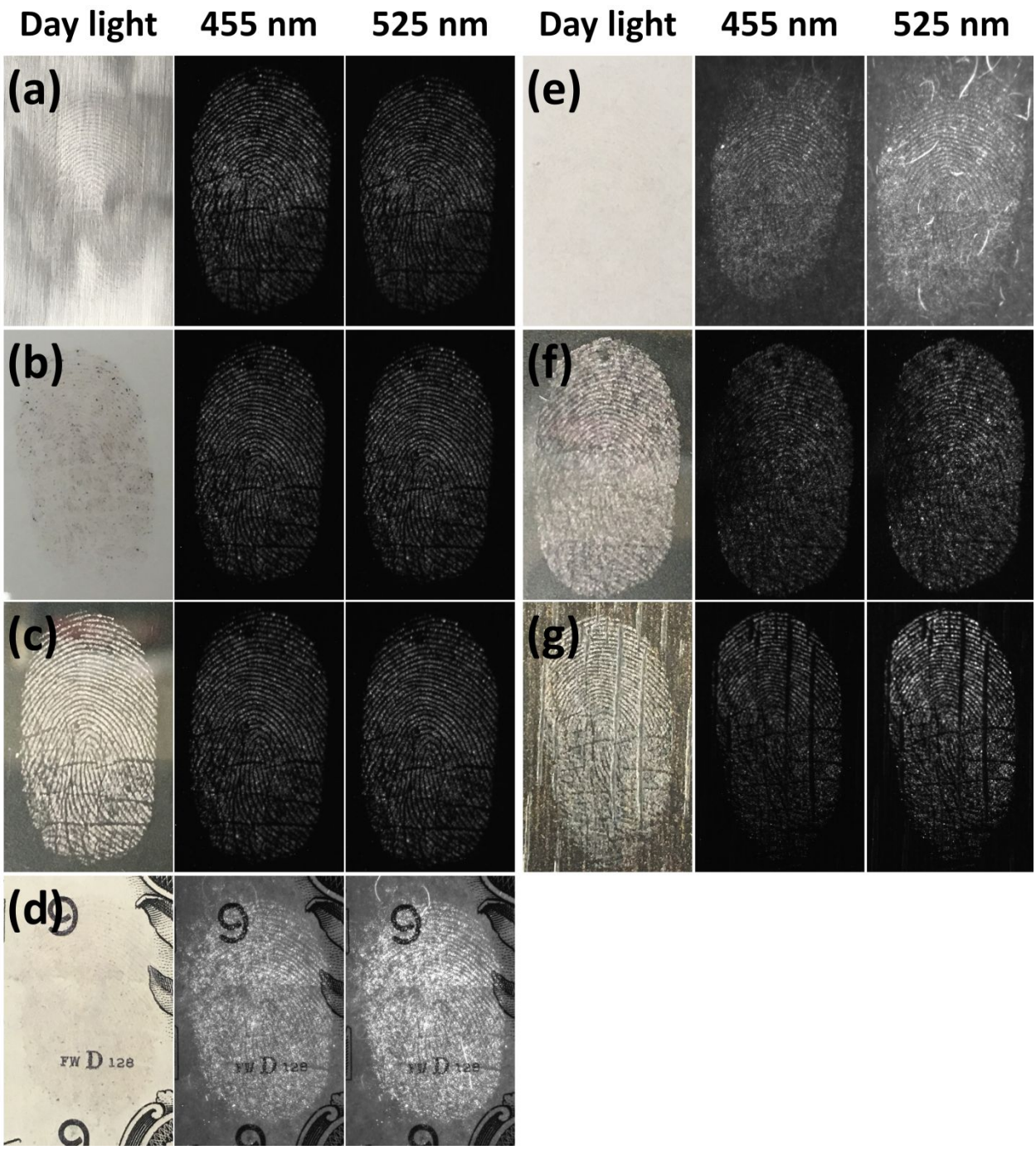


Figure S7. Bright-field and fluorescence images of developed fingerprints of donor 1 on various surfaces. Bright-field optical images of developed LFPs taken with a Nikon D80 camera with an AF-Micro Nikkor 105mm 1:2.8 lens under room light. (a) aluminum foil,

(b) ceramic, (c) glass, (d) money (e) paper, (f) petri-dish, and (g) wood. All fluorescence images were obtained with two (455 and 525 nm) excitation wavelengths. Different exposure times were employed for each substrate because the FND@PVP binding differed among substrates. A SYBR Green (515~570 nm) emission filter was employed with 455 nm excitation light, whereas an Ethidium Bromide (570~640 nm) emission filter was employed with 525 nm excitation. The developed LFPs were clearly observed on all surfaces due to strong binding of FND@PVP to finger residues.

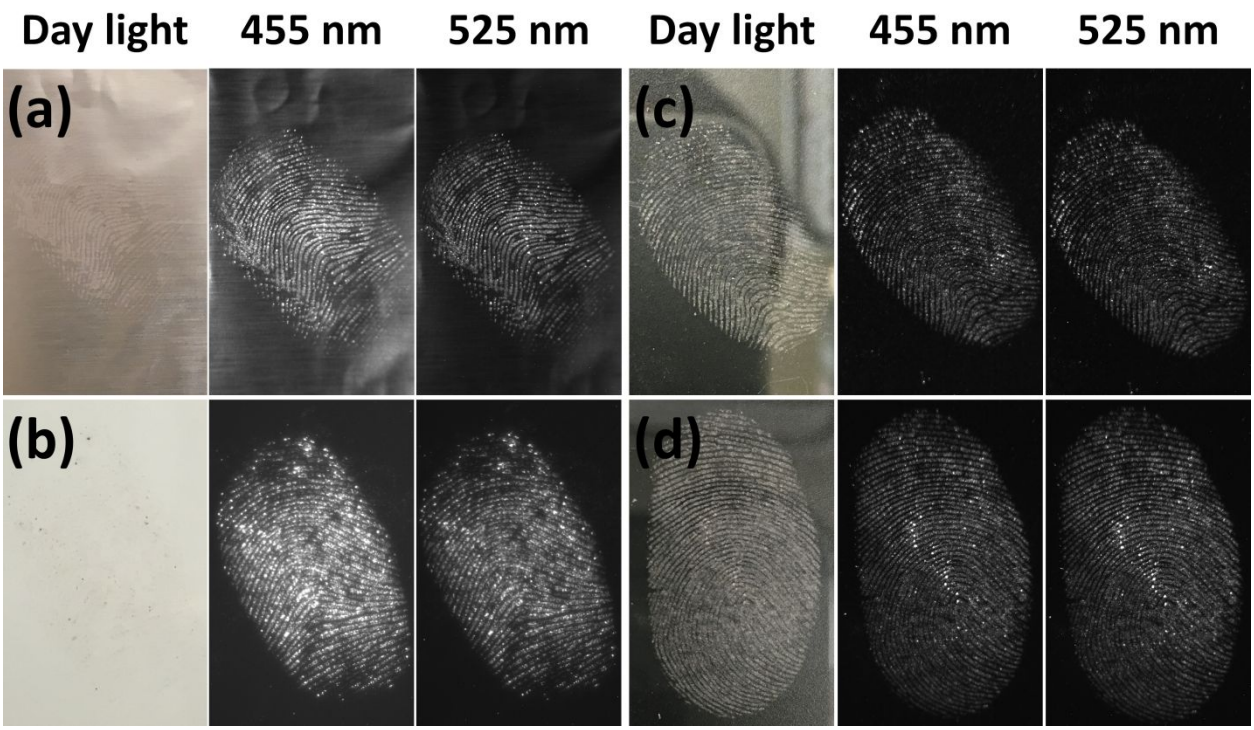


Figure S8. Bright-field and fluorescence images of developed fingerprints of donor 2 on various surfaces. Bright-field optical images of developed LFPs taken with a Nikon D80 camera with an AF-Micro Nikkor 105mm 1:2.8 lens under room light. (a) aluminum foil, (b) ceramic, (c) glass, and (d) petri-dish. 455 and 525 nm excitation wavelength were employed to obtain fluorescence images. Different exposure times were employed for each substrate because the FND@PVP binding differed among substrates. A SYBR Green (515~570 nm) emission filter was employed with 455 nm excitation light, whereas an Ethidium Bromide (570~640 nm) emission filter was employed with 525 nm excitation.

The developed LFPs were clearly observed on all surfaces due to strong binding of FND@PVP to finger residues.

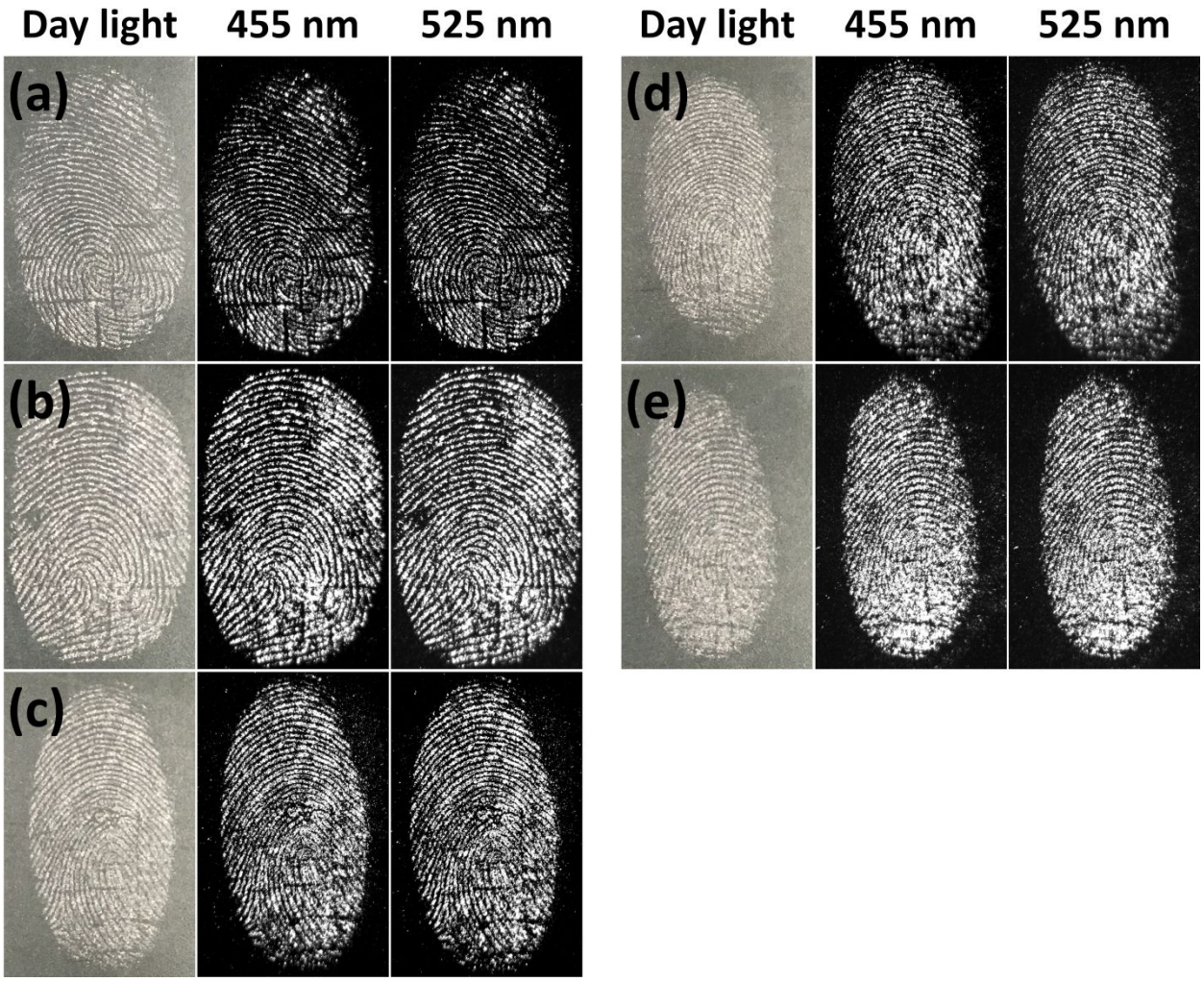


Figure S9. Representative photographs under natural light and fluorescence images for developed LFP from 5 fingers using FND@PVP. Photographs of developed LFPs taken with a Nikon D80 camera with an AF-Micro Nikkor 105mm 1:2.8 lens under room light. (a) thumb, (b) index finger, (c) middle finger, (d) ring finger, and (e) little finger. The prepared samples were imaged at two different excitation wavelengths (455 or 525 nm). At 455 nm excitation, the specimen was exposed for 4 min 30 s with a SYBR Green

(515~570 nm) emission filter. The FND@PVP labeled LFP was imaged under 525 nm excitation wavelength for 30 s exposure time with an Ethidium Bromide (570~640 nm) emission filter.

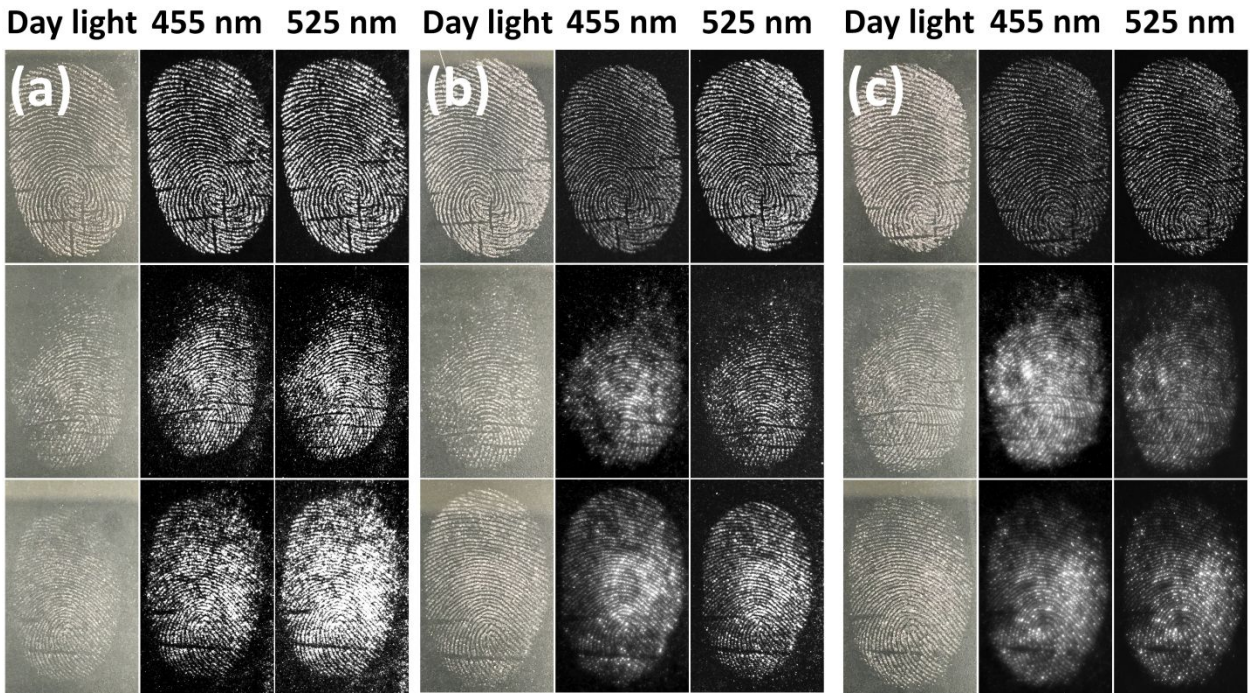


Figure S10. Digital photographs and fluorescence images of developed LFPs from 3 donors with (a) 1, (b) 3, and (c) 7 day old LFPs. Digital photographs of developed LFPs taken with a Nikon D80 camera with an AF-Micro Nikkor 105mm 1:2.8 lens under room light. Each FND@PVP labeled LFP on cover slip was imaged with 455 or 525 nm excitation and a SYBR Green (515~570 nm) or an Ethidium Bromide (570~640 nm) emission filter, respectively. Different exposure times were applied for each aged fingerprint because the FND@PVP binding decreased over time.

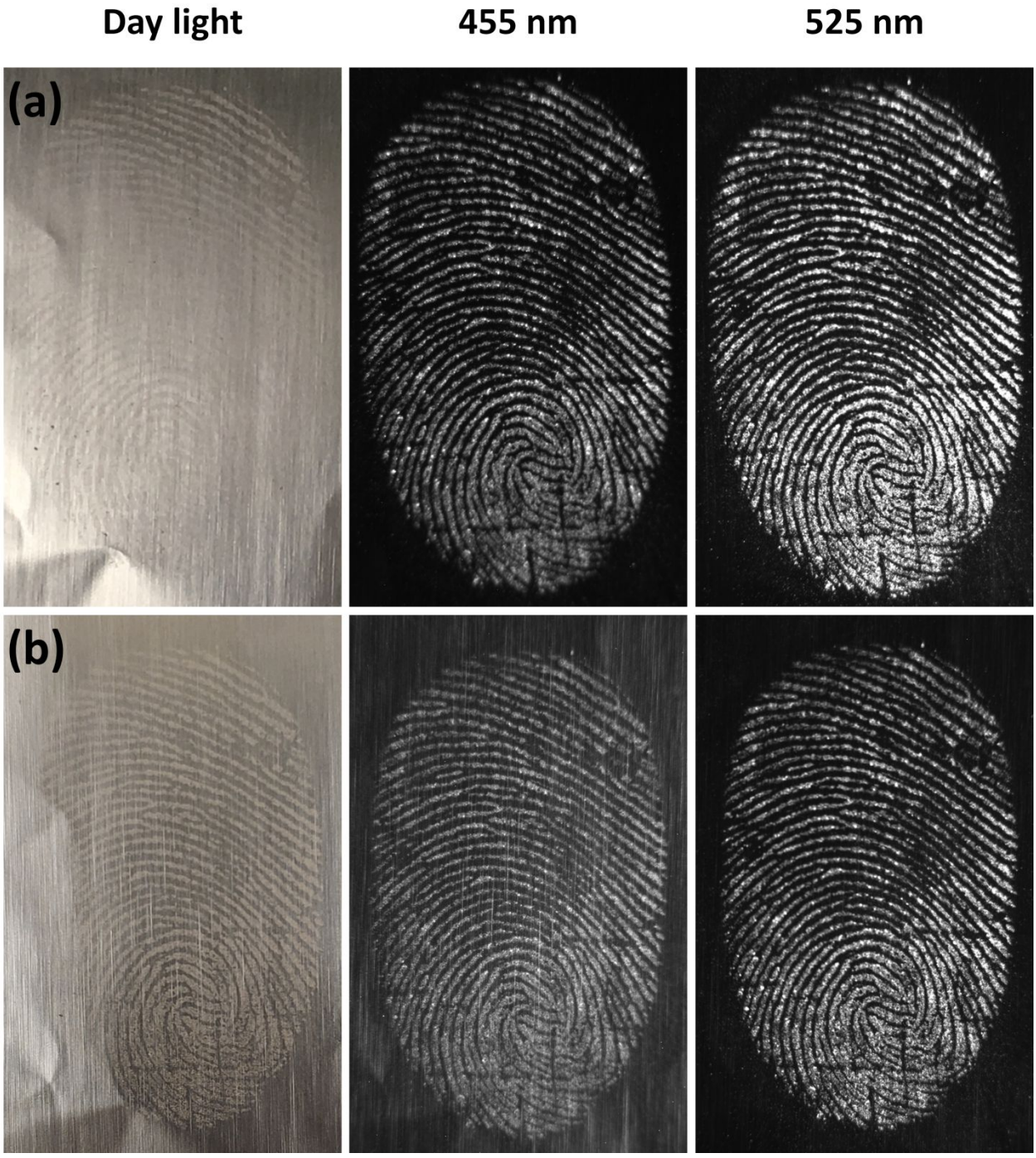


Figure S11. Photographs and fluorescence images of (a) as developed and (b) after 10 months FND@PVP labeled LPFs on aluminum foil. The developed LFPs could be imaged again after 10 months due to the excellent photostability of FND and high interaction

between FND@PVP and fingerprint residues. For 455 nm excitation, the FND@PVP treated LFP was exposed for 4 min with a SYBR Green (515~570 nm) emission filter. The FND@PVP labeled LFP was imaged with 525 nm excitation for 40 s with an Ethidium Bromide (570~640 nm) emission filter.

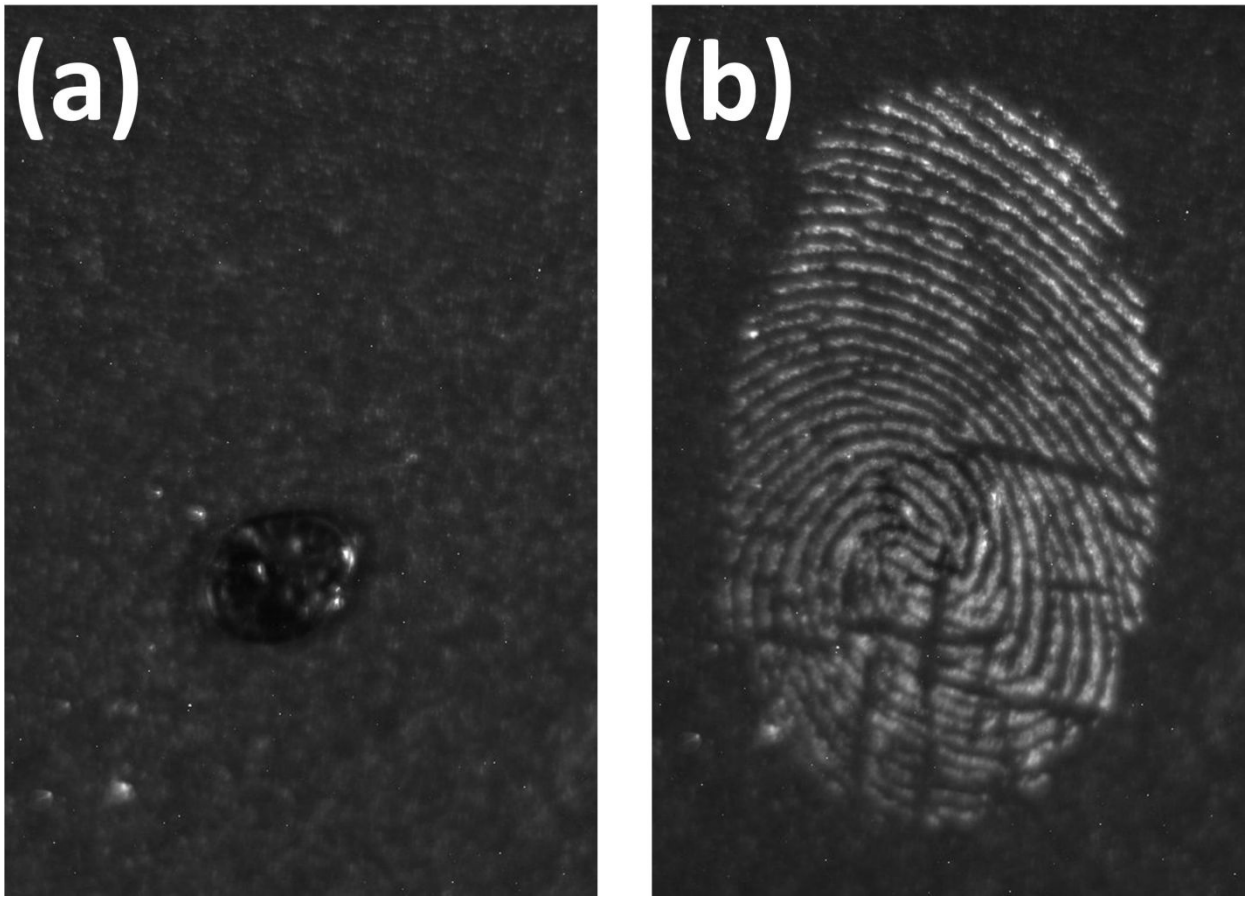


Figure S12. Fluorescence images of (a) mouse blood and (b) developed latent fingerprint using FND@PVP on mouse blood. Each image was excited at 455 nm with a 4 min exposure time with a SYBR Green (515~570 nm) emission filter.