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Emission Spectra of Various Tile & Fiber Samples

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The emission spectra of various tiles and fibers which are considered as candidate materials for the SDC calorimeter have been measured to aid in a search for a PMT which has an optimal matching quantum efficiency to the emission spectrum of the tile/fiber system. The emission spectra were measured with a Hewlett-Packard model 8451A diode array spectrophotometer. The samples were excited using an external Hg lamp whose light was brought through a quartz fiber. Depending on the sample, an excitation wavelength of 313, 404 or 530 nm was selected by selecting Hg emission lines with bandpass filters.

1. Scintillating Tiles

Three types of scintillating tiles were measured: SCSN38, SCSN81, and BC408. The tiles used were 6 mm thick and 7.5 cm x 2.5 cm cross section. The 313 nm wavelength light from the quartz fiber was directed to the sample surface with a 45° angle of incidence (see Figure 1(a)). The 313 nm wavelength was chosen to excite the primary shifter (either PTP or Butyl-PBD). The measured emission spectra are shown in Figure 2. The emission from both the primary and secondary fluors is visible due to front surface illumination. The light below 400 nm would not be present for back surface illumination or for scintillation light. In Figure 3, the absorption and emission (excitation at 340 nm) spectra of 3HF scintillator are shown [1].

2. Wavelength Shifting Fibers

Emission spectra were measured for these types of WLS fibers: green(BCF91A and double clad Y11), Orange(O2) and Red(R3). For the green fibers, the spectrum measurements were made with the 404 nm excitation light. Previously measured emission spectra of O2 [1] excited at 483 nm and R3 at 540 nm are shown in Figure 4. However, when considering the case in which 3HF scintillating tile is read out by O2 WLS fiber, the peak of the 3HF emission occurs at 530 nm and there is almost no light output around 483 nm. Therefore, to measure a more realistic emission spectrum for this case, 530 nm excitation light was used for both the O2 and R3 WLS fiber samples. To obtain a reasonable light output, 60 pieces of 1mm diameter WLS fiber in 5 cm length were bundled. The ends of fibers were polished to prevent irregular scattering of light output in front of the spectrophotometer. The input excitation light had a 45° incidence angle as shown in Figure 1(b). The measured spectra are shown in Figure 5 and 6.

3. Tile/Fiber Samples

Table 1: Tile/fiber samples measured and peak values of emission spectrum.

type of tile/fiber	emission peak (nm)
SCSN81/BCF91A	502
SCSN38/G2	516
SCSN81/G2	516
3HF/O2	596
3HF/R3	630

The scintillating tiles used were 2.65 mm thick and 11 cm x 11 cm in cross section, polystyrene-based scintillators. The "α tile" is a shape and size shown in Figure 6(a) where a WLS fiber is embedded in a box shaped path. A WLS fiber, 1 mm in diameter and 56 cm long, was routed out through the key hole shaped groove path (see Fig 6(a)) and spliced to a 45 cm long clear fibers at each end. Measured tile/fiber samples are listed in Table 1. The center of the tiles were excited with the 313 nm light. The collected light from the tile/WLS fiber was brought to the spectrophotometer optics by the light guide clear fibers. The measured spectra are shown in Figure 7. The differences in these spectra compared to the fiber only cases (Figure 5) are coming from the different illumination spectra and also longer length of the shifter fibers being used (more self-absorbtion occurs) which push the spectra of tile/fiber samples farther into the red wavelength region.

References

[1] From Dr. Masa Mishina, private communication

Figure 1: A block diagram of setup for (a)tile and (b)fiber emission spectrum measurement.

Figure 2: Emission spectra of (a)SCSN38, (b)SCSN81 and (c)BC408 excited at 313 nm.

Figure 3: Absorption and emission (excitation at 340 nm) spectra of 3HF tiles[1].

Figure 4: Emission spectra of O2 (excitation at 483 nm) and R3 (excitation at 540nm)[1].

Figure 5: Emission spectra of (a)Y11 (double clad) and (b)BCF91A excited at 404 nm and (c)O2 and (d)R3, excited at 530 nm.

Figure 6: (a) A schematic diagram of tested tile/fiber sample (b)A block diagram of setup for the emission spectrum measurement of tile/fiber system.

Figure 7: Emission spectra of (a)SCSN81/BCF91A, (b)SCSN38/G2, (c)SCSN81/G2, (d)3HF/O2 and (e)3HF/R3 excited at 313 nm.

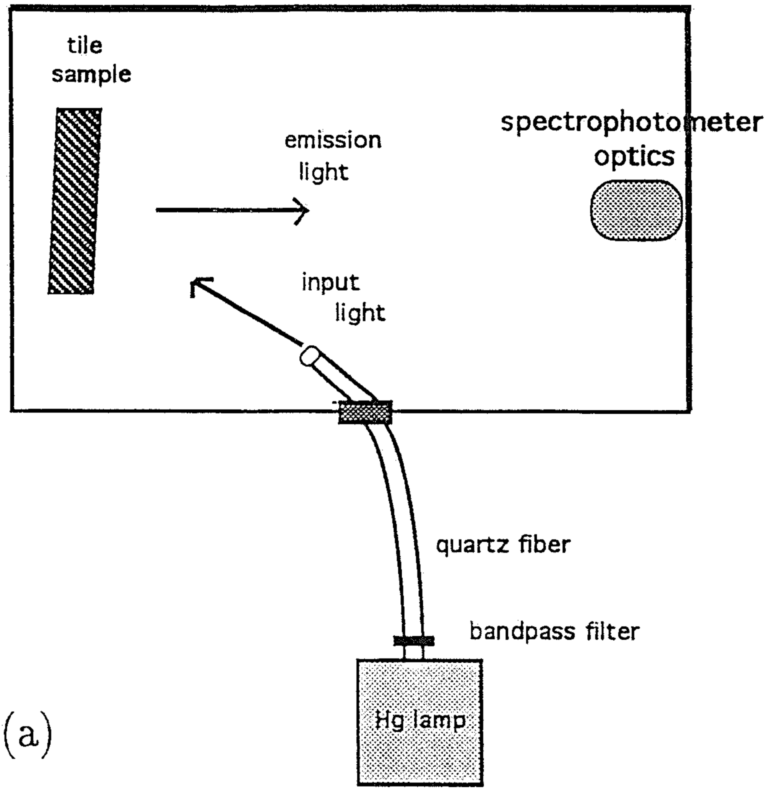


Figure 1(a)

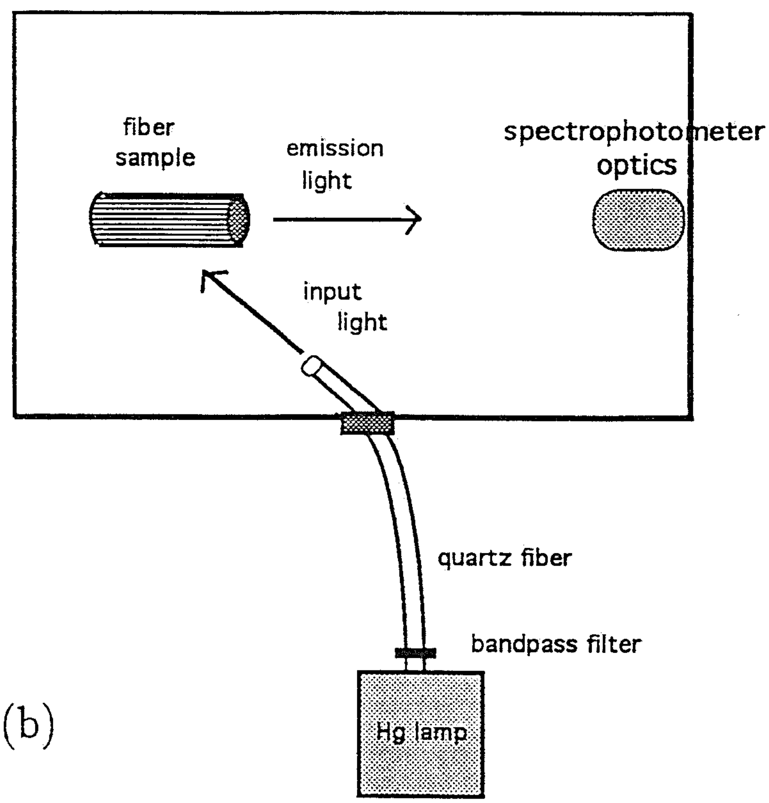
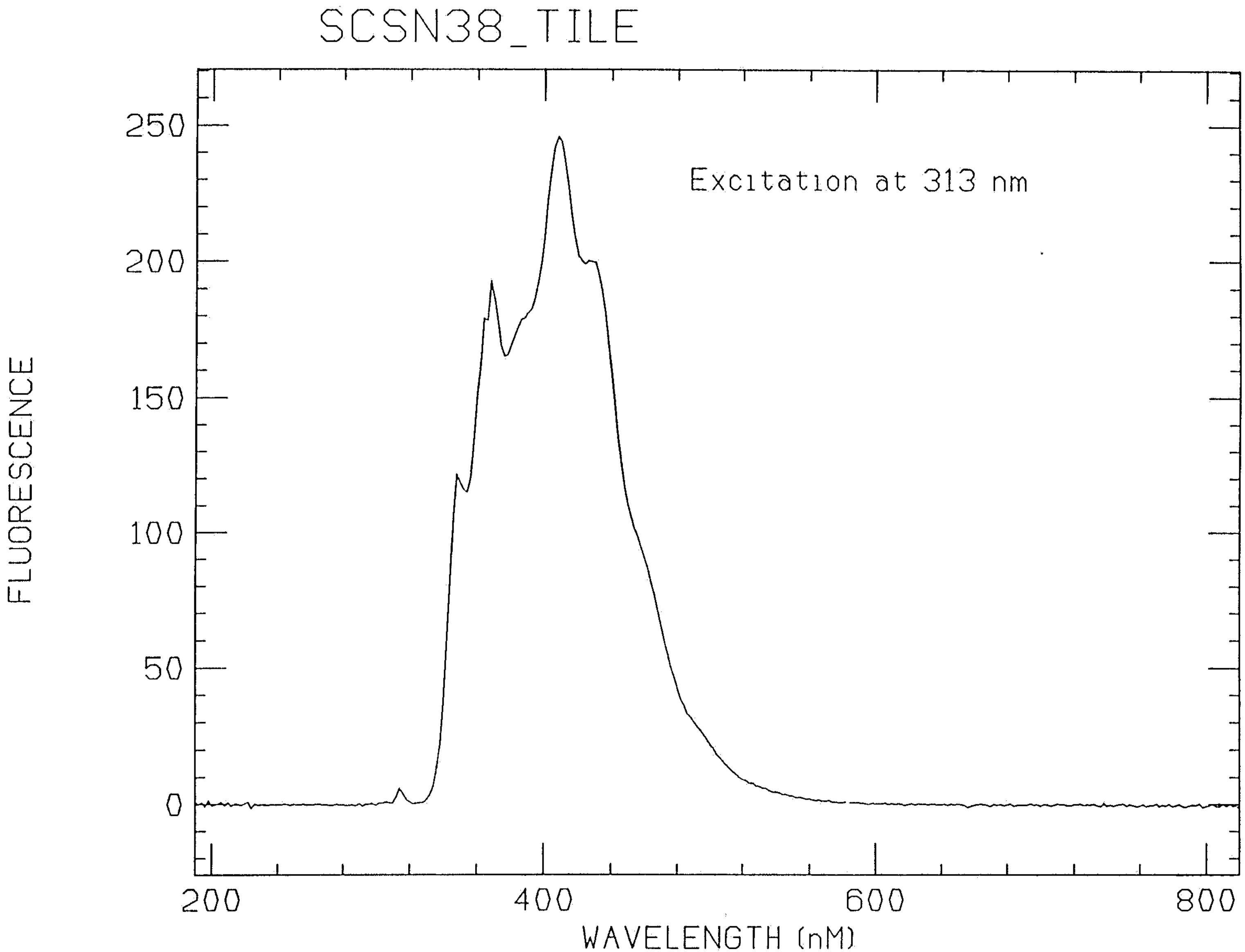
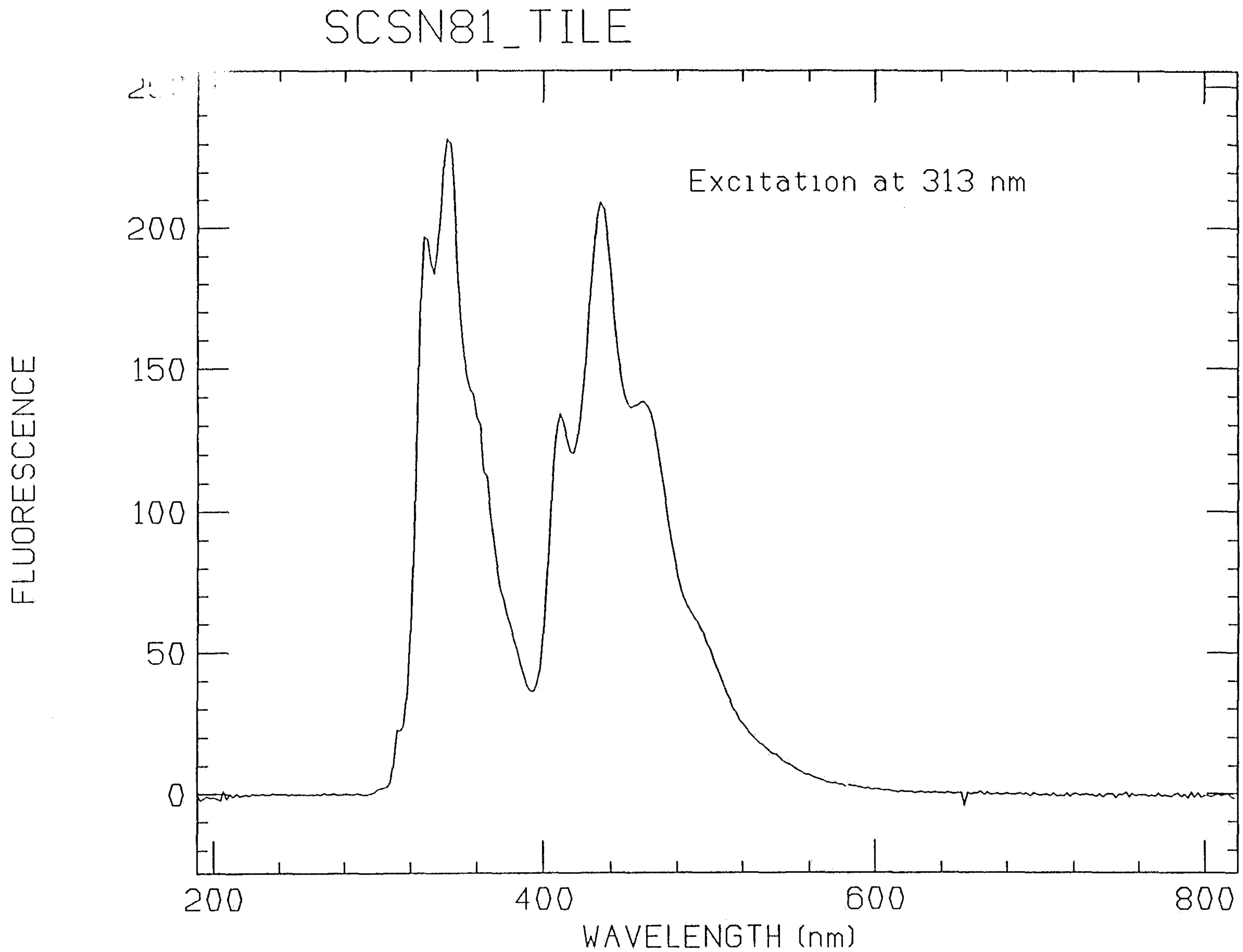


Figure 1(b)



SCSN38_TILE
Excitation at 313 nm
FLUORESCENCE
WAVELENGTH (nM)
0
50
100
150
200
250
200
400
600
800

Figure 2(a)



SCSN81_TILE
Excitation at 313 nm
FLUORESCENCE
WAVELENGTH (nm)
200
150
100
50
0
200
400
600
800

Figure 2(b)

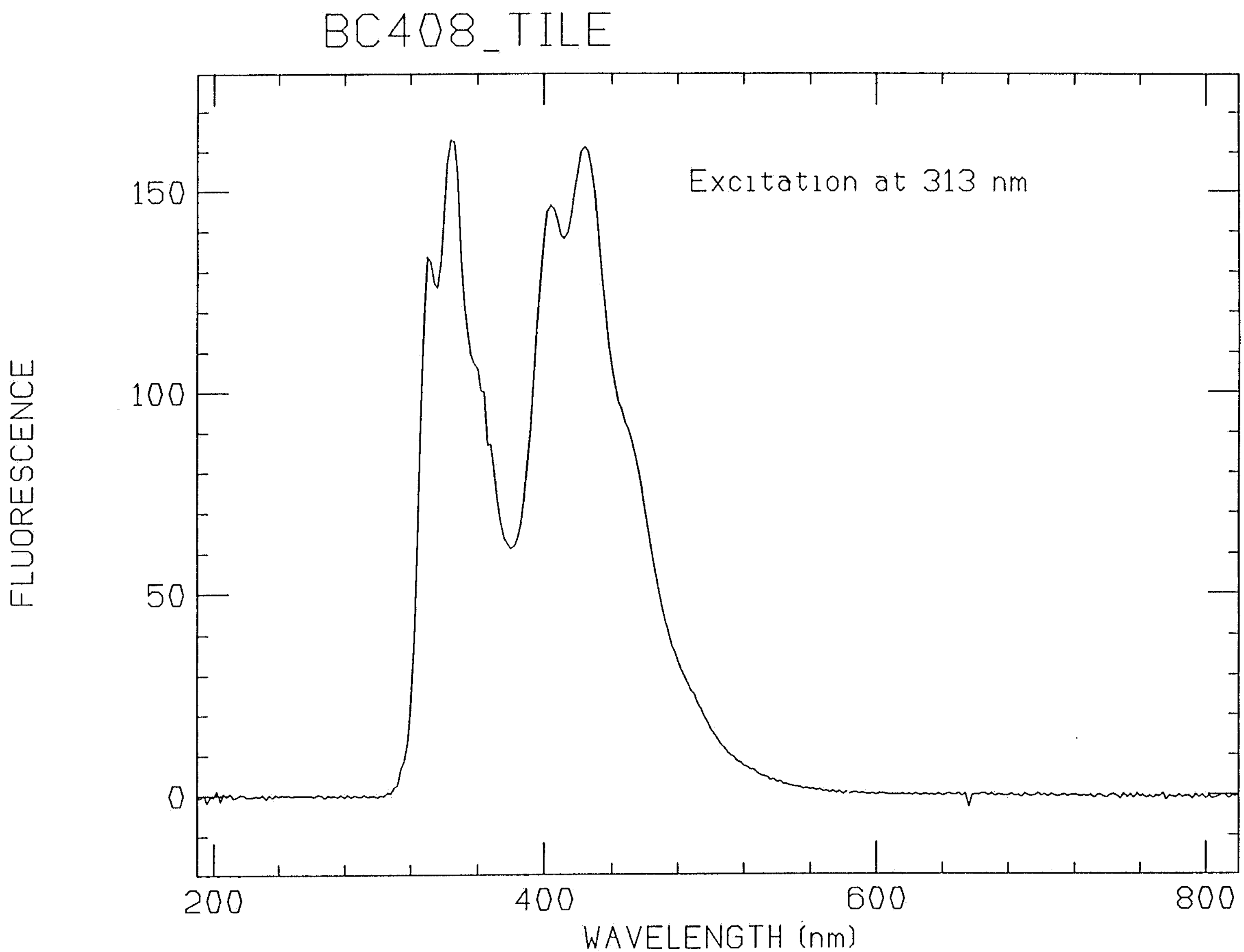

BC408_TILE
Excitation at 313 nm
FLUORESCENCE
WAVELENGTH (nm)
0
50
100
150
200
400
600
800

Figure 2(c)

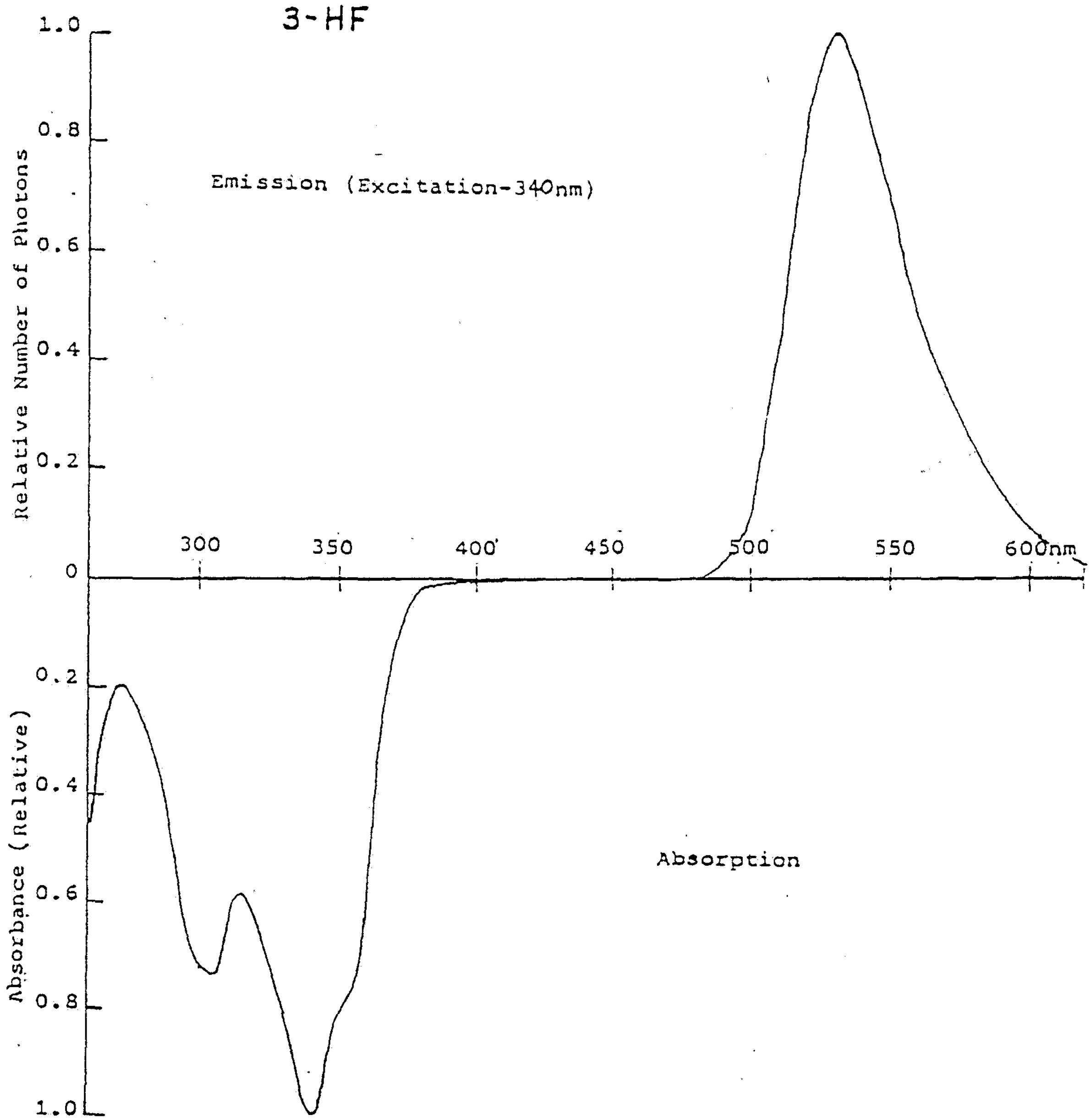

3-HF
Emission (Excitation-340nm)
Relative Number of Photons
Absorption
Absorbance (Relative)
1.0
0.8
0.6
0.4
0.2
0
0.2
0.4
0.6
0.8
1.0
300
350
400
450
500
550
600nm

Figure 3

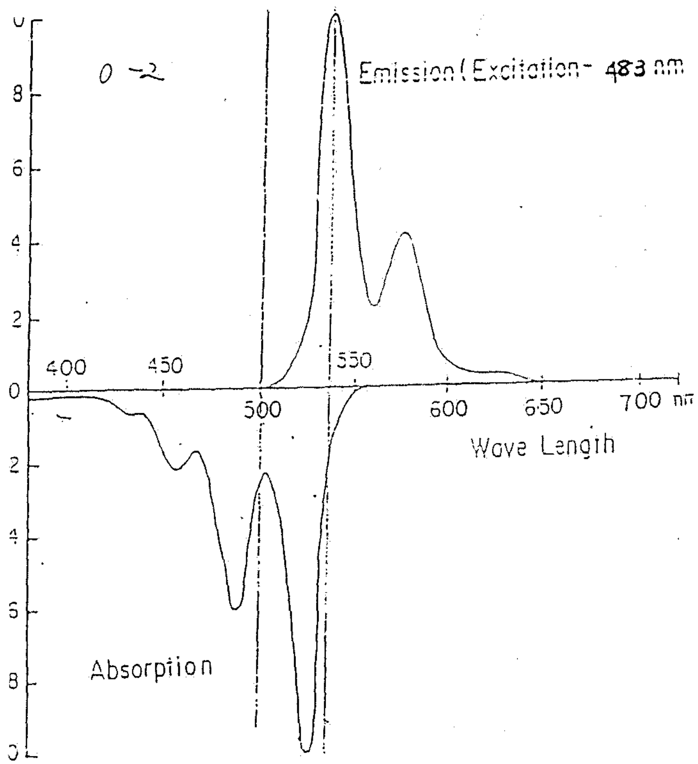


Figure 4(a)

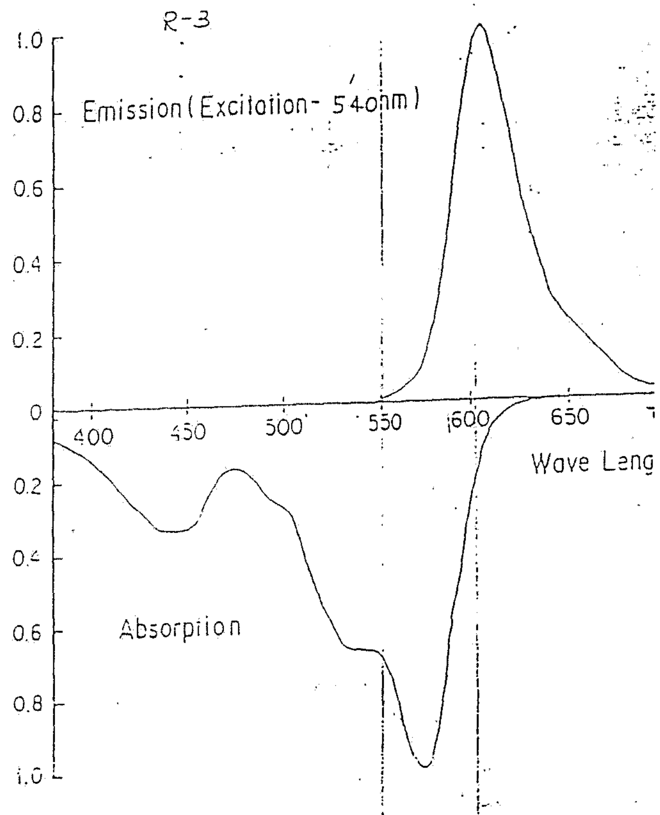
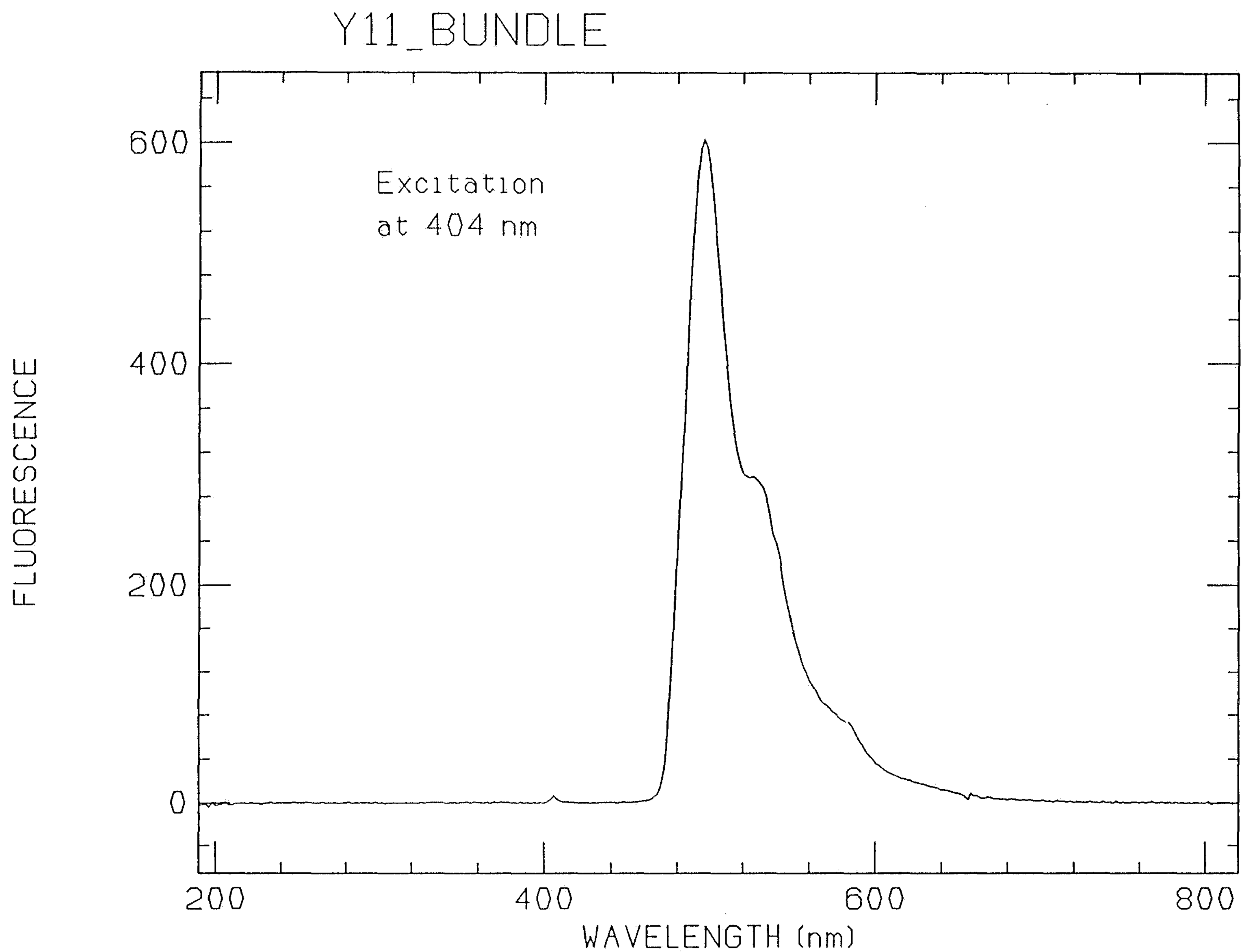


Figure 4(b)



Y11_BUNDLE
Excitation
at 404 nm
FLUORESCENCE
600
400
200
0
200
400
600
800
WAVELENGTH (nm)

Figure 5(a)

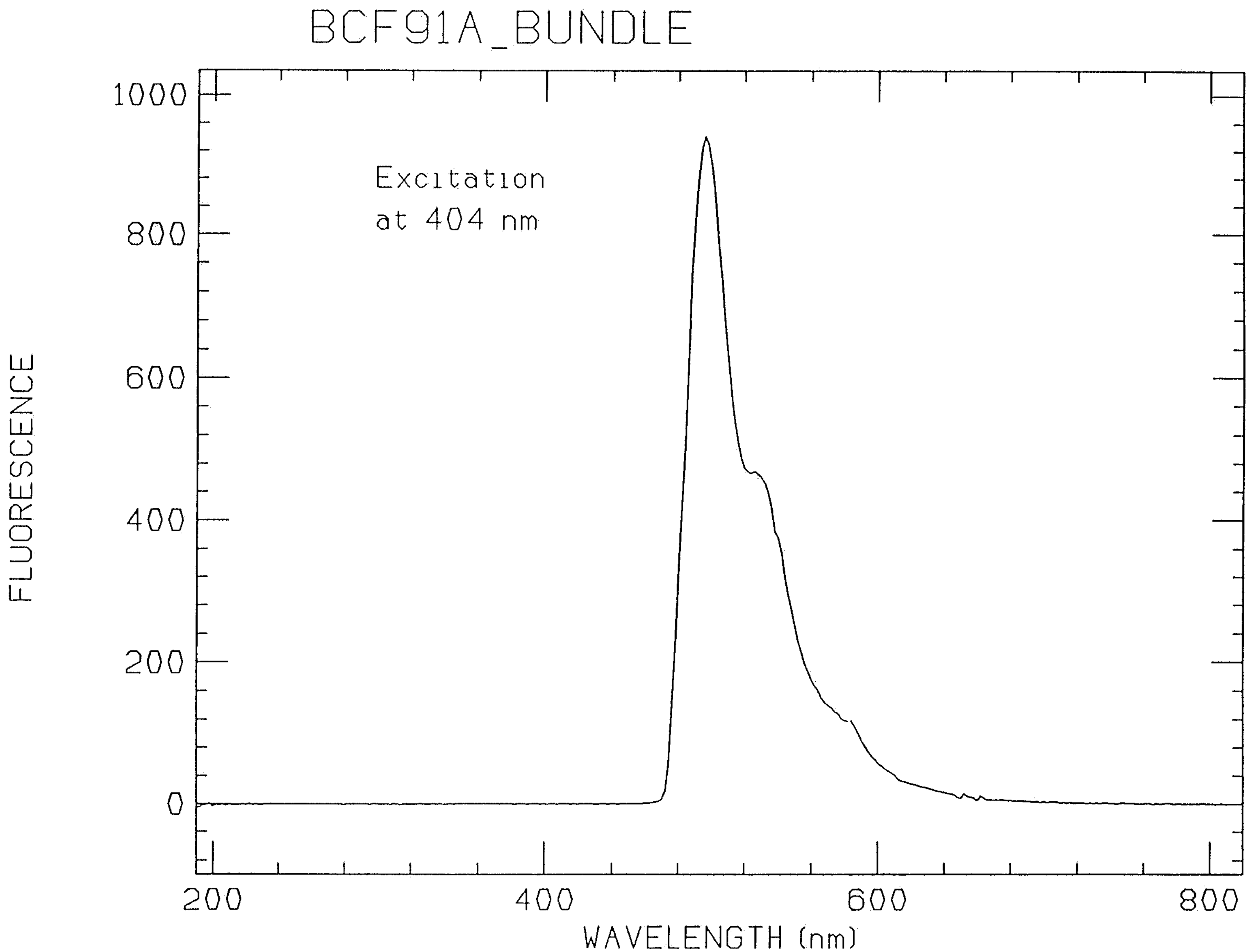
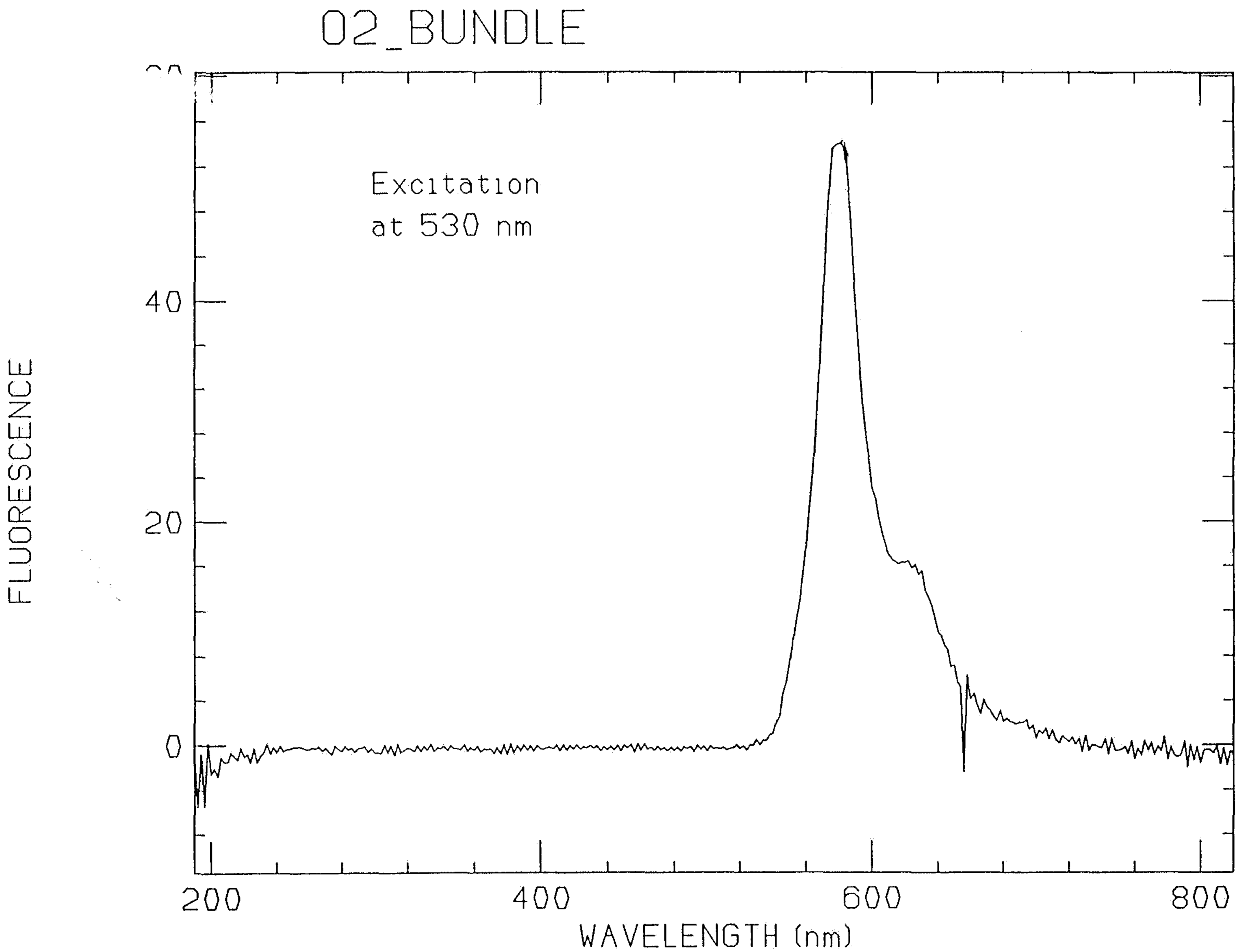

BCF91A_BUNDLE
1000
800
600
400
200
0
Excitation
at 404 nm
FLUORESCENCE
200
400
600
800
WAVELENGTH (nm)

Figure 5(b)



02_BUNDLE
Excitation
at 530 nm
FLUORESCENCE
40
20
0
200
400
600
800
WAVELENGTH (nm)

Figure 5(c)

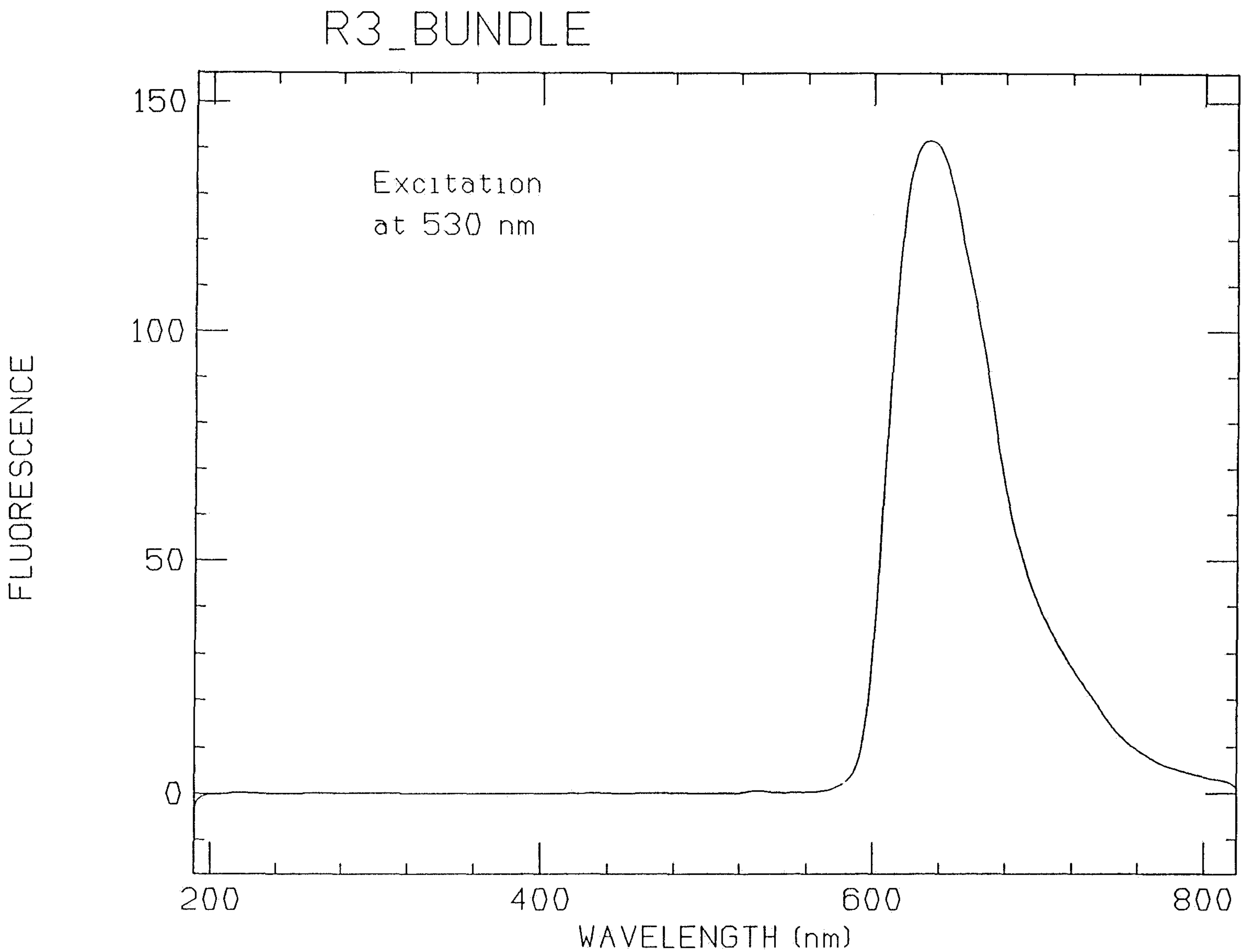

R3_BUNDLE
Excitation
at 530 nm
150
100
50
0
FLUORESCENCE
200
400
600
800
WAVELENGTH (nm)

Figure 5(d)

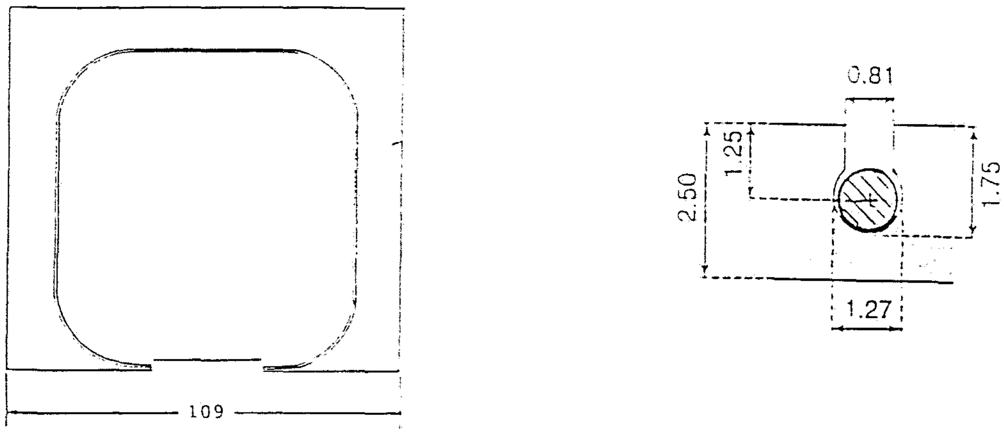


Figure 6(a)

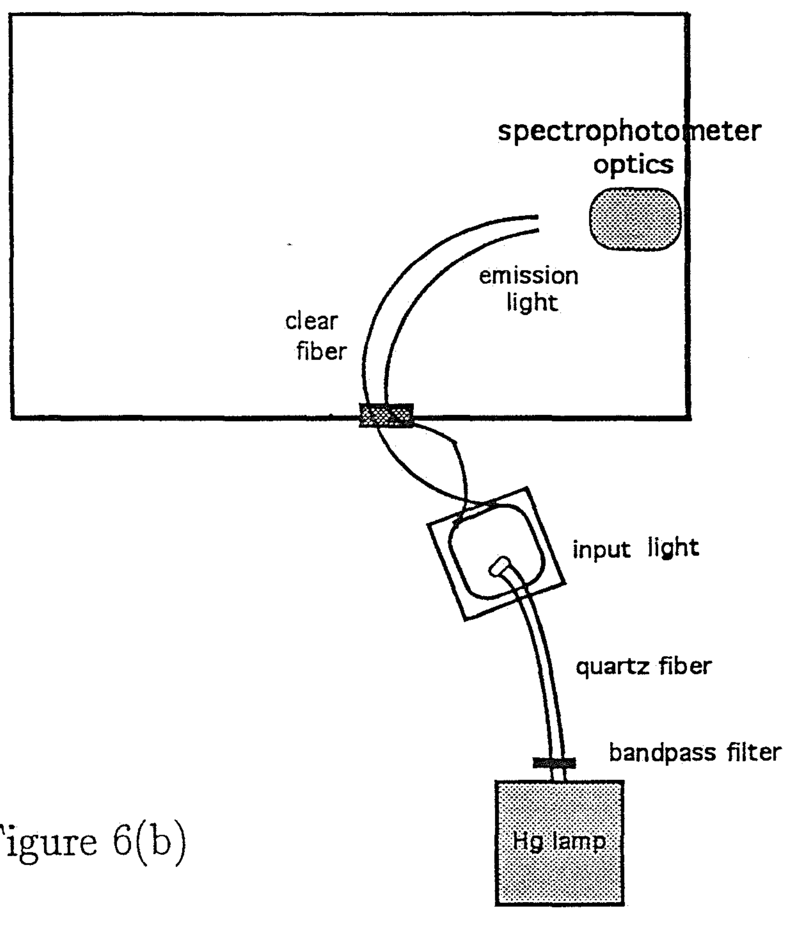


Figure 6(b)

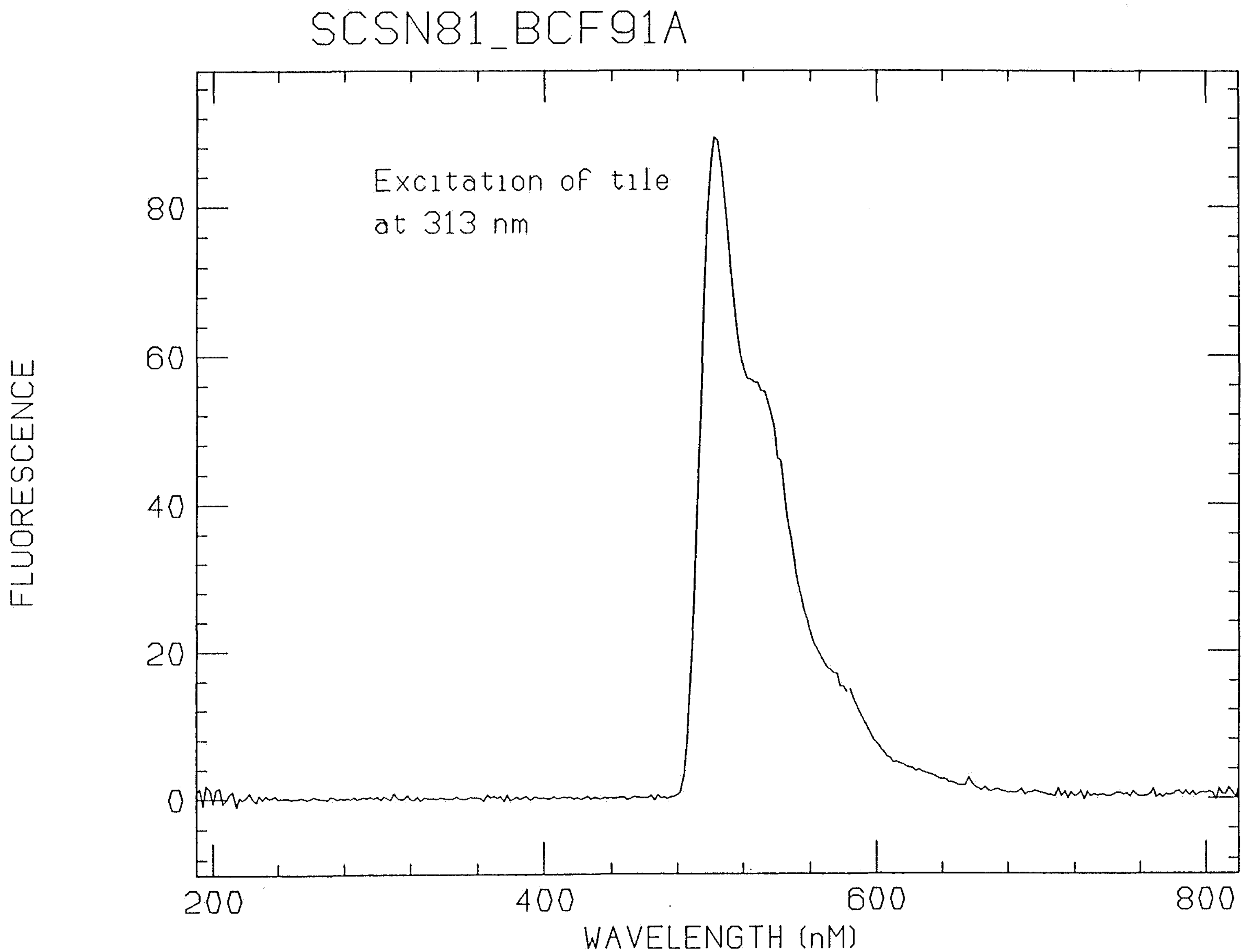

SCSN81_BCF91A
Excitation of tile
at 313 nm
80
60
40
20
0
FLUORESCENCE
200
400
600
800
WAVELENGTH (nM)

Figure 7(a)

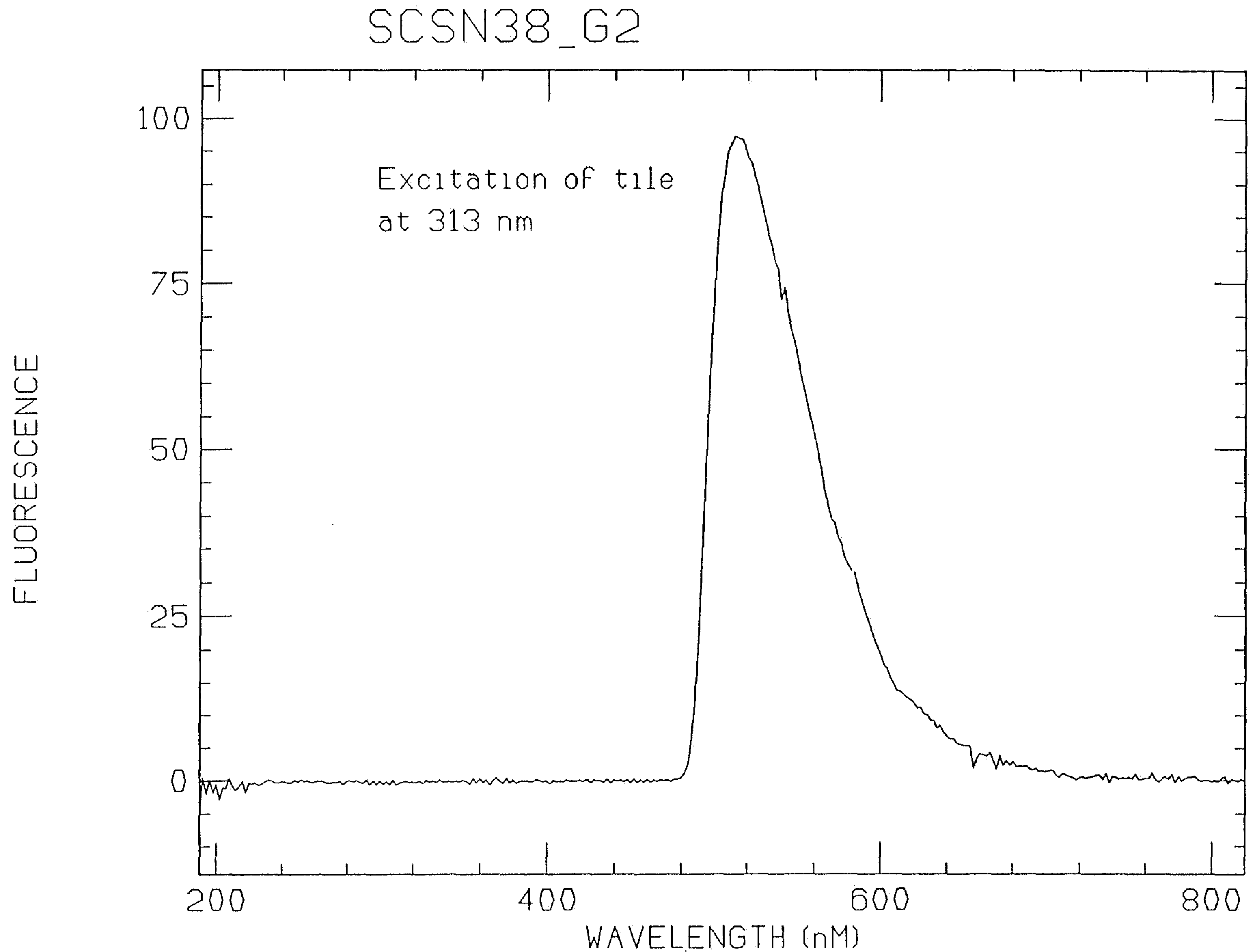
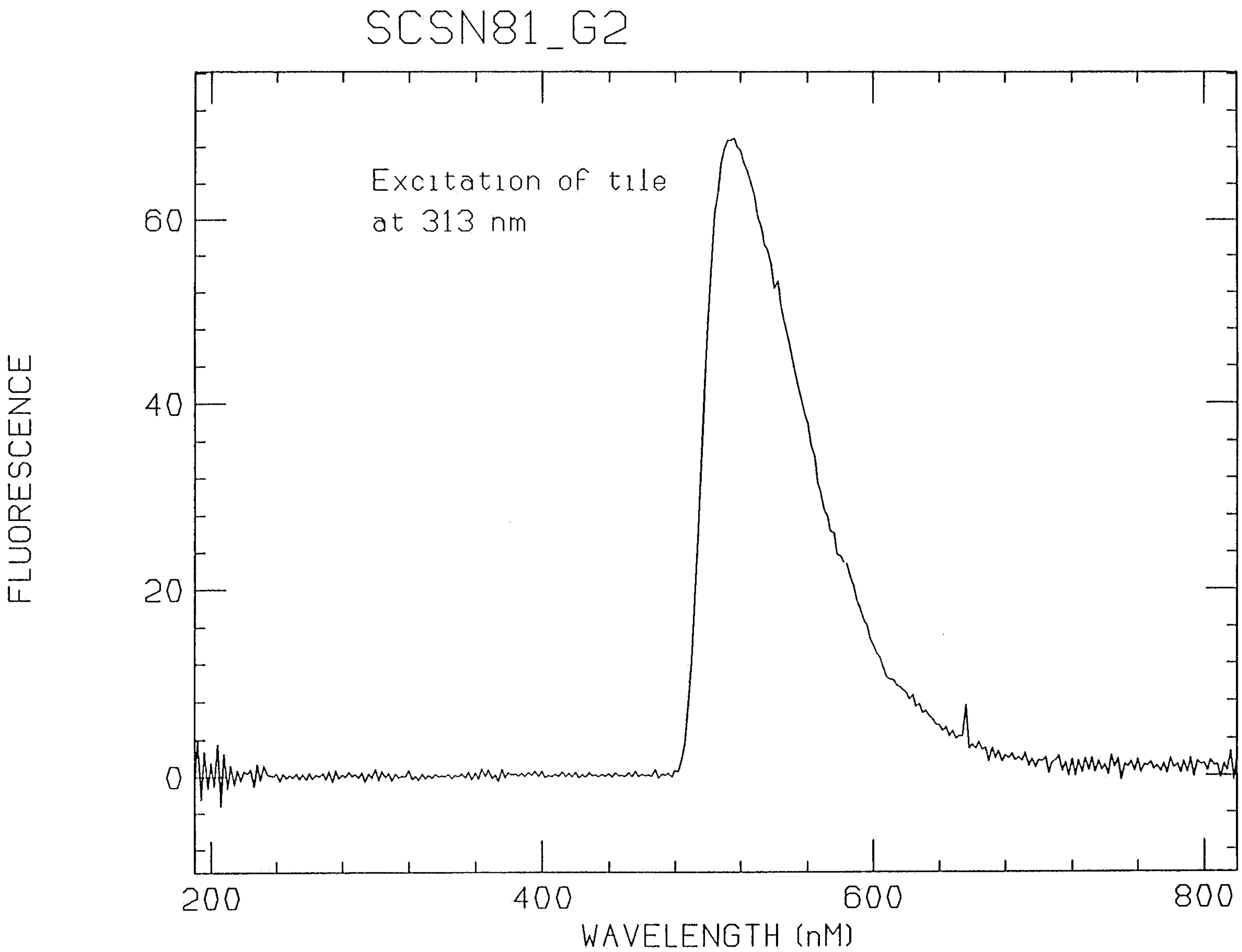

SCSN38_G2
Excitation of tile
at 313 nm
FLUORESCENCE
100
75
50
25
0
200
400
600
800
WAVELENGTH (nM)

Figure 7(b)



SCSN81_G2
Excitation of tile
at 313 nm
60
40
20
0
FLUORESCENCE
200
400
600
800
WAVELENGTH (nM)

Figure 7(c)

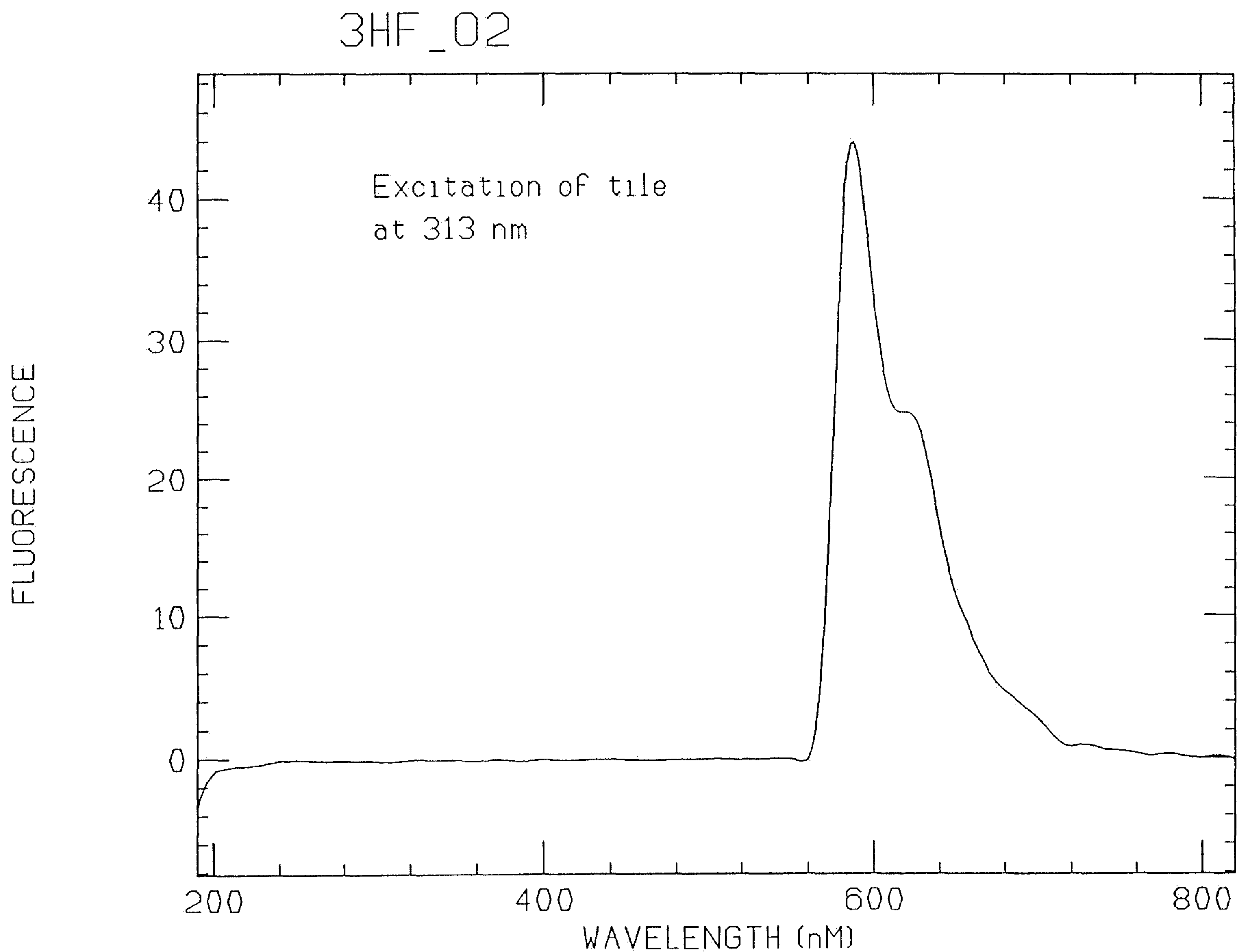

3HF_02
Excitation of tile
at 313 nm
FLUORESCENCE
0
10
20
30
40
200
400
600
800
WAVELENGTH (nM)

Figure 7(d)

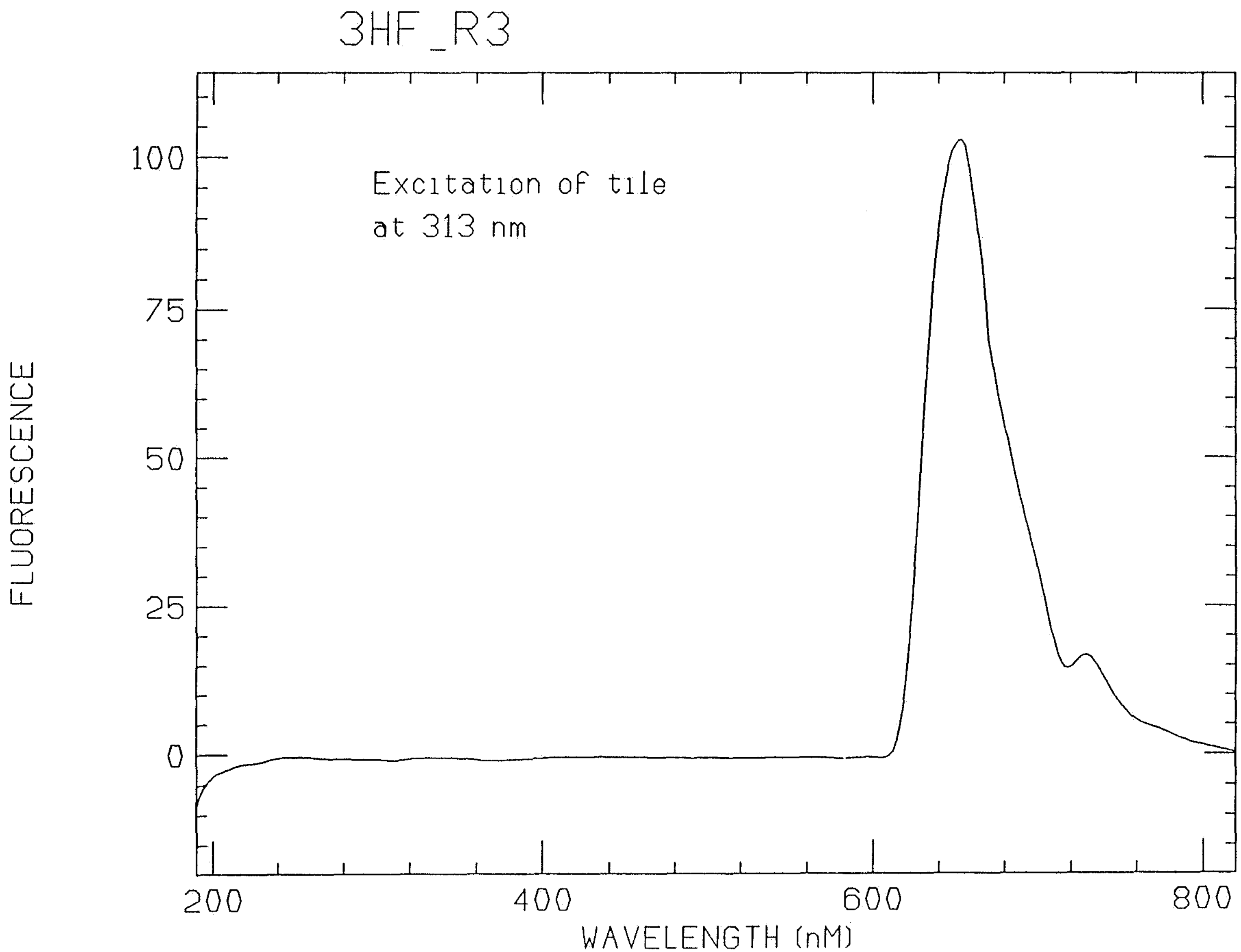

3HF_R3
Excitation of tile
at 313 nm
FLUORESCENCE
100
75
50
25
0
200
400
600
800
WAVELENGTH (nM)

Figure 7(e)