



First ICO/ICTP/TWAS Central American Workshop in Lasers, Laser Applications and Laser Safety Regulations

Optical spectroscopy: fundamentals and applications

Module: Laser and LED applications

Lecture 1, May 9, 2012 (4:30 PM – 5:30 PM)

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Content



This lecture will be divided in the following parts:

1) Fundamentals of optical spectroscopy

2) Light sources (e. g. frequency spectrum, linewidths, and tuning ranges)

3) Optical components (e.g. mirrors, prisms and gratings)

4) Spectroscopy equipment (e.g. spectrographs, monochromators, detectors)

5) Applications [Lecture 2] (physics, geophysics, biology, medicine and environmental sciences)

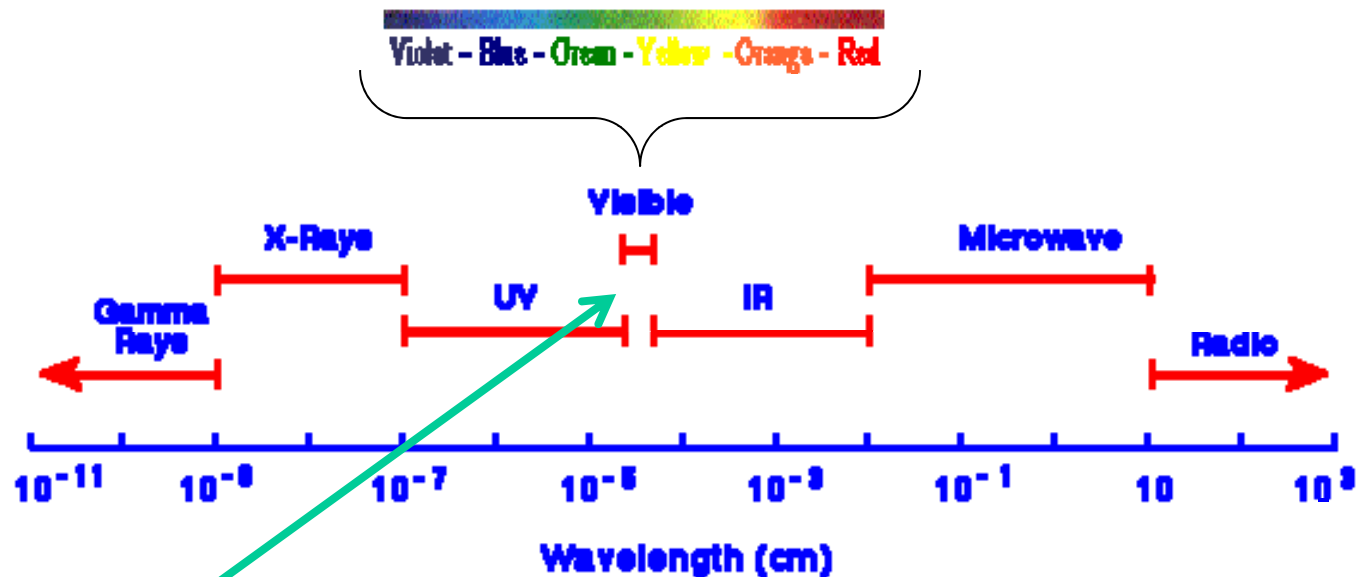


Fundamentals of optical spectroscopy



Spectroscopy:
the study of the interaction between radiation and matter

Electromagnetic spectrum:



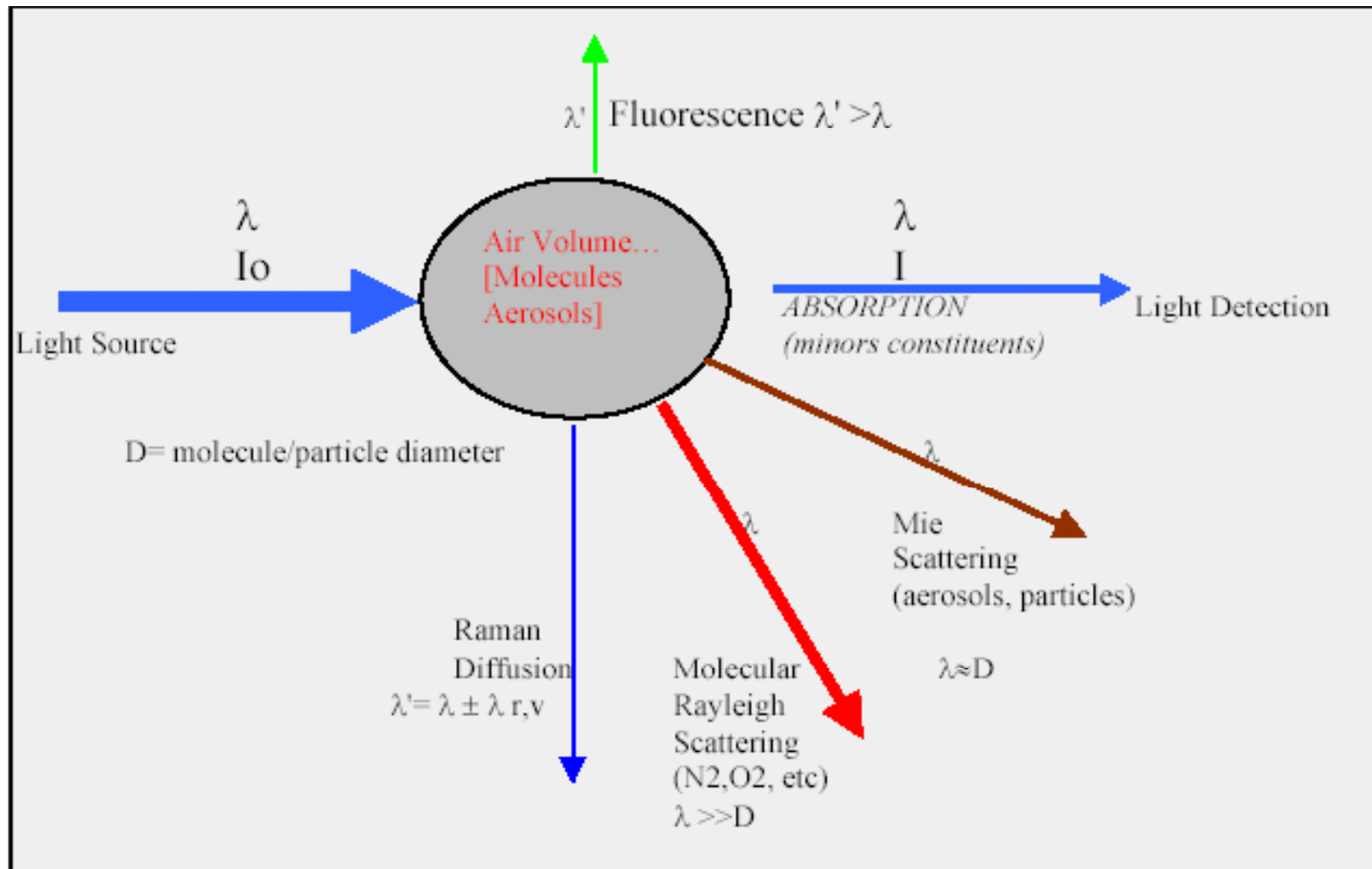
Optical spectroscopy:
When in the radiation-matter interaction the radiation is visible light



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Light-matter interaction



Balin, 1998



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Absorption and Fluorescence

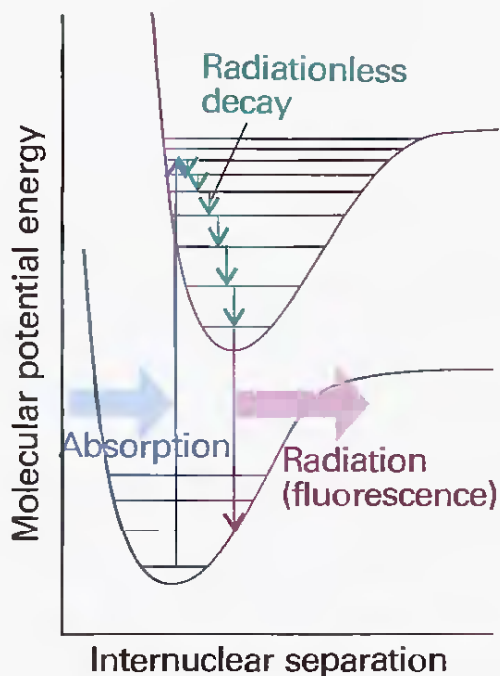


Fig. 14.21 The sequence of steps leading to fluorescence. After the initial absorption, the upper vibrational states undergo radiationless decay by giving up energy to the surroundings. A radiative transition then occurs from the vibrational ground state of the upper electronic state.

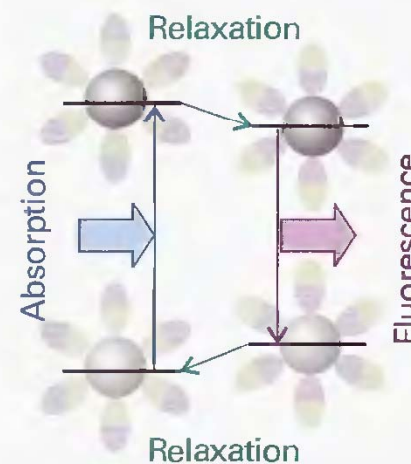


Fig. 14.23 The solvent can shift the fluorescence spectrum relative to the absorption spectrum. On the left we see that the absorption occurs with the solvent (the ellipses) in the arrangement characteristic of the ground electronic state of the molecule (the sphere). However, before fluorescence occurs, the solvent molecules relax into a new arrangement, and that arrangement is preserved during the subsequent radiative transition.

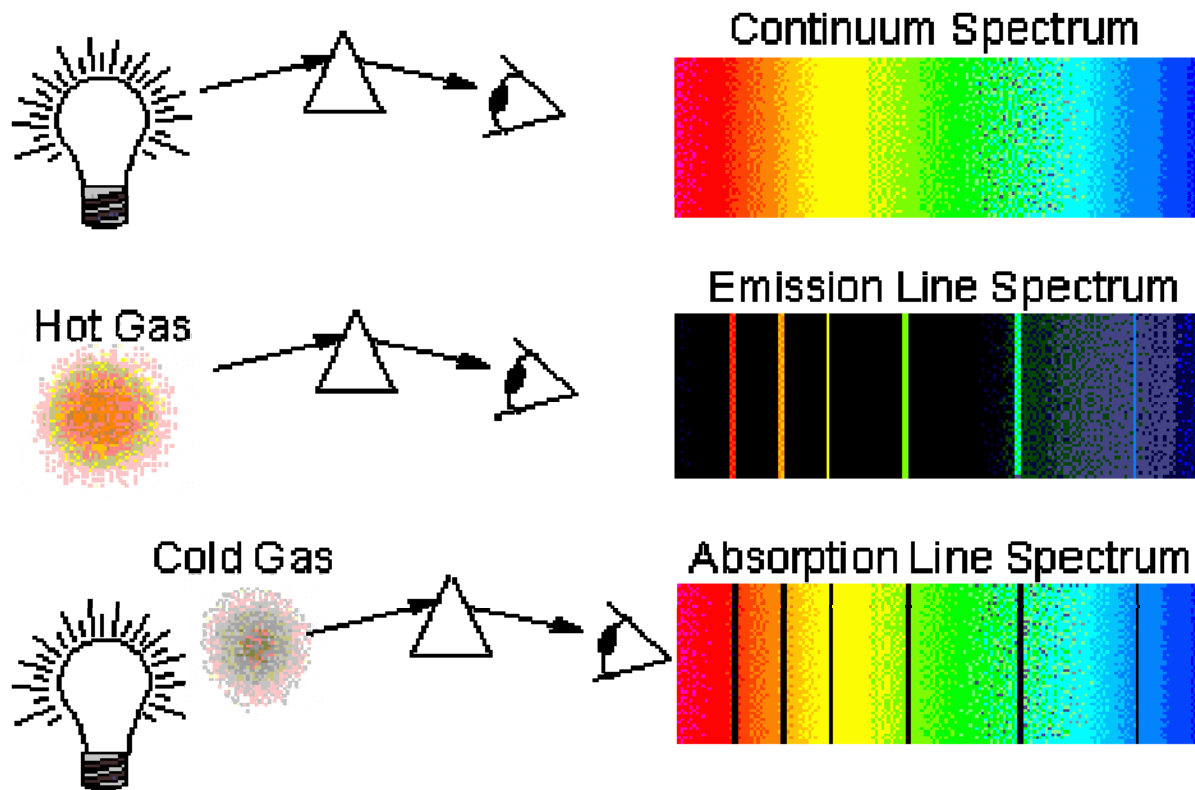
Atkins and de Paula 2006



Fundamentals of optical spectroscopy



How do we performed spectroscopy?





Fundamentals of optical spectroscopy



How can we understand continuous and line spectra?

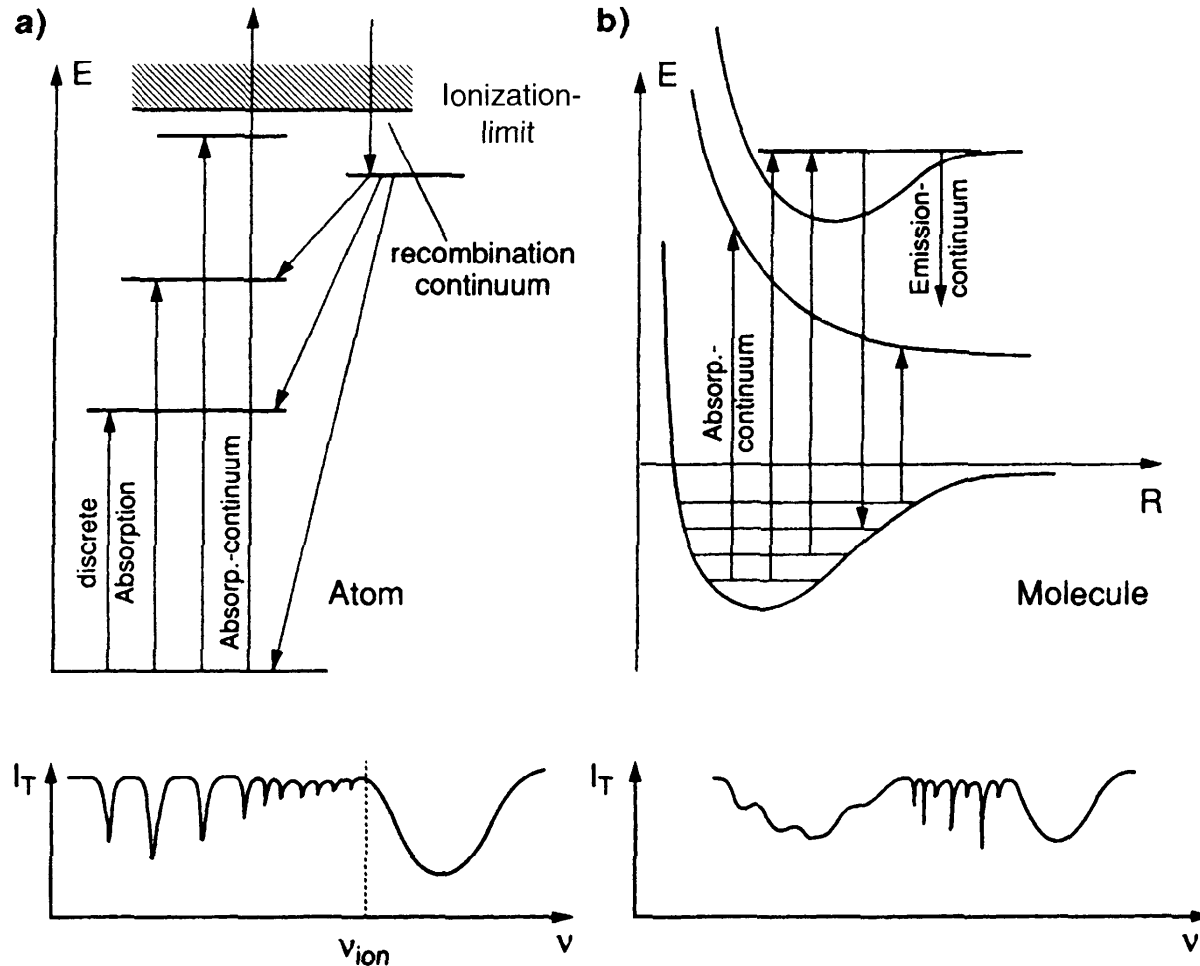


Fig. 2.11a,b. Schematic diagram to illustrate the origin of discrete and continuous absorption and emission spectra for atoms (a) and molecules (b)

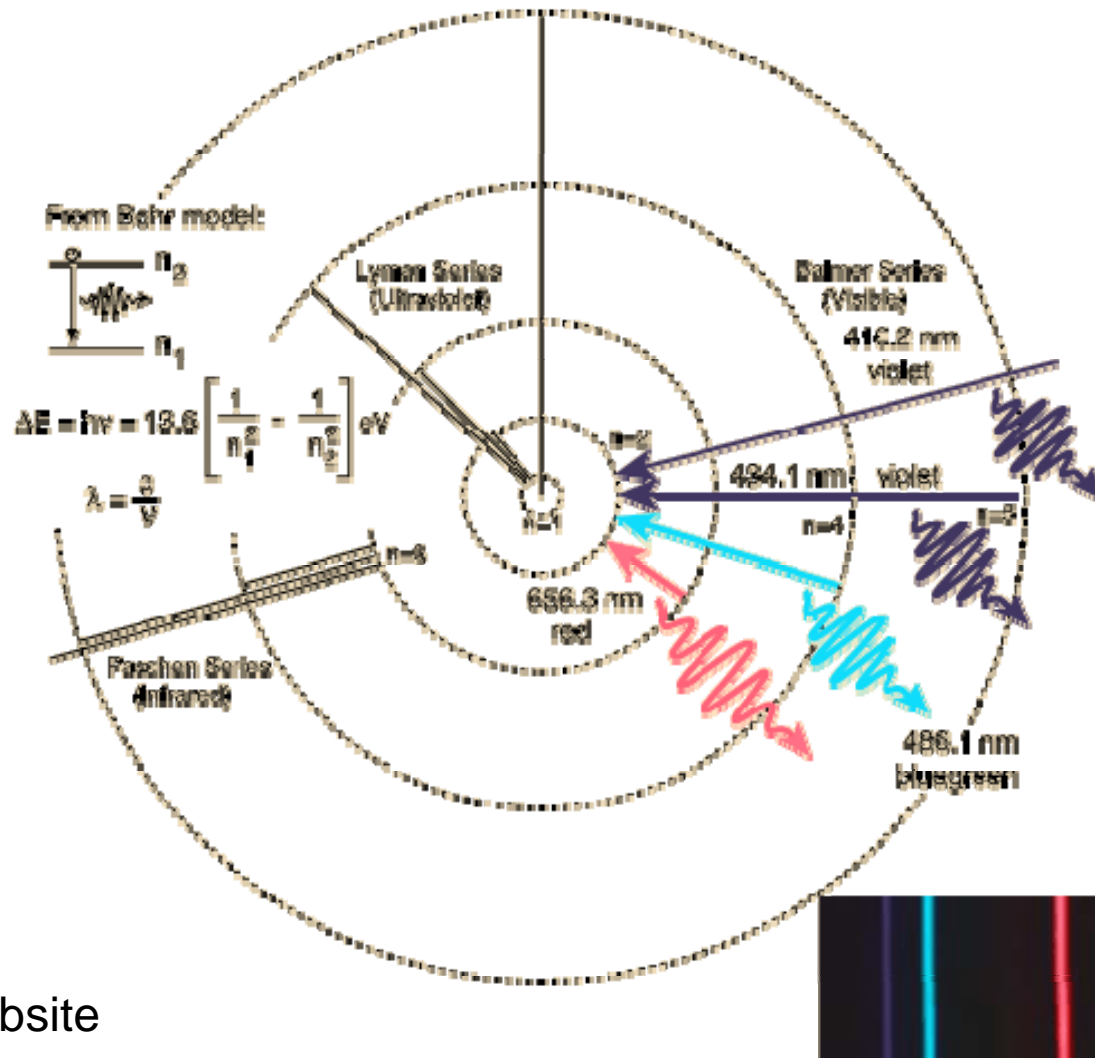
Demtröder 2003



Fundamentals of optical spectroscopy



The spectrum of atomic hydrogen:



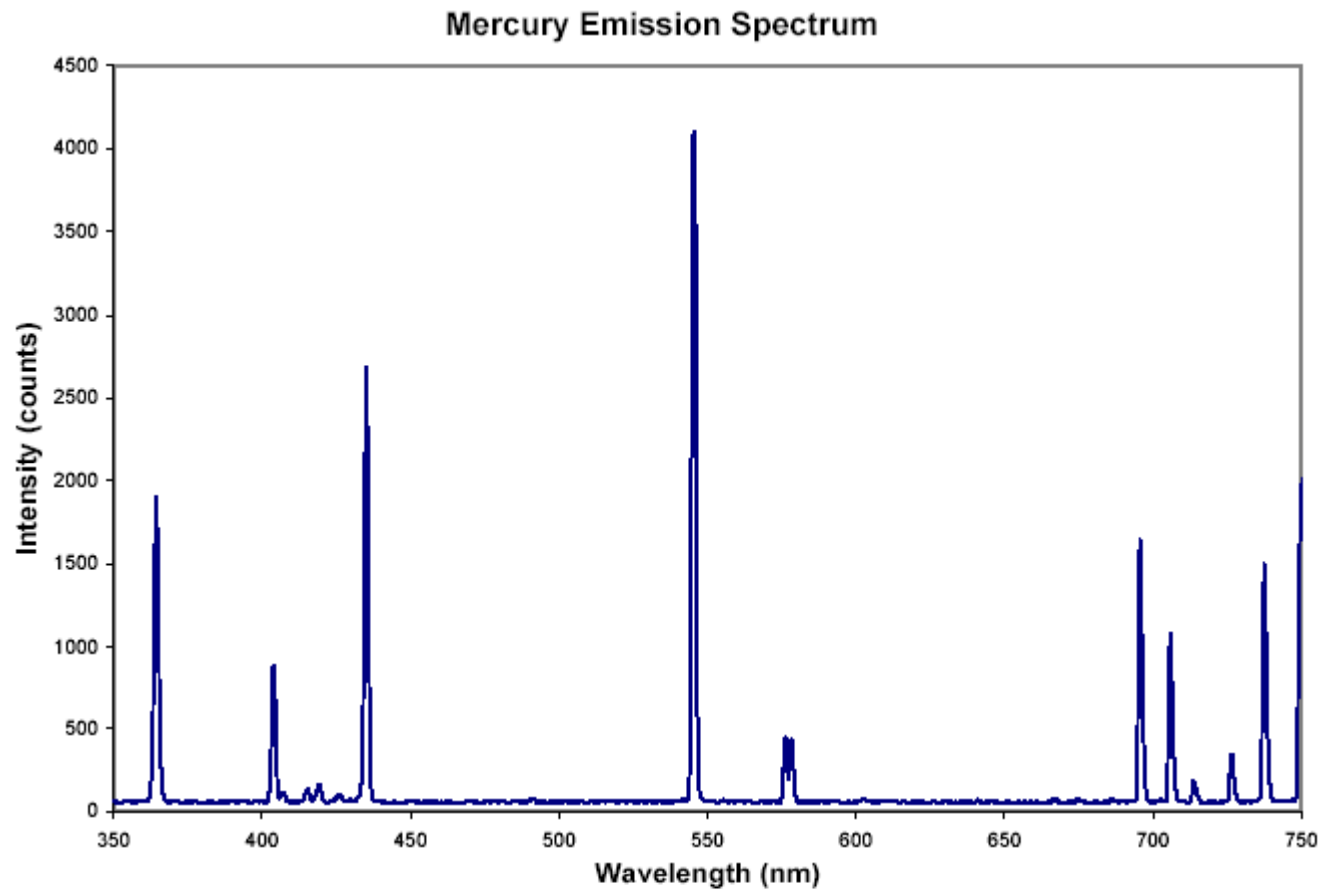
Hyperphysics website



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Nowadays:



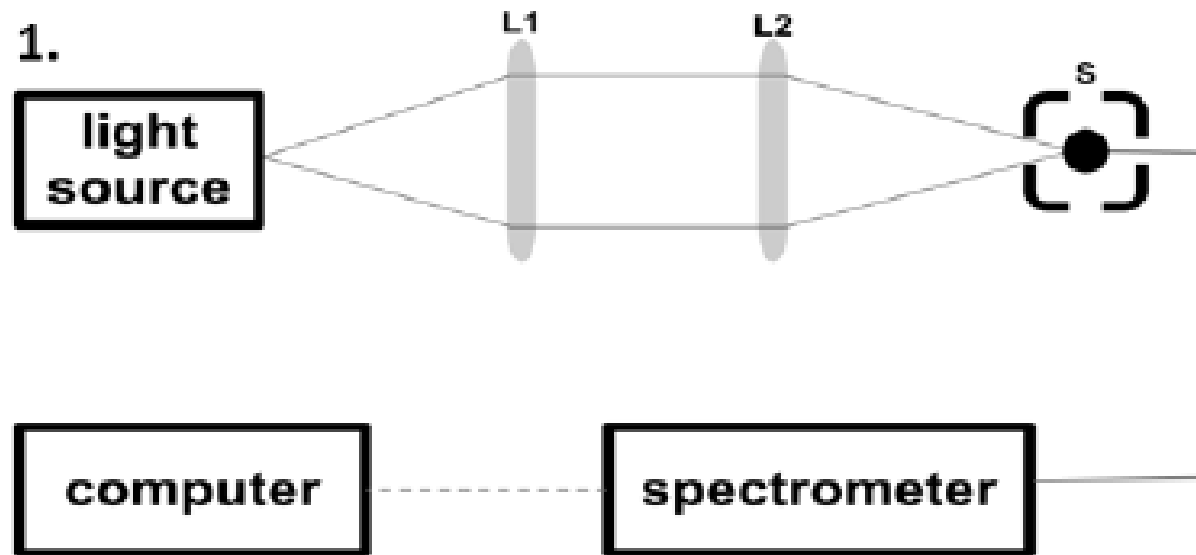


Fundamentals of optical spectroscopy



What do we need (experimental) to perform spectroscopic measurements?

Absorbance experimental setup (scheme)



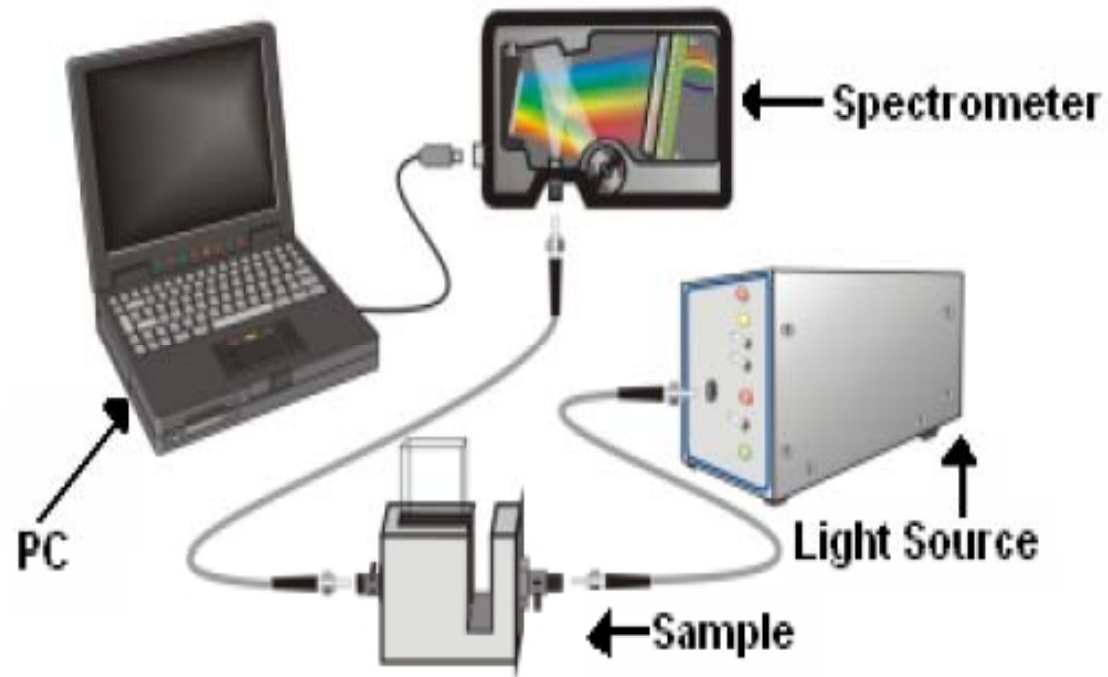
A. Pérez, et al., 2012



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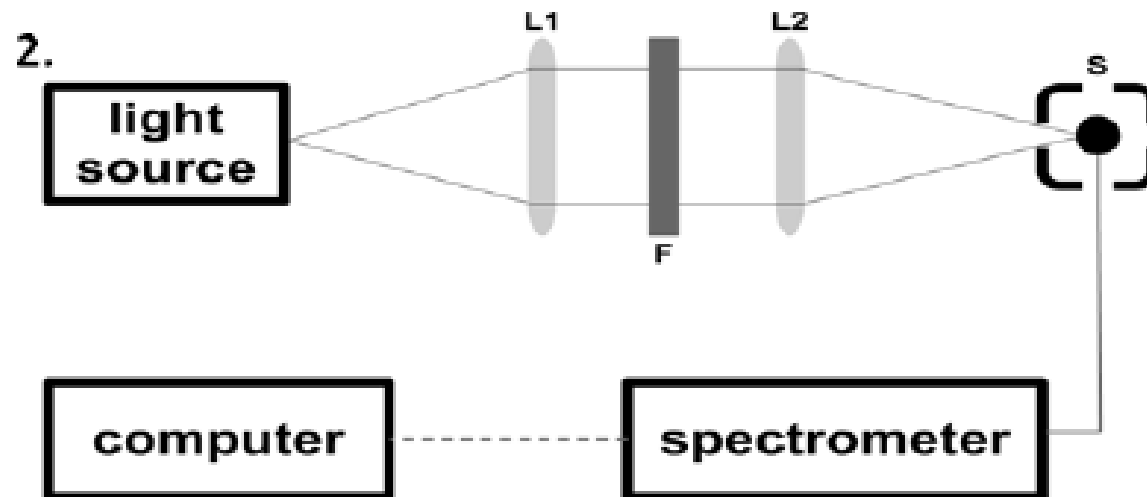
A new absorbance experimental setup



Ocean Optics website



Photoluminescence experimental setup (scheme)



We can use this setup to measure reflectivity detecting the signal in other directions!!!

A. Pérez, et al., 2012



Fundamentals of optical spectroscopy



What kind of results do we get?

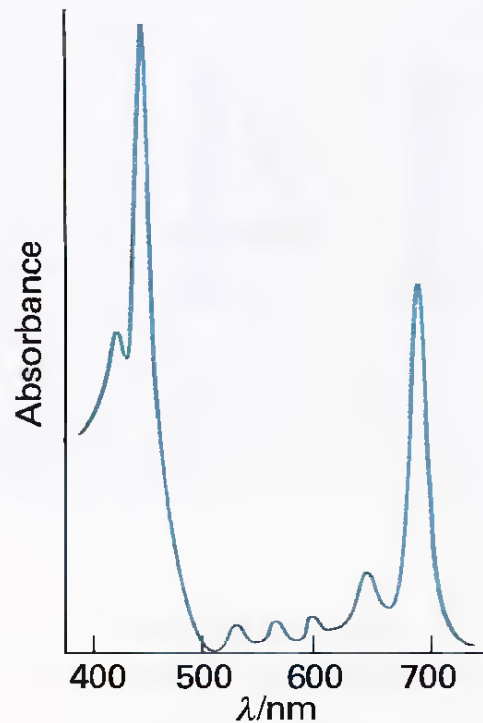
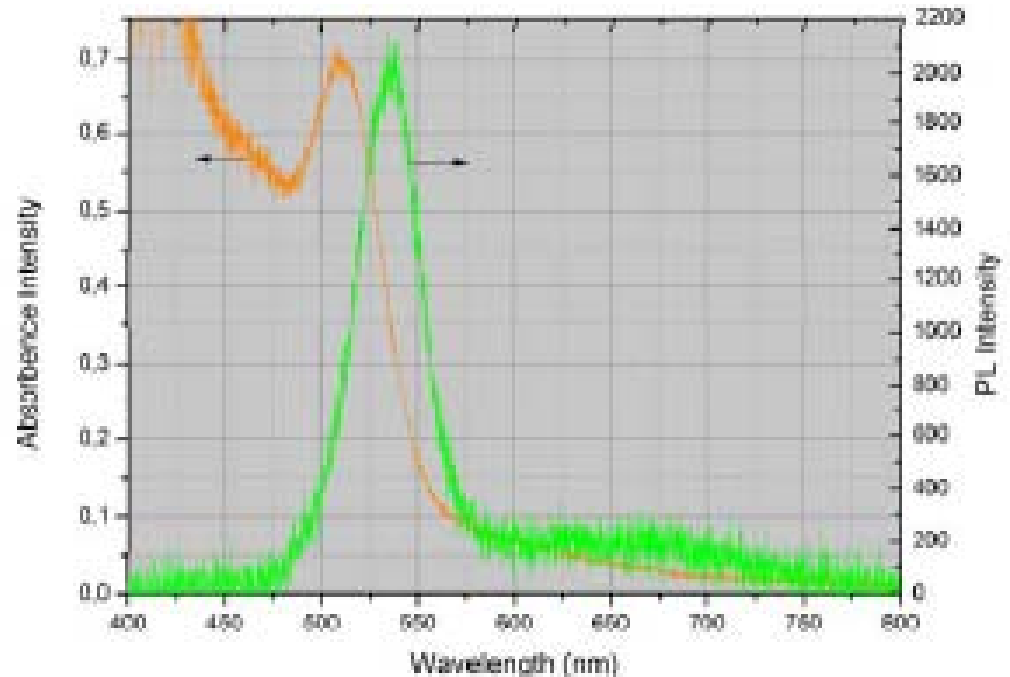


Fig. 14.1 The absorption spectrum of chlorophyll in the visible region. Note that it absorbs in the red and blue regions, and that green light is not absorbed.



M. Pacheco et al. 2011

We know the origin of these bands!!!

Atkins and de Paula 2006



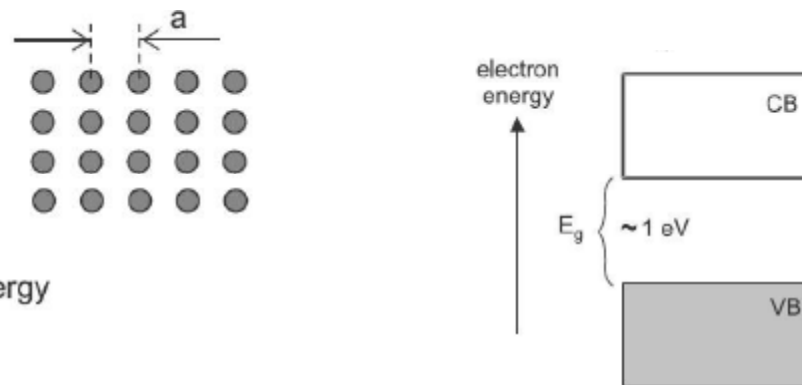
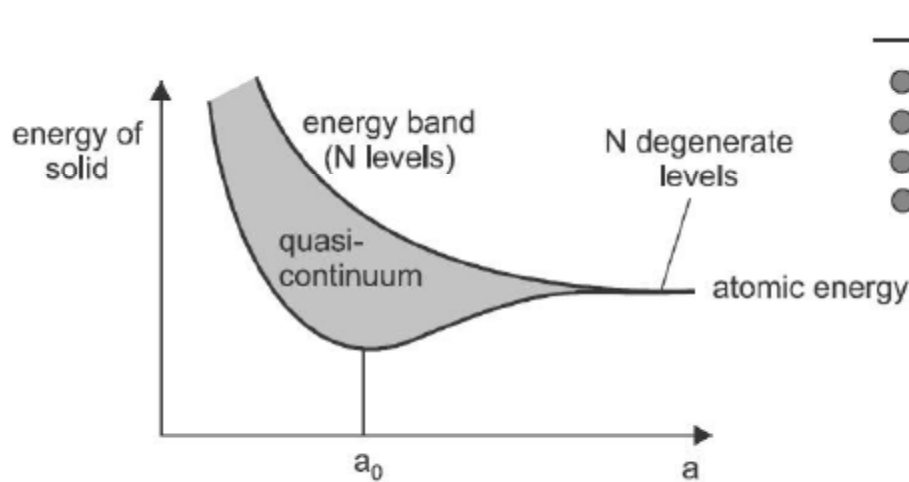
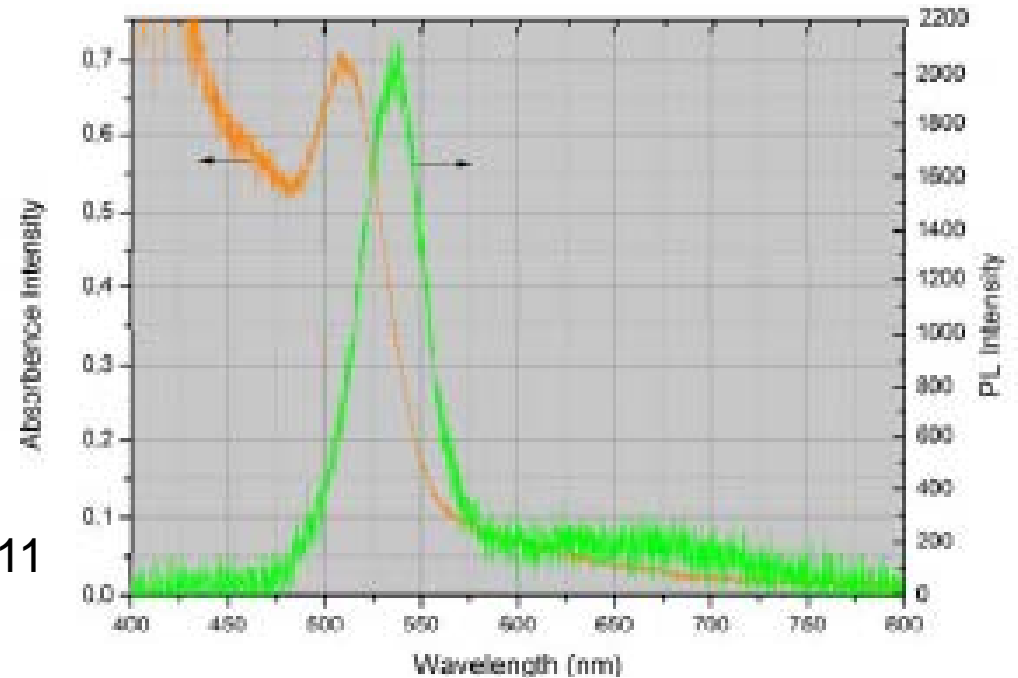
Fundamentals of optical spectroscopy



What kind of results do we get?

Absorbance and PL in semiconductor QDs

M. Pacheco et al., 2011



Quimby, 2007



Fundamentals of optical spectroscopy



What kind of results do we get?

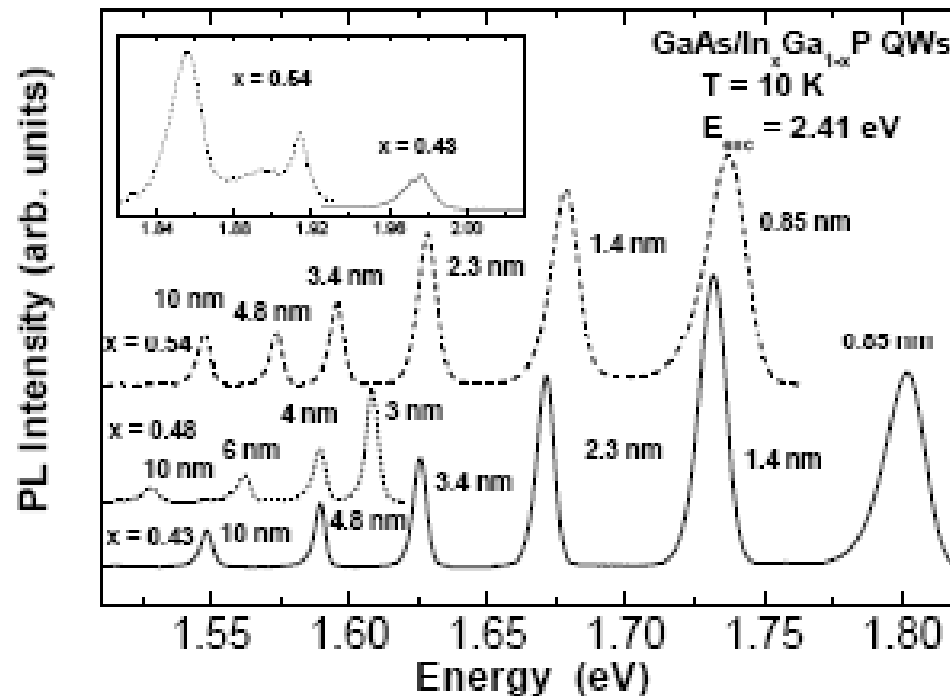


Figura 5.1: Espectros de PL de las muestras 0.54 (líneas a rayas), 0.43 (líneas continuas) y 0.48 (línea punteada). El anexo muestra la correspondiente PL de las barreras para las muestras 0.54 y 0.43.

C. Rudamas et al. 2002

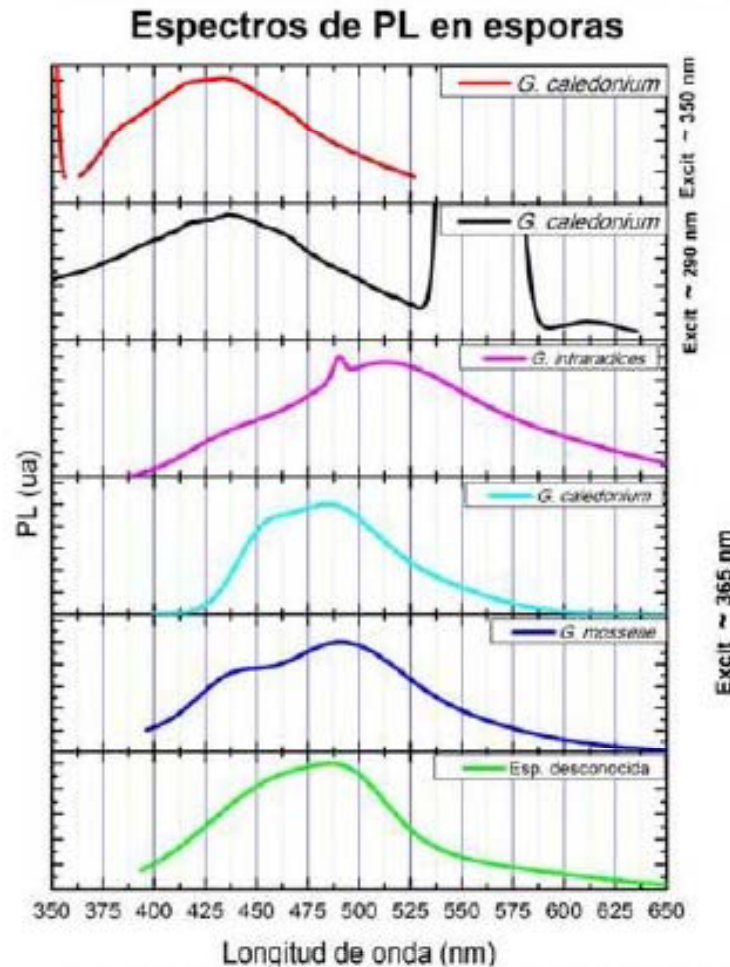
We can characterize other structures!!!



Fundamentals of optical spectroscopy



What kind of results do we get?



A. Pérez et al., 2012

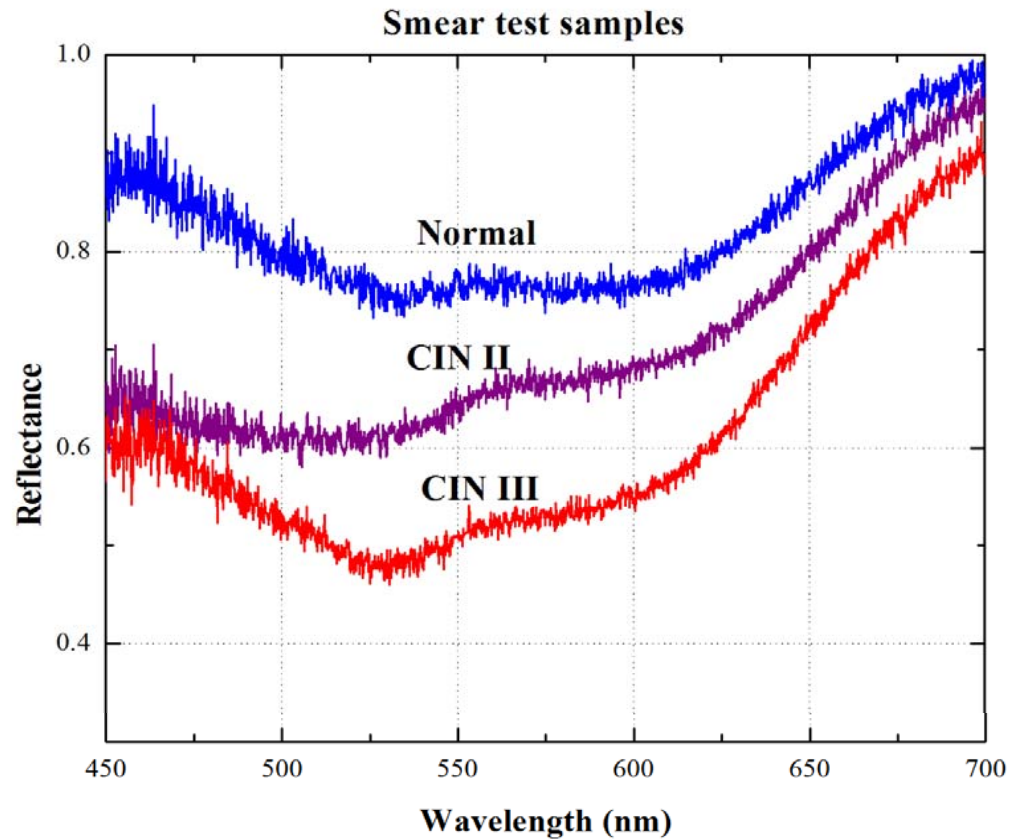
We do not know the origin of these bands!!!



Fundamentals of optical spectroscopy



What kind of results do we get?



Y. Fernández et al., 2012