26. Light Emitting Fluids

Wednesday, November 30, 2022 11:45 AM

Today: Light emitting fluids (last of dye/molecular techniques)

Recap, Dye Techniques

Want dye to have strong interaction with light, to create contrast to unseeded fluid.
How does dye, or any matter interact with light?

1) Reflection
2) Refraction
3) Diffraction
4) Absorption

For maximum absorption:

Vantablack is the trademarked name (owned by Surrey NanoSystems Limited)[1] for a chemical substance made of vertically aligned carbon nanotube arrays[2] and is one of the darkest artificial substances[3] known, absorbing up to 99.965% of radiation in the visible spectrum.[4][5]

From <https://en.wikipedia.org/wiki/Vantablack>

Vantablack S-VIS, a sprayable paint that uses randomly-aligned carbon nanotubes and only has high absorption in the visible light band, has been exclusively licensed to Anish Kapoor's studio for artistic use.[18] This has caused outrage among some other artists, including Christian Furr and Stuart Semple.

From <https://en.wikipedia.org/wiki/Vantablack#Exclusive_licence_within_arts>

Light Emitting fluids: Photons are emitted for a range of reasons.

Black Body Radiation = yellow flame color, from BBR of soot particles. Random λ (wavelength) photons from thermal energy. Has a peak, but is very broad band.

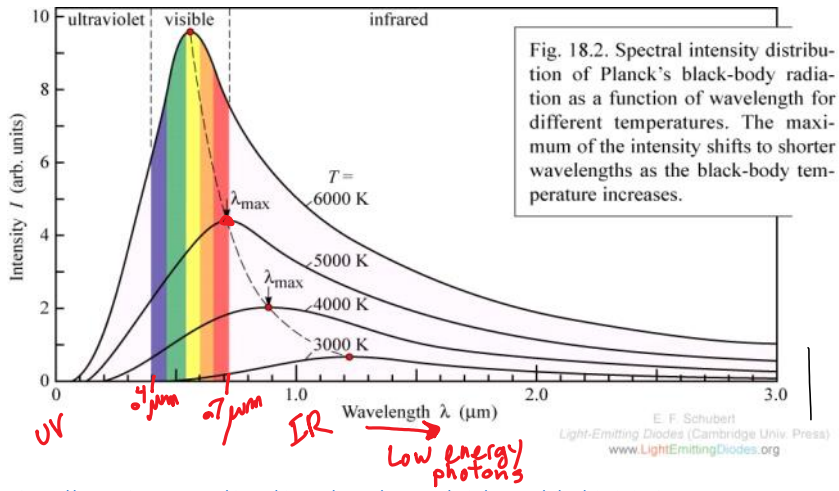
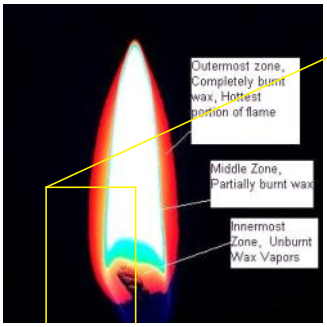
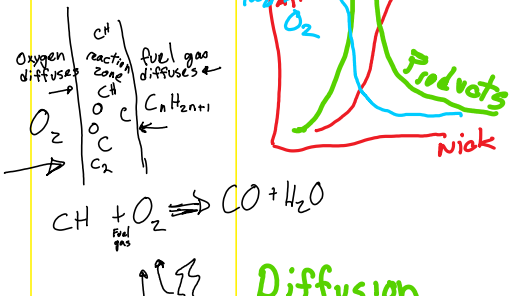


Fig. 18.2. Spectral intensity distribution of Planck's black-body radiation as a function of wavelength for different temperatures. The maximum of the intensity shifts to shorter wavelengths as the black-body temperature increases.

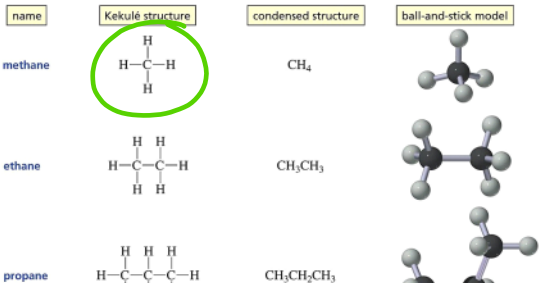
https://www.phy.questu.ca/rknop/classes/enma/2010-10/wiki/images/8/84/Black_body.jpg

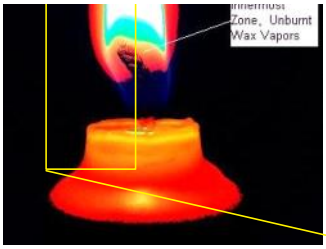
Yellow flames: candles, wood fires. Happens when fuel and air are ~~not premixed~~, when there is excess carbon. Carbon collects together into microscopic soot particles that are hot! Gives off BBR, thermal photons corresponding to temperature.

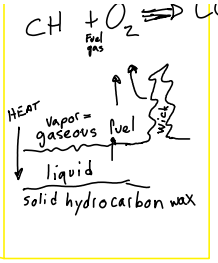




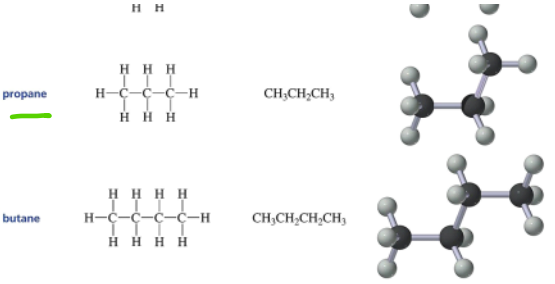
Paraffin wax = Alkane = pure hydrocarbon, hydrogen+carbon = C_nH_{2n+2} .
Wax ~ 20-40 C atoms

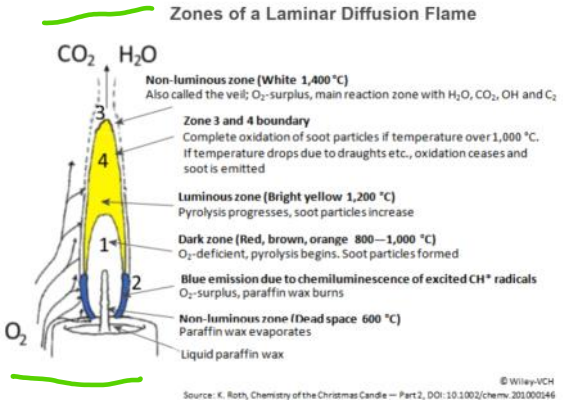






Diffusion flame VS. Premixed





Carbon Black = Soot = pure carbon

Observed Blue at bottom?
A yes
B no

https://commons.wikimedia.org/wiki/File:Alkane_4_structure.jpg

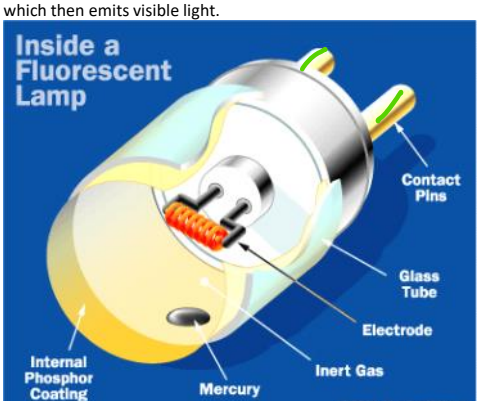
Blue Flames = reaction region. C_2 and CH radicals give off blue, high energy photons. More on this below, in chemiluminescence.

Soot - Thermal emission

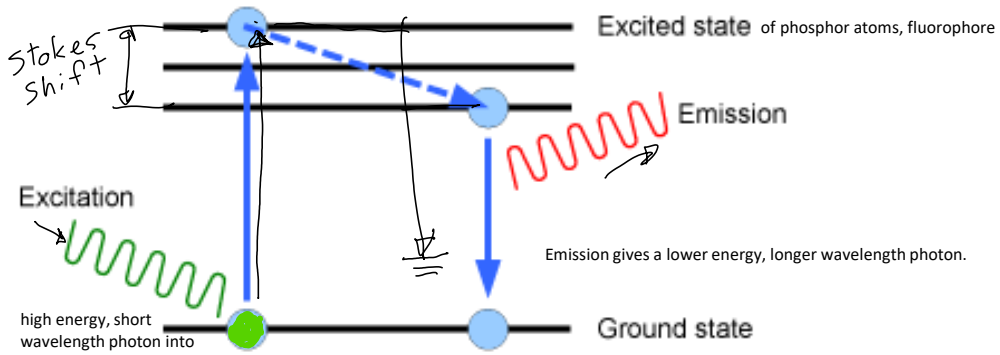
Fluorescence = absorption of photons at a specific short λ, emits at a longer λ.

E.g. some laundry detergents and fabric softeners absorb in the UV, and emit blue or orange

Fluorescent bulbs: Current is conducted through mercury vapor, energizes it to emit UV photons which hit a phosphor coating on the inside of the tube, which then emits visible light.



http://home.howstuffworks.com/fluorescent-lamp.htm/



Emission gives a lower energy, longer wavelength photon.

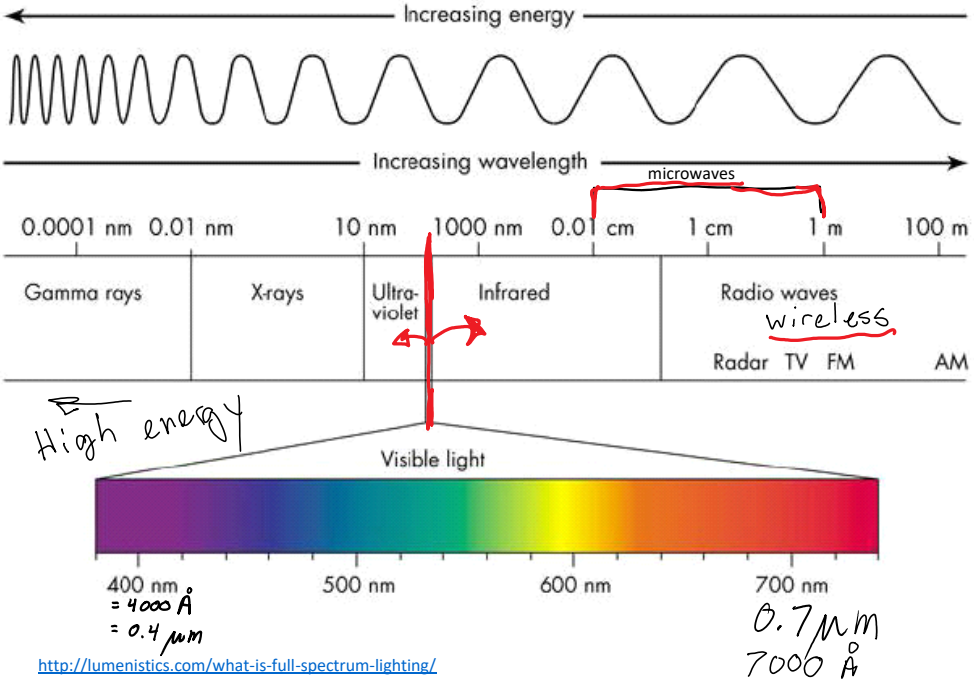
high energy, short wavelength photon into fluorophore

http://www.art.ca/en/preclinical/optical-molecular-imaging/fluorescence.php

Wavelength change between absorption and emission = Stokes shift:

- some heat lost from excited state,
- and/or returns to ground state + highest vibrational mode, not all the way down.

EM spectrum review



http://lumenistics.com/what-is-full-spectrum-lighting/

We talk about how wavelength = color, but it's really frequency and energy = color

$c = \lambda f$

$[\frac{m}{s}] \quad [m][\frac{1}{s}]$

Speed of light = wavelength x frequency
In dense media c decreases, wavelength decreases
Frequency and photon energy stays constant, color is constant.

Luminescence = cold body emission, usually at specific λ.
A general term. More specific: chemiluminescence, bioluminescence, electroluminescence

Chemoluminescence - Cyalume, party bracelets: chemical reaction releases photon, which then drives fluorescence. Needs mix of chemicals for reaction, and choice of color.
Flames: C_2, CH^+, radicals = highly reactive intermediate molecules (between reactant and product species) that only exist in the thin reaction zone. Excited by reactions, emit blue photons to get to lower energy state.
Also, hot soot gives off black body radiation; yellow glow.
https://www.aldacenter.org/outreach/flame-challenge

Burner flame

Ever seen noctiluminescent clouds
A = yes
B = no

noctiluminescent clouds

A = yes

B = no

https://www.businessinsider.com/what-is-airglow-2014-9

Airglow:
Molecules of OH, sodium and oxygen in the high (90 km) atmosphere give off characteristic photons when excited by UV light fr om the sun.

From <https://www.flowvis.org/Flow%20Vis%20Guide/dye-techniques-3-light-emitting-fluids/>

Bioluminescence - Fireflies, deep sea fish, worms. Good for flow vis?
https://www.youtube.com/watch?v=Fvob6L8q3I8 Red tide, blue waves off San Diego

https://www.nationalgeographic.com/animals/fish/group/anglerfish/

Electroluminescence - LEDs, sodium vapor, mercury vapor lamps etc. Specific λ.

E.g. electric pickle http://www.youtube.com/watch?v=tMhXCG6k6oA

Laser : population inversion, specific λ, resonant cavity with mirrors. Gas dynamic laser: after supersonic expansion, lower vibrational states relax before higher ones = inversion. A type of 'chemical laser'

More combustion examples:

http://www.flamingtornado.com/ Fire art by Nate Smith
http://www.youtube.com/watch?v=fTlW1zucWn8&list=UUj7HhOlDAW1fmoXhhPtnTEw&feature=c4-overview

BLEVE: Boiling Liquid Expanding Vapor Explosion

BLEVE (Boiling Liquid Expanding Vapor Explosion) Demonstration - How It Happens Training Video, 2009. http://www.youtube.com/watch?v=UM0jtD_OWLU&feature=youtube_gdata_player.