Problem 8

Tonic Water Glows

Under UV Light

Contents

Theory

How to glow

Stage 1: Excitation

A photon of energy hvEX is supplied by an external source such as an incandescent lamp or a laser and absorbed by the fluorophore, creating an excited electronic singlet state (S1'). This process distinguishes fluorescence from chemiluminescence, in which the excited state is populated by a chemical reaction.

Stage 2: Excited-State Lifetime

The excited state exists for a finite time (typically 1–10 nanoseconds). During this time, the fluorophore undergoes conformational changes and is also subject to a multitude of possible interactions with its molecular environment. Then, the energy of S1' is partially dissipated, yielding a relaxed singlet excited state (S1) from which fluorescence emission originates.

Stage 3: Fluorescence Emission

A photon of energy hvEM is emitted, returning the fluorophore to its ground state S0. Due to energy dissipation during the excited-state lifetime, the energy of this photon is lower, and therefore of longer wavelength, than the excitation photon hvEX. The difference in energy or wavelength represented by (hvEX – hvEM) is called the Stokes shift. The Stokes shift is fundamental to the sensitivity of fluorescence techniques because it allows emission photons to be detected against a low background, isolated from excitation photons. In contrast, absorption spectrophotometry requires measurement of transmitted light relative to high incident light levels at the same time.

Briefly

1. The energy within the light is enough for excitement.

2. The most energy used must be within light reaction.

3. The fluorescence light must be visible.

Why Tonic Water

Conjugated system

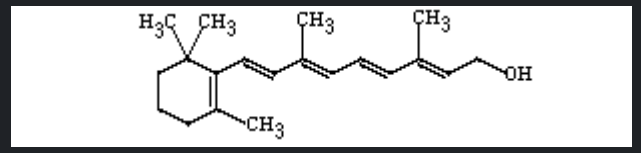
Double and triple bonds also use p-electrons in addition to a s-bond for bonding. In contrast to s-electrons, which are characterized by the rotational symmetry of their wave function with respect to the bond direction, p-electrons are characterized by a wave function having a node at the nucleus and rotational symmetry along a line through the nucleus. . p-bonds are usually weaker than s-bonds because their (negatively charged) electron density is further from the positive charge of the nucleus, which requires more energy.

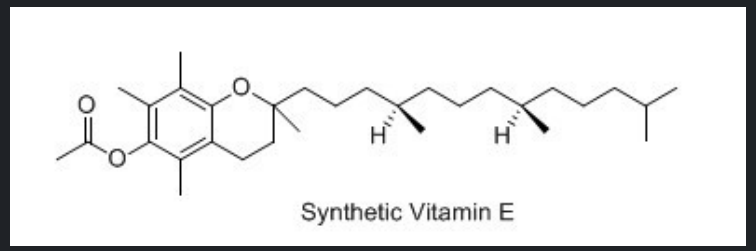
From the perspective of quantum mechanics, this bond weakness is explained by significantly less overlap between the component p-orbitals due to their parallel orientation. These less strongly bound electrons can be excited by photons with lower energy. If two double bonds are separated by a single bond, the double bonds are termed conjugated. Conjugation of double bonds further induces a red-shift in the absorption

Briefly

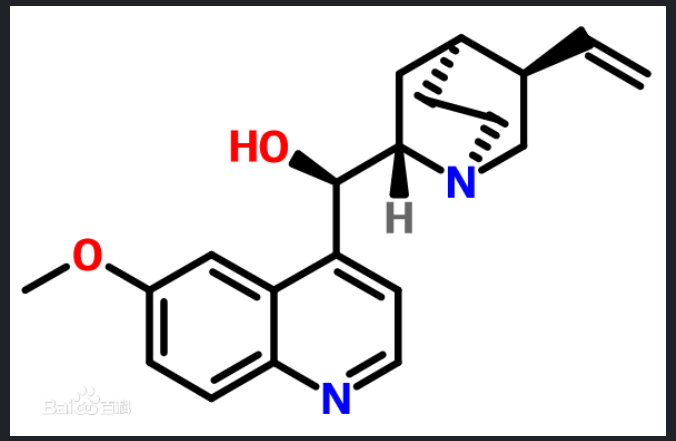
1) The conjugated system can absorb more light that has longer wavelength. Thus, the fluorescence light is visible.

Class			Freq-uency	Wave-length	Energy
Ionizing radiation	γ	Gamma rays	300 EHz	1 pm	1.24 MeV
	HX	Hard X-rays	30 EHz	10 pm	124 keV
	SX	Soft X-rays	3 EHz	100 pm	12.4 keV
	EUV	Extreme ultraviolet	300 PHz	1 nm	1.24 keV
	NUV	Near ultraviolet	30 PHz	10 nm	124 eV
Visible			3 PHz	100 nm	12.4 eV
	NIR	Near infrared	300 THz	1 μm	1.24 eV
	MIR	Mid infrared	30 THz	10 μm	124 meV
	FIR	Far infrared	3 THz	100 μm	12.4 meV
Micro-waves and radio waves	EHF	Extremely high frequency	300 GHz	1 mm	1.24 meV
	SHF	Super high frequency	30 GHz	1 cm	124 μeV
	UHF	Ultra high frequency	3 GHz	1 dm	12.4 μeV
	VHF	Very high frequency	300 MHz	1 m	1.24 μeV
	HF	High frequency	30 MHz	10 m	124 neV
	MF	Medium frequency	3 MHz	100 m	12.4 neV
	LF	Low frequency	300 kHz	1 km	1.24 neV
	VLF	Very low	30 kHz	10 km	124 peV



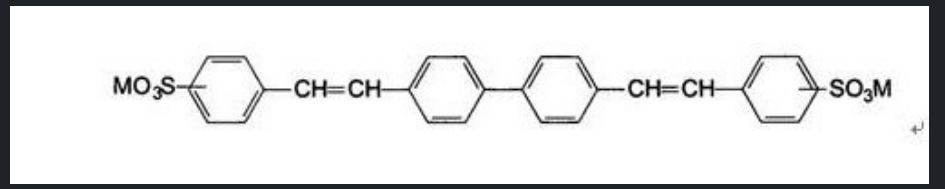


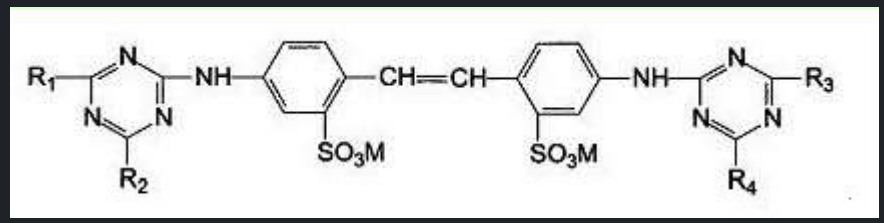
Vitamin A&E



Quinine

Plenty in Tonic Water





Synthetic fluorescer

All the substance above has the conjugated system. Therefore, not only Tonic Water, but any substance that conjugated system dominates its structure can glow, including Vitamin A & E.

Experiments

UV Light – 365nm

Tonic Water glows Brightly.

Then we try to find out what will influence the glowing effect. We set one dish for experiment and another for comparison.

Acidity & Basicity

H_2SO_4 (PH=1)

Apparently brighter

PH=7 by NaOH

Visibly Dimer

$Ca(OH)_2$ (PH=14)

Apparently Dimer

Na+ & Cl-

NaCl

Obviously Much Dimer

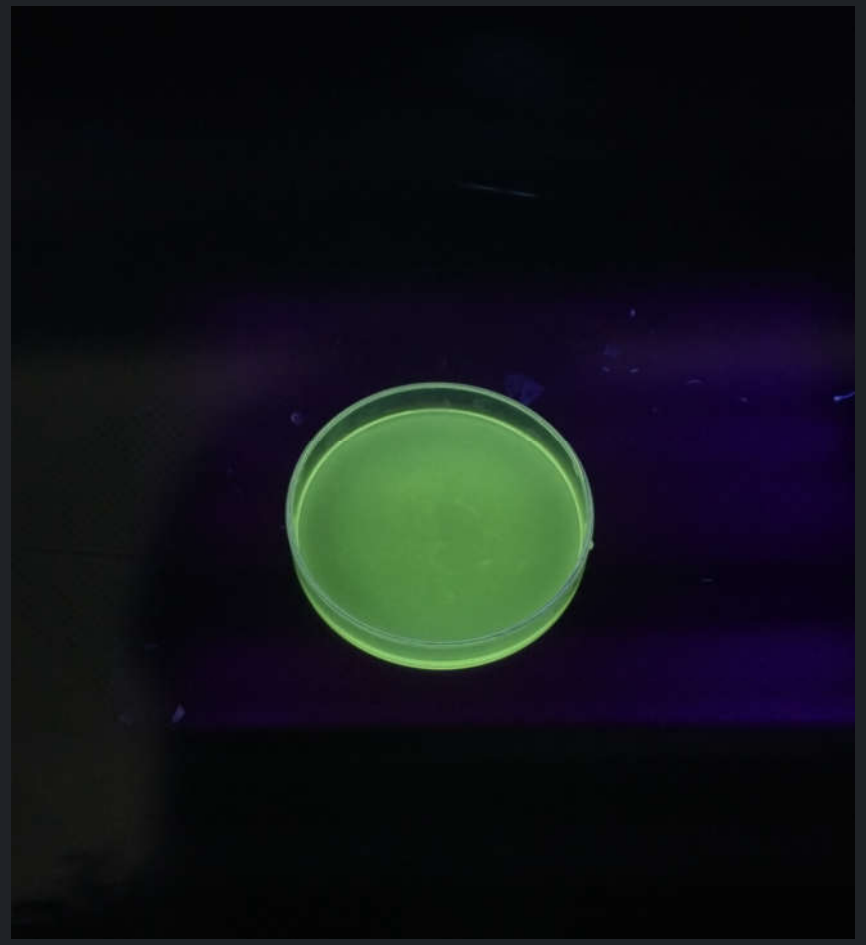
HCl

Obviously Much Dimer

NaOH (PH=9)

Not greatly influenced

Further Thinking: Vitamin A & E

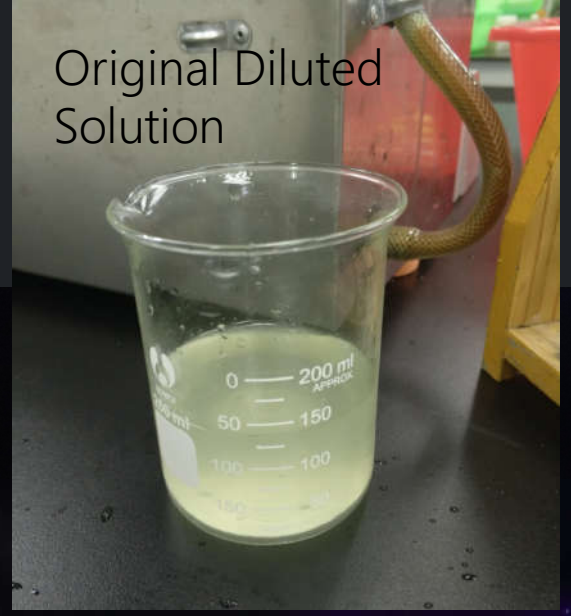


UV - 300nm

Concentration

Concentrated
A lot brighter

535



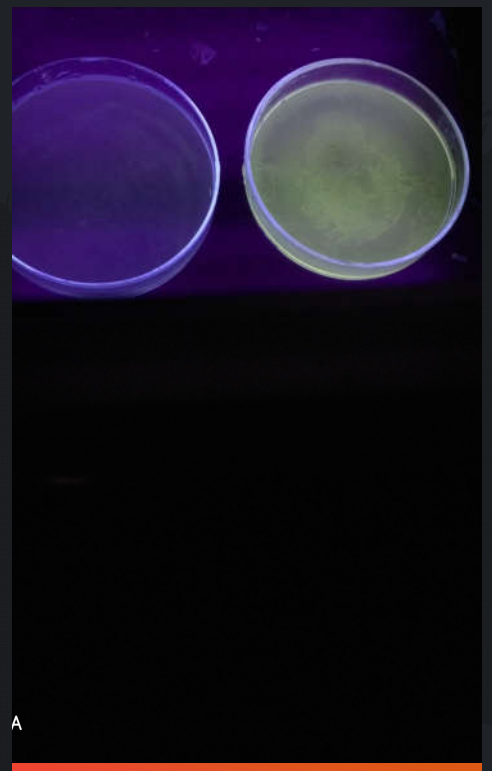
Diluted
Much dimer

535

Acidity & Basicity

H_2SO_4 (PH=1)

PH=7 By NaOH



NaOH

Cl-’s influence

KCl

535

NaCl

535

Results

Thanks for your listening