CEMA-CC-4-8-TH

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Infrared Spectroscopy: Basic concepts

An important tool of the organic chemist > Information about the Functional group present in molecule

Electromagnetic (EM) wave range:



Wavelength relationships:

Wavelength(λ): The distance wave travels in one complete cycle of wave propagation. Unit: cm or nm. Can be measured as the distance between any two points with the same phase.



Frequency(v): the number of complete cycle of the wave propagation in one second Unit: $Hz = sec^{-1}$.

Speed(c): distance travelled in one second. Unit: cm.sec⁻¹

(For every electromagnetic waves, the speed is same as that of light $c = 3X10^{10}$ cm/sec)

 $c = \lambda * v$ or $v = c/\lambda$

Energy of radiation, E = hv ($h = Plank's \ constant$) = $h \ c/\lambda$ = $h \ c \ \tilde{v} \ (\tilde{v} = wavenumber = 1/\lambda)$

An increase in Wavenumber directly proportional to increase in Energy of radiation

Infrared (IR) refers to that part of the electromagnetic spectrum between the visible and microwave regions.

IR region = $4000 - 400 \text{ cm}^{-1}$.

The cm^{-1} unit is the wavenumber scale and is given by 1 / (wavelength in cm).

IR radiation can interacts with the vibrations of covalent bonds within molecule.

When the radiant IR energy matches the energy of a specific molecular vibration, absorption occurs. That raise the molecule to more excited vibrational level. The number of vibrational bands occur depends on the no. of different vibrational modes possible. These vibrations include the stretching and bending modes.

In practice, not all modes are reflected in the spectrum, only the major ones could be seen.

The no. of modes of vibrations are more for non-linear molecules, than for linear molecules.



For non-linear molecules like H₂O several possible stretching and bending modes are shown above.

For linear molecules:

Stretching and bending modes of vibrations are shown here for CO₂:



symmetrical stretching

scissoring (bending in the plane of the paper)

For symmetrical stretching there will not be any change in dipole moment for CO_2 .

For asymmetrical stretching, there is net change in dipole moment in the molecule, thus make it IR active. [Although the net dipole moment said to be zero for this molecule]

So, CO_2 gives a strong band in the IR at 2350 cm⁻¹. You may notice this band in Background spectra which you run on the instruments.

Note: For a molecule to absorb IR, the molecule's vibrations must cause fluctuations in the dipole moment of the molecule because, the electromagnetic radiation can only interact with another electric field, caused from changing dipole moment for absorption to occur.

Thus, H_2 , N_2 , O_2 , Br_2 , etc. are all IR inactive because of no change in dipole moments while vibrating. HCl, HBr, IBr they are IR active compounds.

In practice, it is the **polar covalent bonds** are IR "active" and their excitation can be observed in an IR spectrum. The **polar covalent bonds** are present in the **Functional groups** of the organic molecules.

We will get different IR bands depending on the kind of functional groups that are present in the organic molecule.

A typical IR spectrum, in the X- axis the wavenumbers in cm⁻¹ is plotted, is proportional to energy. The y-axis is plotted as % Transmittance (%T). An absorption of radiant IR energy is therefore represented by a "trough" or like "inverted peak" in the curve.



4000-1500 cm⁻¹ known as the Functional group region. To interpret an IR spectrum, the first information is obtained from the functional group region, < 1500 cm⁻¹ known as the Fingerprint region, less polar single bond vibrations appear here. The *fingerprint region*, the spectra tend to be more complex and much harder to assign. But, some characteristic bands are important for skeletal structure of the molecule.

- Recall that when bond order increases, also increases bond strength.
- Stronger the bond, more energy required for stretching, higher the wavenumber.
 C-C bonds: C-C (1000 cm⁻¹), C=C (1600 cm⁻¹) and C°C (2200 cm⁻¹),
 C-H bonds: C-C-H (2900 cm⁻¹), C=C-H (3100 cm⁻¹) and C≡C-H (3300 cm⁻¹)
- Recall the atoms size trend. In the periodic table atoms size increases.
- For heavier atoms attached, easy to vibrate, less energy required, lower the wavenumber. As examples of this,
 - $\begin{array}{l} \textbf{C-H} & (3000 \ cm^{-1}) \\ \textbf{C-C} & (1000 \ cm^{-1}) \\ \textbf{C-Cl} & (800 \ cm^{-1}) \\ \textbf{C-Br} & (550 \ cm^{-1}) \\ \textbf{C-I} & (about \ 500 \ cm^{-1}) \end{array}$

Considering ball and spring model for a covalent bond, flexible bonds and heavier atoms attached to it are easier to vibrate



HOW TO ANALYZE YOUR SPECTRUM???

Get a Big Picture	e first, draw some lines at 3000, 2500, 2000, 1500 cm ⁻¹ .		
•Above 3000 cm ⁻¹	Single hydrogen bonds attached to O, N, sp C or sp ² C		
	(i.e. N-H > O-H> ≡C-H> =C-H)		
•3000-2500	Single bond C-H (sp ³ C –H) stretching, Aldehydic C-H stretching		
•2500-2000	C≡C, C≡N triple bond stretching		
•2000-1500	C=O (~1700) ; C=C and N=O,(~1600) , Aromatic C=C (~ 1600)		
•Under 1500	[Fingerprint region] C-H and N-H bending *; C-O, C-X, C-C stretching		
	* N-H bending is in between 1550-1640 cm ⁻¹		

• Some functional groups can be "viewed" as combinations of different bond types in spectrum Example: Ester RCOOR (like carbonyl and ether), Acid RCOOH (like carbonyl and hydroxy).



Alkenes: The compounds that have a carbon-carbon double bond. So, it will have C=C stretch from 1680-1640 cm⁻¹ and =C–H stretch from 3100-3000 cm⁻¹ (not need to assign bending modes)



Alkynes: Alkynes are compounds that have a carbon-carbon triple bond (-C=C-). The $\equiv C-H$ (sp C-H) appear near 3300 cm⁻¹ as strong band for 'terminal alkynes' and not for the 'internal alkynes' since they lack of it.

The –C≡C– stretch appears as a weak band from 2260-2100 cm⁻¹



Aromatics/ Arenes: The =C–H stretch in aromatics is observed at 3100-3000 cm⁻¹ (sp²C-H). The C=C in ring stretch absorption appear in pair around 1600 cm⁻¹ and 1475 cm⁻¹.

- Characteristic "Overtones" or the combination of weak bands appear b/w 2000-1665 cm⁻¹.
- Characteristic C-H out of plane bending ("oop") appear b/w 690-900 cm⁻¹.
- These two type of characteristic peaks could be used to find out the aromatic ring substitution pattern (ref: "Intro to spec... by Pavia, page 44, will discuss later!)



Alcohols: Alcohols have characteristic IR absorptions associated with both the O-H and the C-O stretching vibrations.

O–H stretch around 3500-3300 cm⁻¹ : broad and strong peak because of intermolecular hydrogen bonding

C–O stretch 1260-1030 cm⁻¹ : (phenol > 3° > 2° >1°)

(1220) (1150) (1100) (1050) in cm⁻¹



Example:



Amines: The N–H stretches of amines are in the region 3500-3300 cm⁻¹. These bands are weaker and sharper than those of the alcohol O–H stretches which appear in the same region.

In primary (1°) amines (RNH_2), there are two bands in this region, the asymmetrical N–H stretch and the symmetrical N–H stretch.

Secondary (2°) amines (R₂NH) show only a single weak band in the 3300-3000 cm⁻¹ region, since they have only one N–H bond.

Tertiary amines (R₃N) do not show any band in this region since they do not have an N–H bond.



Carbonyl Compounds: C=O absorb from 1850-1650 cm⁻¹ depending on its type of functionality and conjugation. In practice: Esters > Aldehyde > Ketone > Amide

1735 1720 1700 1680 Carboxylic Acid 1730-1700

C=O peak is always very strong and sharp due to polarity of this bond compared to C=C which is weaker.

Factors that mainly affect the wavenumbers for C=O are:

- 1. Electron donating or withdrawing effect
- 2. Resonance or conjugation effect
- 3. Ring strain effect for cyclic compounds

Aldehydes (-CHO):

H–C=O stretch appear at 2830-2695 cm⁻¹ in pair
 C=O stretch: aliphatic aldehydes 1740-1720 cm⁻¹
 Conjugated aldehydes 1710-1685 cm⁻¹



Ketones:

C=O appear at 1700-1720 cm⁻¹ for normal aliphatic ketones. Conjugated ketone absorbs at 1680-1700 cm⁻¹



Carboxylic acids: Shows a strong, wide band for the O–H stretch in the region 3300-2500 cm⁻¹. Unlike the O–H stretch band observed in alcohols, the carboxylic acid O–H stretch appears as a very broad band, a somewhat "messy" absorption, with the broad O–H band superimposed on the sharp C–H stretching bands. **C=O stretch from 1760-1690 cm⁻¹**

C–O stretch from 1320-1210 cm⁻¹



Esters: The carbonyl stretch C=O of aliphatic esters appears from 1750-1735 cm⁻¹; that of conjugated esters appears from 1730-1715 cm⁻¹. The C–O stretch from 1300-1000 cm⁻¹ and for esters C-O is also very strong band.





Expt 1: IR of Acetanilide





IR of Trimyristin



Bond	Type of bond	Specific type of bond	Absorption peak cm ⁻¹ (nm)	Appearance
			1260 cm ⁻¹ (7937 nm)	strong
		methyl	1380 cm ⁻¹ (7246 nm)	weak
			2870 cm ⁻¹ (3484 nm)	medium to strong
	-111		2960 cm ⁻¹ (3378 nm)	medium to strong
	ацкуї		1470 cm ⁻¹ (6803 nm)	strong
		methylene	2850 cm ⁻¹ (3509 nm)	medium to strong
			2925 cm ⁻¹ (3419 nm)	medium to strong
		methine	2890 cm ⁻¹ (3460 nm)	weak
			900 cm ⁻¹ (11111 nm)	strong
		C=CH ₂	2975 cm ⁻¹ (3361 nm)	medium
С—Н	<u>vinyl</u>		3080 cm ⁻¹ (3247 nm)	medium
		C=CH	3020 cm ⁻¹ (3311 nm)	medium
		monosubstituted alkenes	900 cm ⁻¹ (11111 nm)	strong
			990 cm ⁻¹ (10101 nm)	strong
		cis- <mark>d</mark> isubstituted alkenes	670–700 cm ⁻¹ (14286-14925 nm)	strong
		trans-disubstituted alkenes	965 cm ⁻¹ (10363 nm)	strong
		trisubstituted alkenes	800-840 cm ⁻¹ (11905-12500 nm)	strong to medium

	benzene/sub. benzene	3070 cm ⁻¹ (3257 nm)	weak
aromatic	monosubstituted benzene	700–750 cm ⁻¹ (13333-14286 nm)	strong
		690–710 cm ⁻¹ (14085-14493 nm)	strong
	ortho-disub. benzene	750 cm ⁻¹ (13333 nm)	strong
	meta-disub. benzene	750-800 cm ⁻¹ (12500-13333 nm)	strong
		860–900 cm ⁻¹ (11111-11628 nm)	strong
	para-disub. benzene	800-860 cm ⁻¹	strong
alkynes	any	3300 cm * (3030 nm)	medium
aldehydes	any	2720 cm ⁻¹ (3676 nm) 2820 cm ⁻¹ (3546 nm)	medium

$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	1		monosub. alkenes	1645 cm ⁻¹ (6079 nm)	medium
acyclic CC cis-1,2-disub. alkenes 1660 cm ⁻¹ (6024 nm) medium trans-1,2-disub. alkenes 1675 cm ⁻¹ (5970 nm) medium trisub, tetrasub. alkenes 1670 cm ⁻¹ (5988 nm) weak conjugated CC 1600 cm ⁻¹ (6061 nm) strong with benzene ring dienes 1600 cm ⁻¹ (6061 nm) strong with C=O 1600 cm ⁻¹ (6154 nm) strong C=C (both sp ²) any 1640-1680 cm ⁻¹ (5952-6098 nm) medium 1500 cm ⁻¹ (6250 nm) nm) medium aromatic C=C any 1600 cm ⁻¹ (6297 nm) strong c=C (both sp ²) any 1600 cm ⁻¹ (6297 nm) medium 1500 cm ⁻¹ (6697 nm) 1580 cm ⁻¹ (6697 nm) medium 1600 cm ⁻¹ (6250 nm) strong (usually 3 or 4) nm) nm) 1600 cm ⁻¹ (6250 nm) nm) strong (usually 3 or 4) 1600 cm ⁻¹ (6250 nm) nm) strong (usually 3 or 4) 1600 cm ⁻¹ (6250 nm) nm) strong (usually 3 or 4) 1600 cm ⁻¹ (6250 nm) nm) strong (usually 3 or 4) 1600 cm ⁻¹ (6250 nm) nm) strong (usually 3 or 4) <t< td=""><td></td><td>1,1-disub. alkenes</td><td>1655 cm⁻¹ (6042 nm)</td><td>medium</td></t<>			1,1-disub. alkenes	1655 cm ⁻¹ (6042 nm)	medium
$ \begin{array}{c} \mbox{trans-1,2-disub.} & 1675 \mbox{cm}^{-1} (5970 \\ \mbox{alkenes} & \mbox{nm} & \mbox{medium} \\ \mbox{trisub., tetrasub.} & 1670 \mbox{cm}^{-1} (5988 \\ \mbox{nm} & \mbox{nm} & \mbox{trong} \\ \mbox{strong} & \mbox{trong} \\ \mbox{trong} & \mbox{trong} & \mbox{trong} & \mbox{trong} \\ \mbox{trong} & \mbox{trong} & \mbox{trong} & \mbox{trong} \\ \mbox{trong} & \mbox{trong} & \mbox{trong} & \mbox{trong} & \mbox{trong} \\ \mbox{trong} & \mbox{trong} $		acyclic C—C	cis-1,2-disub. alkenes	1660 cm ⁻¹ (6024 nm)	medium
$ \begin{array}{c} \mbox{trisub., tetrasub.} & 1670 \mbox{ cm}^{-1} (5988 \ nm) & weak \\ \mbox{alkenes} & nm) & 1600 \mbox{ cm}^{-1} (6250 \ nm) & strong \\ \mbox{tong} & nm) & 1600 \mbox{ cm}^{-1} (6061 \ nm) & strong \\ \mbox{tong} & 1625 \mbox{ cm}^{-1} (6154 \ nm) & strong \\ \mbox{tong} & nm) & strong \\ \mbox{with C=O} & 1600 \mbox{ cm}^{-1} (6250 \ nm) & strong \\ \mbox{C=C (both sp}^2) & any & 1640-1680 \mbox{ cm}^{-1} (6897 \ nm) & 1500 \mbox{ cm}^{-1} (6897 \ nm) & 1500 \mbox{ cm}^{-1} (6897 \ nm) & 1500 \mbox{ cm}^{-1} (6897 \ nm) & 1580 \mbox{ cm}^{-1} (6897 \ nm) & 1580 \mbox{ cm}^{-1} (6329 \ nm) & 1580 \mbox{ cm}^{-1} (6329 \ nm) & 1600 \mbox{ cm}^{-1} (6250 \ nm) & 1700 \mbox{ cm}^{-1} (5814 \ nm) & 1700 \m$			trans-1,2-disub. alkenes	1675 cm ⁻¹ (5970 nm)	medium
$\begin{array}{cccc} \mbox{conjugated} C-C & & & & & & & & & & & & & & & & & &$			trisub., tetrasub. alkenes	1670 cm ⁻¹ (5988 nm)	weak
$\begin{array}{c c c c c c c c c c c c c c c c c c c $				1600 cm ⁻¹ (6250 nm)	strong
dienes1625 cm^{-1} (6154 nm)strongwith benzene ring1600 cm^{-1} (6250 nm)strongwith C=O1600 cm^{-1} (6250 nm)strongC=C (both sp ²)any1640–1680 cm^{-1} (5952-6098 nm)mediumaromatic C=Cany1500 cm^{-1} (6667 nm)weak to strong (usually 3 or 4) nm)aromatic C=Cterminal alkynes2100–2140 cm^{-1} (4673-4762 nm)weakC=Cterminal alkynes2190–2260 cm^{-1} (4425-4566 nm)weakc=Cisubst. alkynes2190–2260 cm^{-1} (4425-4566 nm)weak		conjugated C-C	dienes	1650 cm ⁻¹ (6061 nm)	strong
with C=O 1600 cm ⁻¹ (6250 nm) strong C=C (both sp ²) any 1640-1680 cm ⁻¹ (5952-6098 nm) medium 1450 cm ⁻¹ (6897 nm) 1450 cm ⁻¹ (6697 nm) weak to strong (usually 3 or 4) aromatic C=C any 1580 cm ⁻¹ (6329 nm) weak to strong (usually 3 or 4) $C=C$ terminal alkynes 2100-2140 cm ⁻¹ (4673-4762 nm) weak $C=C$ terminal alkynes 2190-2260 cm ⁻¹ (4425-4566 nm) weak saturated aliph./cyclic 6-membered 1720 cm ⁻¹ (5814 nm) very weak (often indisinguishable)		with benzene ring		1625 cm ⁻¹ (6154 nm)	strong
$C=C \text{ (both sp}^{2}) \text{ any } \begin{cases} 1640-1680 \text{ cm}^{-1} \\ (5952-6098 \text{ nm}) \\ 1450 \text{ cm}^{-1} (6897 \text{ nm}) \\ 1mm \\ 1500 \text{ cm}^{-1} (6667 \text{ nm}) \\ 1580 \text{ cm}^{-1} (6329 \text{ nm}) \\ 1580 \text{ cm}^{-1} (6329 \text{ nm}) \\ 1600 \text{ cm}^{-1} (6250 \text{ nm}) \\ 1720 \text{ cm}^{-1} (5814 \text{ nm}) \\ 1720 \text{ cm}^{-1} (5814 \text{ nm}) \end{cases} \text{ weak (often indisinguishable)}$		with C=O	with C=O		strong
aromatic C=C any $ \begin{array}{c} 1450 \ cm^{-1} (6897 \ nm) \\ 1500 \ cm^{-1} (6667 \ nm) \\ 1580 \ cm^{-1} (6329 \ nm) \\ 1600 \ cm^{-1} (6250 \ nm) \\ 1600 \ cm^{-1} (6250$		C=C (both sp ²)	any	1640–1680 cm ⁻¹ (5952-6098 nm)	medium
aromatic C=C any $\begin{bmatrix} 1500 \text{ cm}^{-1} (6667 \\ nm) \\ 1580 \text{ cm}^{-1} (6329 \\ nm) \\ 1600 \text{ cm}^{-1} (6250 \\ nm) \\ 1600 c$				1450 cm ⁻¹ (6897 nm)	
aromatic C=C any $1580 \text{ cm}^{-1} (6329 \text{ nm})$ 1600 cm $^{-1} (6250 \text{ nm})$ 1700 cm $^{-1} (425-4566 \text{ nm})$ 1720 cm $^{-1} (5814 \text{ nm})$ 1720 cm $^{-1} (5814 \text{ nm})$	aromatic C=C C≡C		any	1500 cm ⁻¹ (6667 nm)	1
C=C terminal alkynes disubst. alkynes saturated aliph./cyclic 6-membered 1600 cm ⁻¹ (6250 nm) 2100–2140 cm ⁻¹ (4673-4762 nm) 2190–2260 cm ⁻¹ (4425-4566 nm) 1720 cm ⁻¹ (5814 nm)		aromatic C=C		1580 cm ⁻¹ (6329 nm)	weak to strong (usually 5 of 4)
C=C terminal alkynes 2100-2140 cm ⁻¹ (4673-4762 nm) disubst. alkynes 2190-2260 cm ⁻¹ (4425-4566 nm) saturated aliph./cyclic 6-membered nm) terminal alkynes 2100-2140 cm ⁻¹ (4673-4762 nm) (4425-4566 nm) terminal alkynes 2190-2260 cm ⁻¹ (4673-4762 nm) terminal alkynes 2190-2260 cm ⁻¹ (473-4762 nm) terminal alkynes				1600 cm ⁻¹ (6250 nm)	
C≡C disubst. alkynes saturated aliph./cyclic 6-membered disubst. alkynes 2190–2260 cm ⁻¹ (4425-4566 nm) very weak (often indisinguishable)		C≡C	terminal alkynes	2100–2140 cm ⁻¹ (4673-4762 nm)	weak
saturated aliph./cyclic 1720 cm ⁻¹ (5814 6-membered nm)			disubst. alkynes	2190-2260 cm ⁻¹ (4425-4566 nm)	very weak (often indisinguishable)
			saturated aliph./cyclic 6-membered	1720 cm ⁻¹ (5814 nm)	

C-C

	α	β-unsaturated	1685 cm ⁻¹ (5935 nm)
C=0	aldehyde/ketone ar	romatic ketones	1685 cm ⁻¹ (5935 nm)
	c	velic 5-membered	$1750 \text{ cm}^{-1} (5714 \text{ nm})$
	c	vclic 4-membered	1775 cm ⁻¹ (5634 nm)
	aldehydes	1725 cm ⁻¹ (5 nm)	(5797 influence of conjugation (as with ketones)
	saturated carboxyl acids	ic 1710 cm ⁻¹ (5) nm)	(5848
carboxylic acids/derivates	unsat./aromatic ca acids	rb. 1680–1690 cr (5917-5952 n	cm ⁻¹ 2 nm)
	esters and lactones	1735 cm ⁻¹ (5 nm)	(5764 influenced by conjugation and ring size (as with ketones)
	anhydrides	1760 cm ⁻¹ (50 nm) 1820 cm ⁻¹ (50 nm)	(5682 (5495
	acyl halides	1800 cm ⁻¹ (5 nm)	(5556
	amides	1650 cm ⁻¹ (6 nm)	(6061 associated amides
	carboxylates (salts) 1550–1610 cr (6211-6452 n	cm ⁻¹ 2 nm)
	amino acid zwitter	tions 1550–1610 cr (6211-6452 n	cm ⁻¹ cnm)
	low concentration	3610-3670 cm	cm ⁻¹

0.11	alcohols, <u>phenols</u>	high concentration	3200–3400 cm ⁻¹ (2941-3125 nm)	broad
0-н	carboxylic acids	low concentration	3500–3560 cm ⁻¹ (2809-2857 nm)	
		high concentration	3000 cm ⁻¹ (3333 nm)	broad
	£0		3400–3500 cm ⁻¹ (2857-2941 nm)	strong
N H	prunary <u>anunes</u>	any	1560–1640 cm ⁻¹ (6098-6410 nm)	strong
N—H	secondary amines	any	>3000 cm ⁻¹ (>3333 nm)	weak to medium
	ammonium ions	any	2400–3200 cm ⁻¹ (3125-4167 nm)	multiple broad peaks
		primary	1040–1060 cm ⁻¹ (9434-9615 nm)	strong, broad
	alcohols	secondary	~1100 cm ⁻¹ (~9091 nm)	strong
C–0		tertiary	1150–1200 cm ⁻¹ (8333-8696 nm)	medium
	phenols	any	1200 cm ⁻¹ (8333 nm)	
		aliphatic	1120 cm ⁻¹ (8929 nm)	
	emers	aromatic	1220–1260 cm ⁻¹ (7937-8197 nm)	
	carboxylic acids	any	1250–1300 cm ⁻¹	

			(7692-8000 nm)	
	esters	any	1100–1300 cm ⁻¹ (7692-9091 nm)	two bands (distinct from ketones, which do not possess a C-O bond
	aliphatic amines	any	1020–1220 cm ⁻¹ (8197-9804 nm)	often overlapped
	C=N	any	1615–1700 cm ⁻¹ (5882-6192 nm)	similar conjugation effects to C=(
C N	C≡N (<u>nitriles</u>)	unconjugated	2250 cm ⁻¹ (4444 nm)	medium
C-N		conjugated	2230 cm ⁻¹ (4484 nm)	medium
	R-N-C (isocyanides)	any	2165-2110 cm ⁻¹ (4739-4619 nm)	
	R-N=C=S	any	2140–1990 cm ⁻¹ (5025-4673 nm)	
	fluoroalkanes	ordinary	1000–1100 cm ⁻¹ (9091-10000 nm)	
		trifluromethyl	1100–1200 cm ⁻¹ (8333-9091 nm)	two strong, broad bands
с– <u>х</u>	<u>chloroalkanes</u>	any	540-760 cm ⁻¹ (13158-18519 nm)	weak to medium
	<u>bromoalkanes</u>	any	500-600 cm ⁻¹ (16667-20000 nm)	medium to strong
	iodoalkanes	any	500 cm ⁻¹ (20000 nm)	medium to strong
N-O	nitro compounds	\$10\$1.040x3	1540 cm ⁻¹ (6494 nm)	stronger
		anpnatic	1380 cm ⁻¹ (7246 nm)	weaker
		aromatic	1520, 1350 cm ⁻¹ (7407-6579 nm)	lower if conjugated