1.2 Interactions of microwaves with liquids

Microwaves interact with non-magnetic liquids by induction of polarization by the oscillating electric field of the electromagnetic wave. Polarisation is due to the orientation of the permanent dipoles of the molecules through molecular rotation, the distortion of the electron distribution within the molecules and, for conducting liquids, movement of free charge carriers. Microwave spectra are normally represented as plots of the dielectric constant ε' and the dielectric loss ε'' as a function of frequency. The dielectric loss ε'' is the imaginary component of the complex dielectric constant and is a measure of how efficiently the sample can convert the energy of electromagnetic radiation into heat. The real component, ε', describes the ability of the molecule to be polarised by the electric field[1,20-25]. Both ε' and ε'' are dimensionless quantities; the absolute values are obtained by multiplying the values by the permittivity of free space ε_{fs} which is equal to 8.854 x 10^{-12} C^2 J^{-1} m^{-1}.

moment, microwave absorption is dominated by processes involving the re-
For non-conducting liquids in which the molecules possess a permanent dipole moment, microwave absorption is dominated by processes involving the re-orientation of the molecular dipoles. The simplest model for dielectric relaxation at microwave frequencies is due to Debye[26]and may be represented as follows

[1]

[2]

Activity5 Slide 2

Summary of microwave spectral parameters at different temperatures. Solvents with the subscript (a) were taken from D.W.Davidson and R.H. Cole, *J.Chem.Phys*., 1951, **18**, 1417. DMF is N,N-dimethyl formamide.

solvent	temp./°C	ε_0	ε_∞	f_{max}/GHz
water	20.8	79.5	5.7	17.5
water	51.1	70.0	5.4	33.6
water	76.2	61.8	4.9	50.2
toluene[a]	21.4	2.7	2.3	9.2
nitrobenzene[a]	21.4	35.7	3.3	3.58
formamide[a]	21.4	110	5.3	4.33
DMF[a]	21.4	38.5	10	10.9
chlorobenzene[a]	21.4	6.2	3.3	9.46
methanol	20.8	34.5	5.1	2.49
methanol	50.9	29.0	4.7	5.62
methanol	75.0	25.1	4.8	8.49
ethanol	21.4	25.4	4.9	0.95
ethanol	51.8	21.7	3.7	2.45
ethanol	75.0	20.1	4.3	7.16
propan-1-ol	20.8	22.2	3.1	0.44
propan-2-ol	20.8	21.0	3.0	0.36
propan-2-ol	51.7	16.3	3.0	1.49
propan-2-ol	75.2	12.9	3.2	3.73
butan-1-ol	20.8	18.9	2.8	0.31
butan-1-ol	52.3	15.3	2.8	1.00
butan-1-ol	75.2	12.4	3.0	2.53

Activity5 Slide 3 – example of handwritten notes

Microemulsions

Microemulsions are:

- optically transparent
- Thermodynamically stable
- Water in Oil (w/o) or Oil in Water (o/w) or Bicontinous.
- Droplet size is in the nm range
- Contain Large areas of interface.

Wavelength and Reflection of Microwaves

- The frequency 2.45 GHz coresponds to a wavelength of 12.2 cm assuming the microwaves are travelling in a vacum.
- In water 2.45 GHz coresponds to a

  wavelength of 1.87 cm.
- When microwaves are incident on the sample surface, a fraction is reflected and the remainder is transmitid into the sample.
- Transmitid intensity decays exponentially with distance though the sample as energy is absorbed.

Meta data

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