

Dielectric 'Loss Factor' (ϵ'') Measurement Over RF Frequencies Between 0.1 - 40.0 GHz for Common Organic Chemicals

Abstract

Using an Agilent Network Analyzer with open ended dielectric measurement probe (85070e dielectric probe kit), the 'loss factor' (ϵ'') of common organic solvents has been measured between the range 0.1 to 40.0 GHz. Measurements were conducted in 250 mL pyrex reaction vessels filled with 125 mL of solvent. The end of the probe submerged to a depth of 5 mm. The magnitude of ϵ'' at the conventional microwave heating frequency 2.45 GHz is compared between solvents and to the existing data on the loss factor of water.

Keywords: Loss Factor, Dielectric Measurements, Microwave Heating, Organic Solvents.

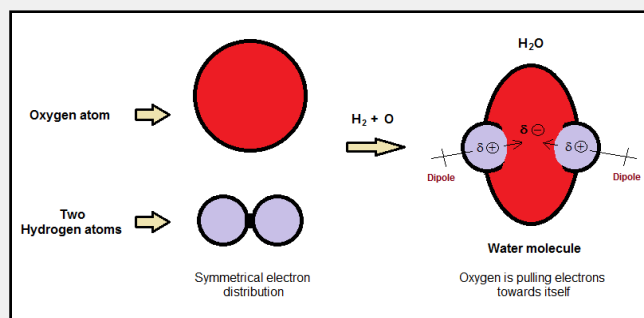
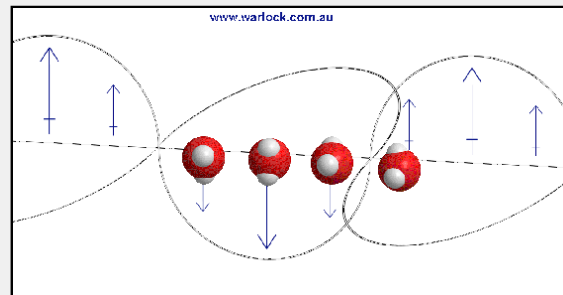
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Introduction

Commercial microwave ovens operate at 2.45 GHz and are most commonly used to heat materials containing a large amount of water. Microwave heating of organic chemicals is often undertaken in commercial ovens and in this study we identify the molecular functional groups responsible for absorbing microwave energy over a spectrum of frequencies.

Microwave radiation will heat organic molecules by aligning 'molecular dipoles' with the electric field, transferring power from the radiation into the movement of the organic molecule (heat).



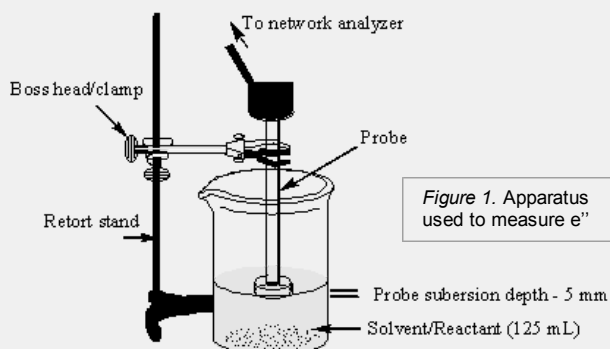
A molecular dipole occurs when two (or more) atoms are unevenly distributing electron density between them. The 'electronegative' atoms (increasing from N, O, F and Br, Cl, F) have a tendency to withdraw a more dense cloud of electrons out of a bond (pair of shared electrons) and towards its nucleus, hence 'polarizing' the bond.

The polarization creates areas of negative (-) and positive (+) charge that have a static attraction to the electromagnetic field. Organic molecules don't absorb electromagnetic radiation at discrete frequencies, instead a spectrum of intensities at different wavelengths occurs. Both permittivity (ϵ' , ability of the material to be polarized and change the electromagnetic field) and loss factor (ϵ'' , how efficiently the absorbed radiation is converted to heat) can be measured then used to calculate the angle of the molecule as it moves to align with the magnetic field ('loss tangent', $\tan \delta$).

In this study we are only concerned with the capacity of a material to absorb radiation on a spectrum of frequencies and to use a measure of ϵ'' to compare with the reported values for water. Throughout the study we look at how organic chemicals absorb electromagnetic radiation over the radiofrequency (RF) spectrum (0.1-40 GHz) using a measure of loss factor (ϵ'').

Equipment

Dielectric measurements were recorded using an Agilent Network Analyzer (E83613) with open-ended dielectric measurement probe (85070e dielectric probe kit). The measurement apparatus was set up as follows;



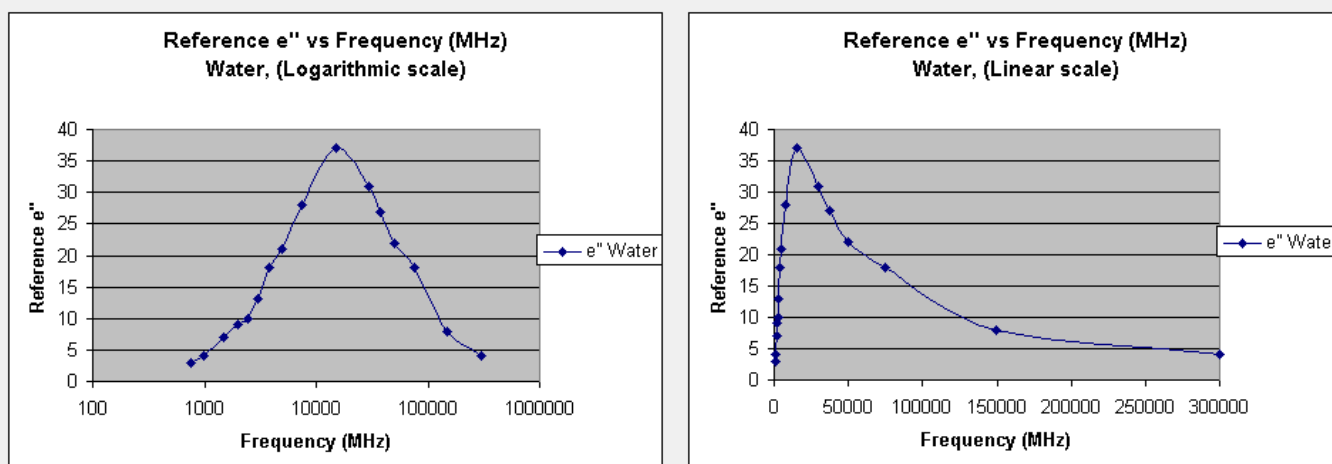
Data Acquisition and Analysis

Procedure;

The tests were performed by filling the pyrex vessel (250 mL) with each organic material (125 mL) and the probe was submersed and held 5 mm below the surface of the liquid. The room temperature and solution temperature were both $\sim 22^\circ\text{C}$. Values for ϵ'' were recorded over the range from 0.1 - 40 GHz, although no useful data could be collected on; Acetaldehyde (>36.20 GHz), Acetone (>37.15 GHz), Acetonitrile (>30.51 GHz) and Nitromethane (>30.51 GHz).

Analysis and Discussion;

The loss factor of materials can change depending on the frequency of the incident electromagnetic radiation. This is because the interaction of RF radiation with the dipole of a molecule will reach an optimum value at the wavelength that rotates the molecule to most efficiently generate heat (vibration). The trend in loss factor (ϵ'') of water at frequencies from 0.1 - 30 GHz is shown in Figure 2 (reference data recorded at 20°C)^[1].



The loss factors on the RF spectrum will also change with temperature. At higher temperatures, the molecules are already vibrating fast and the frequency that best absorbs RF radiation (ϵ'' maximum) will change depending on the existing vibration within the molecule (temperature). The loss factor for water at 22°C (our experimental temperature) and 2.45 GHz is approximately 10 although it decreases with increasing temperature as shown;

Temperature (loss factor at 2.45 GHz)

Temperature	Dielectric loss (ϵ'')
0°C	20
20°C	11
40°C	6
60°C	3
80°C	2
100°C	1.3

The frequency of maximum RF absorption (ϵ'' max) increases with increasing temperature, although the magnitude of the ϵ'' decreases along the same trend. This means that a polar solvent, such as water, becomes 'less polar' with increasing temperature and more like an organic solvent. The RF frequency for maximum ϵ'' and reported loss factor is summarized below (Figure 3) at different temperatures^[1].

Approx. Temperature and ϵ''		Frequency/Wavelength at ϵ'' max		
Temperature ($^{\circ}$ C)	ϵ'' (max) Water	Frequency (MHz)	Frequency (GHz)	Wavelength (cm)
0	40	12492	12.49	2.4
20	37	15779	15.78	1.9
40	34	24983	24.98	1.2
60	30	44746	44.75	0.67
80	26	74950	74.95	0.4
100	23	119920	119.92	0.25

Figure 3. Summarized values for ϵ'' (max) wavelengths at different temperatures^[1]

Our Experimental Data: Common organic solvents (AR grade) and a number of useful reactant chemicals (LR grade) were chosen for a study on dielectric loss factor (Figure 4) to examine the effect of functional groups on dielectric heating of both the solvent and reactant at 2.45 GHz. For each chemical, the measured loss factor (ϵ'') at 2.45 GHz ($\sim 22^{\circ}$ C) is tabulated in brackets.

Reactants	Reference: Water (10)
	Acetaldehyde (0.07)
	n-Butylamine (transparent)
	Cyclohexanol (0.41)
	Diethylamine (0.01)
Ethanolamine (7.39)	
Formamide (46.80)	
Pentanedione (5.56)	
Common Organic Solvents	Acetic Acid (1.35)
	Acetonitrile (1.65)
	Acetone (0.95)
	Dichloromethane (DCM, 0.25)
	Diethyleneglycol (Digol, 5.47)
	N,N-Dimethyl Formamide (DMF, 5.90)
	Dimethylsulfoxide (DMSO, 12.61)
	Ethanol (7.72)
	Diethyl Ether (0.06)
	Ethyl Acetate (0.30)
	Isopropanol (2.81)
	Nitromethane (1.73)
	Pyridine (1.19)
	Tetrahydrofuran (THF, 0.25)

Figure 4. Solvents & reactants analysed at 2.45 GHz

Since solutions have been measured at $\sim 22^{\circ}$ C, the recorded data represents the initial heating capacity from room temperature. We compared the loss factor of materials at 2.45 GHz and considered materials with a loss factor of less than 1 to be mainly transparent, 1-5 is moderately absorbing and above 5 is highly absorbing (Figure 5).

RF Transparent Materials		Moderately RF Absorbing Material		Highly Absorbing Materials	
Solvents	Reactants	Solvents	Reactants	Solvents	Reactants
Diethylether (0.06)	n-Butylamine (transparent)	Pyridine (1.19)	None	Digol (5.47)	Pentanedione (5.56)
THF (0.25)	Diethylamine (0.01)	Acetic Acid (1.35)		DMF (5.90)	Ethanolamine (7.39)
DCM (0.25)	Acetaldehyde (0.07)	Acetonitrile (1.65)		Ethanol (7.72)	Formamide (46.80)
Ethyl Acetate (0.30)	Cyclohexanol (0.41)	Nitromethane (1.73)		DMSO (12.61)	
Acetone (0.95)		Isopropanol (2.81)			

Figure 5. A categorized table of RF absorbing materials

Conclusions

Microwave RF transparent chemicals At 2.45 GHz, solvents containing the 'Ether' functional group (Diethylether and THF) were almost microwave transparent, as was the 'Chlorinated Hydrocarbon' DCM and 'Ester' (Ethyl Acetate) functional groups. The primary and secondary 'Amine' functional groups (n-Butylamine and Diethylamine respectively) were completely transparent. The 'Aldehyde' functional group (acetaldehyde) contains a 'Carbonyl' (C=O, bond) that was transparent in acetaldehyde. 'Ketone' functional group (Acetone) also has a carbonyl group, but showed some absorbance perhaps due to tautomeric forms of the ketone in the acetone molecule. Cyclohexanol is a secondary 'Alcohol' and has an O-H bond, similar to water, but is attached to a cyclic hydrocarbon structure and shows low absorbance.

Moderately RF absorbing chemicals The tertiary aromatic amine (pyridine) is somewhat absorbing due to the dipole created by an electronegative nitrogen atom within the molecule. The 'Carboxylic Acid' functional group (acetic acid) shows only moderate absorbance at room temperature. This may be expected to change with increased temperature, since the molecule contains both carbonyl and O-H functionality, both of which contain electronegative oxygen atoms that create strong dipoles. The 'Nitrile' functional group (acetonitrile) contains a polarized nitrogen-carbon triple bond and absorbs moderately. The 'Nitro' functional group (nitromethane) can be considered 'ionic' but shows only moderate absorbance. Isopropanol is a secondary alcohol (like cyclohexanol) and has an O-H group, attached to a small hydrocarbon chain. It is smaller than cyclohexanol and able to rotate in the electromagnetic field, showing a moderate absorbance that is significantly higher than the cyclohexanol.

Highly RF absorbing chemicals The primary alcohol group (ethanol) absorb strongly, although Digol, which has two primary alcohols on the same carbon chain as ethanol, absorbs less strongly since it is symmetrical. The tertiary 'Formyl Amide' group (DMF) absorbs strongly since the carbonyl is polarized by both nitrogen and oxygen. Polarization occurs to a larger extent in the 'Sulfoxide Ether' group (DMSO) where sulphur is polarized by three oxygen atoms. As such, the solvent DMSO is highly absorbing.

The reactant pentandione contains a '1,3-diketone' system that exists as a tautomer to form the secondary 'olefinic alcohol'. 1,3-Pentanedione shows higher absorbance than the 'alkyl' secondary alcohol (isopropanol) since the olefin contains more electrons that can be polarized. Ethanolamine contains both primary alcohol and primary amine functional groups on the same carbon chain. The primary amine group (n-Butylamine) was proven to be RF transparent and the primary alcohol group (ethanol) strongly absorbing. Having both groups on the same molecule led to a decrease in absorption due to an increase in symmetry between electronegative atoms, decreasing the overall strength of the dipole.

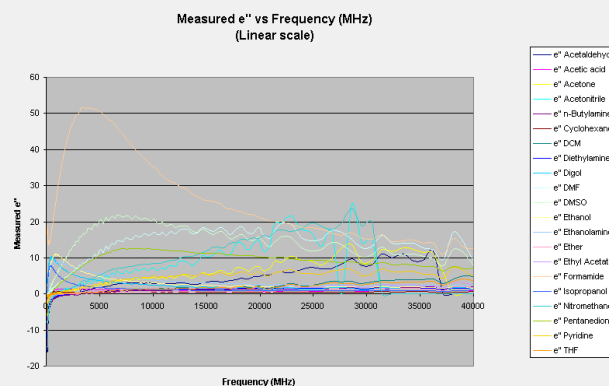
The formamide molecule is a primary 'formyl amide' and has both carbonyl and amine groups. It is very small and has a large dipole. The loss factor for formamide at 0.1 MHz (~19) increases with frequency and reaches ~47 at 2.45 GHz (conventional microwave heating) to a maximum of ~51.5 at 4.27 GHz. It decreases towards ~15 as frequency is increased to 40 GHz. At conventional heating frequencies (2.45 GHz), formamide absorbs five times as much microwave radiation than water and is close to the optimal frequency for dielectric loss at 22°C. In contrast, the maximum dielectric loss for water at 22°C is at a frequency of ~9.20 GHz with an ϵ'' value of 37, less than that of formamide at the 2.45 GHz frequency.

References

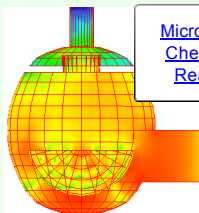
[1] Approximated valued are from; M.Chaplin. London South Bank University, <http://www.lsbu.ac.uk/water/microwave.html>; J. B. Hasted, Liquid water: Dielectric properties, in Water A comprehensive treatise, Vol 1, Ed. F. Franks (Plenum Press, New York, 1972) pp. 255-309.

Analysis of ϵ'' with Frequency

The highly RF absorbant chemicals; formamide, DMSO and DMF, reach their loss maximum at 6.63 and 19.4 GHz respectively. They continue to absorb RF at an ϵ'' greater than 10 at frequencies toward 40 GHz. RF absorbing solvents commonly have a maximum dielectric loss at a specific frequency. The ϵ'' maximums measured were; isopropanol (7.8, 389 MHz), digol (10.4, 475 MHz), ethanol (11.0, 968.3 MHz), ethanolamine (8.9, 1.1 GHz), DMSO (21.8, 6.63 GHz), pentanedione (12.5, 8.6 MHz), DMF (22.0, 19.4 GHz). Loss factors for nitromethane and acetonitrile begin to increase above 3.3 GHz, whereas loss factors for pyridine and acetone begin to increase above 5.7 GHz. Acetaldehyde increases to a maxima at 8.1 GHz ($\epsilon'' = 3.0$) and then steadily increases with frequency.



Data for measured ϵ'' vs frequency have been graphed for comparison and is presented in the section below.



[Microwave Chemistry Reactor](#)

Chemistry Articles

- [Microwave Chemistry Reactor \[HTML\]](#)
- [Dielectric 'Loss Factor' \(\$\epsilon''\$ \) Measurement Over RF Frequencies Between 0.1 - 40.0 GHz for Common Organic Chemicals \[HTML\]](#)
- [Deconstruction of a 300 MHz Cryomagnet for NMR Spectroscopy \[HTML\]](#)

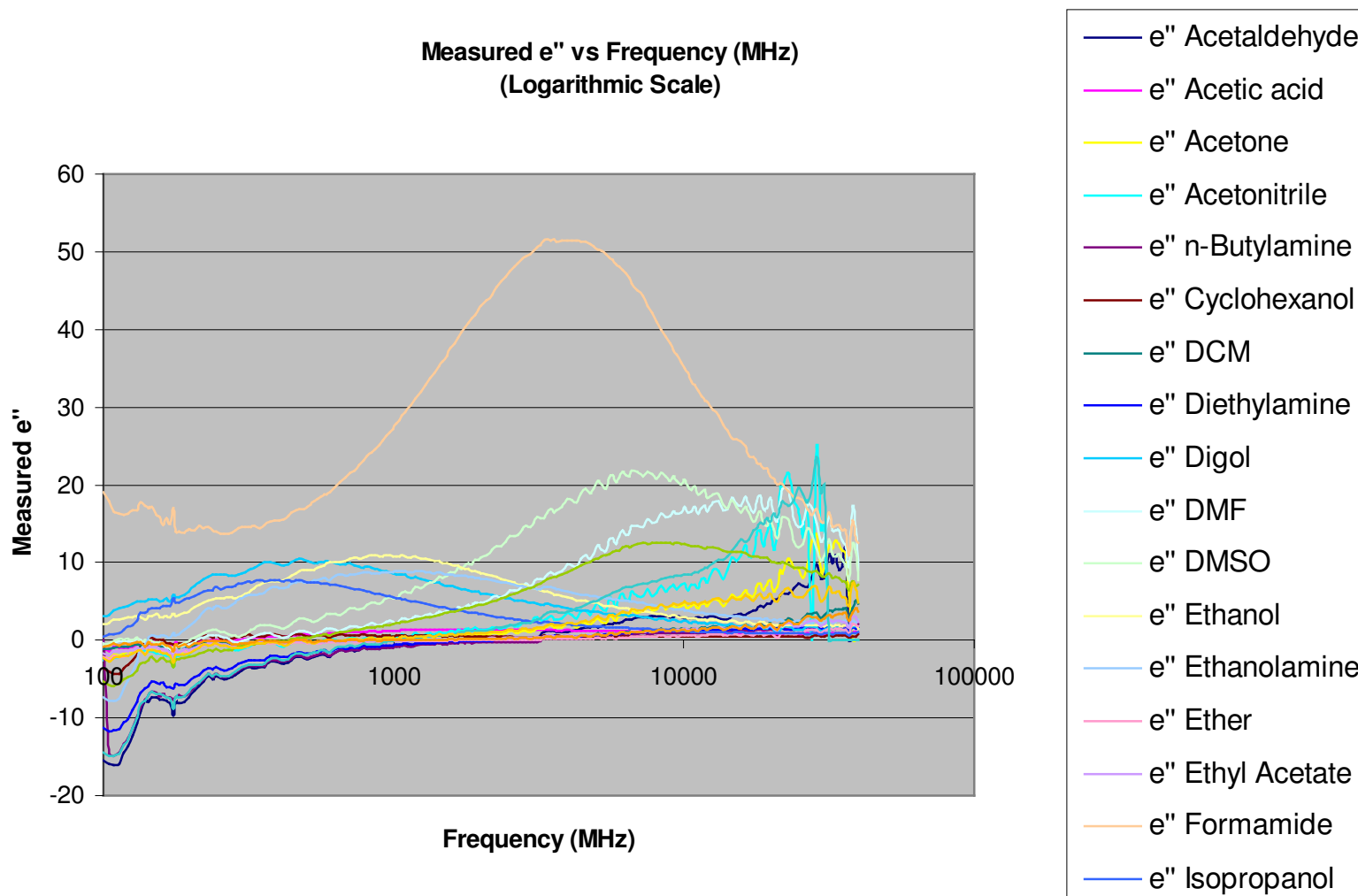


Figure 7. Measured ϵ'' vs Frequency (MHz) for all of the chemicals used on a logarithmic frequency scale.

Solvent/Reactant Breakdown:

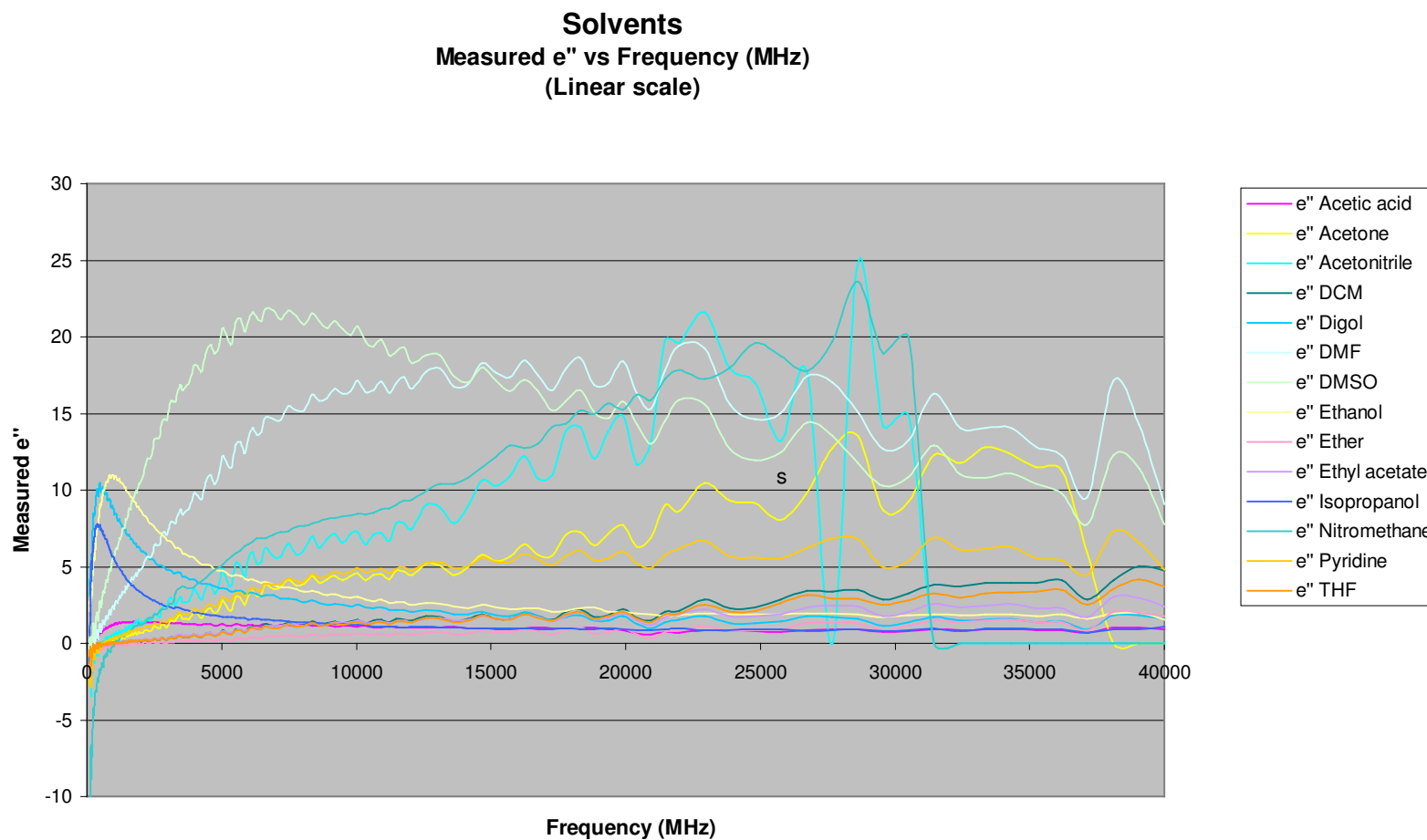


Figure 8. Measured ϵ'' vs Frequency (MHz) for solvents on a linear frequency scale.

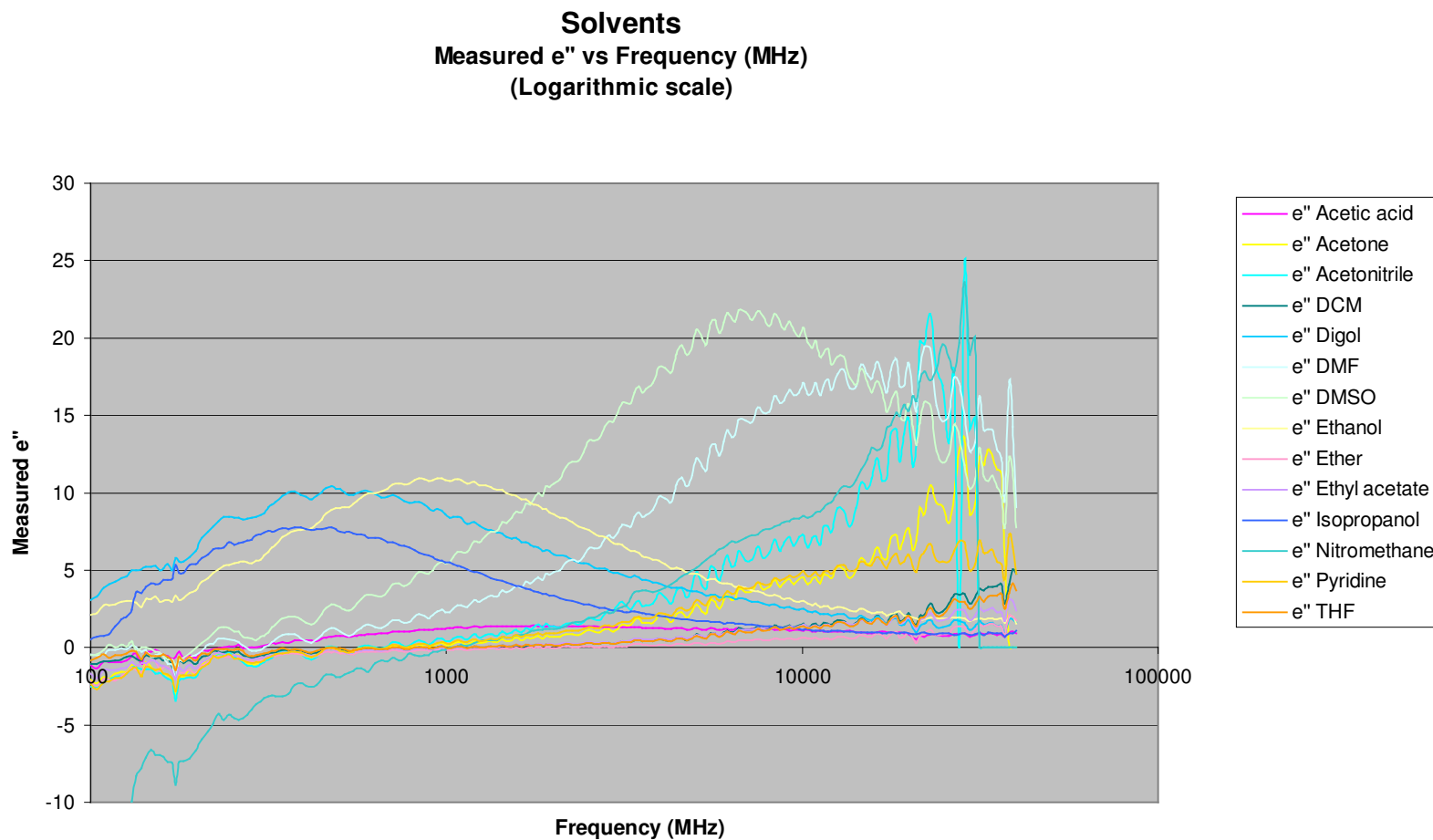


Figure 9. Measured ϵ'' vs Frequency (MHz) for solvents on a logarithmic frequency scale.

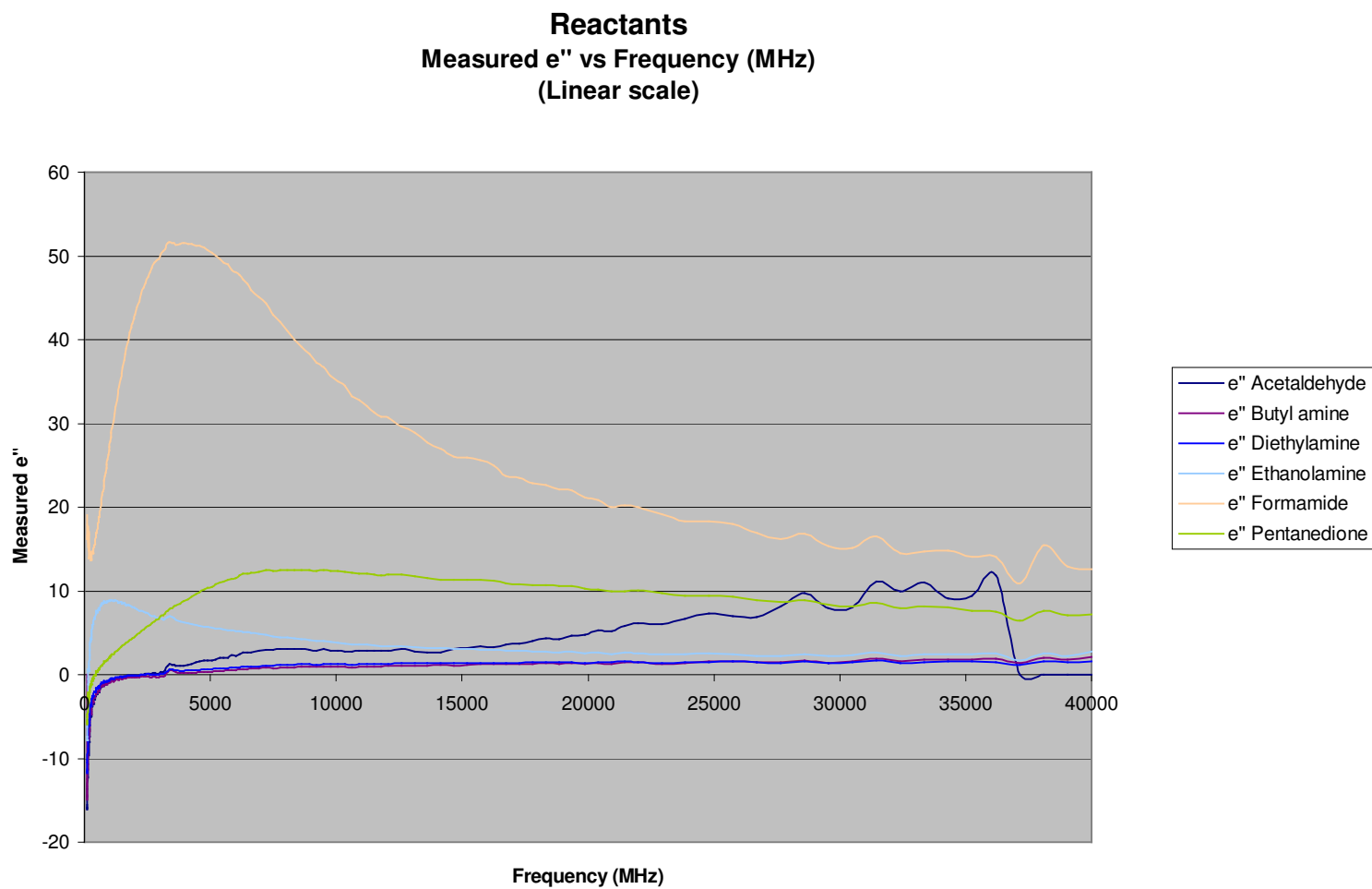


Figure 10. Measured ϵ'' vs Frequency (MHz) for reactants on a linear frequency scale.

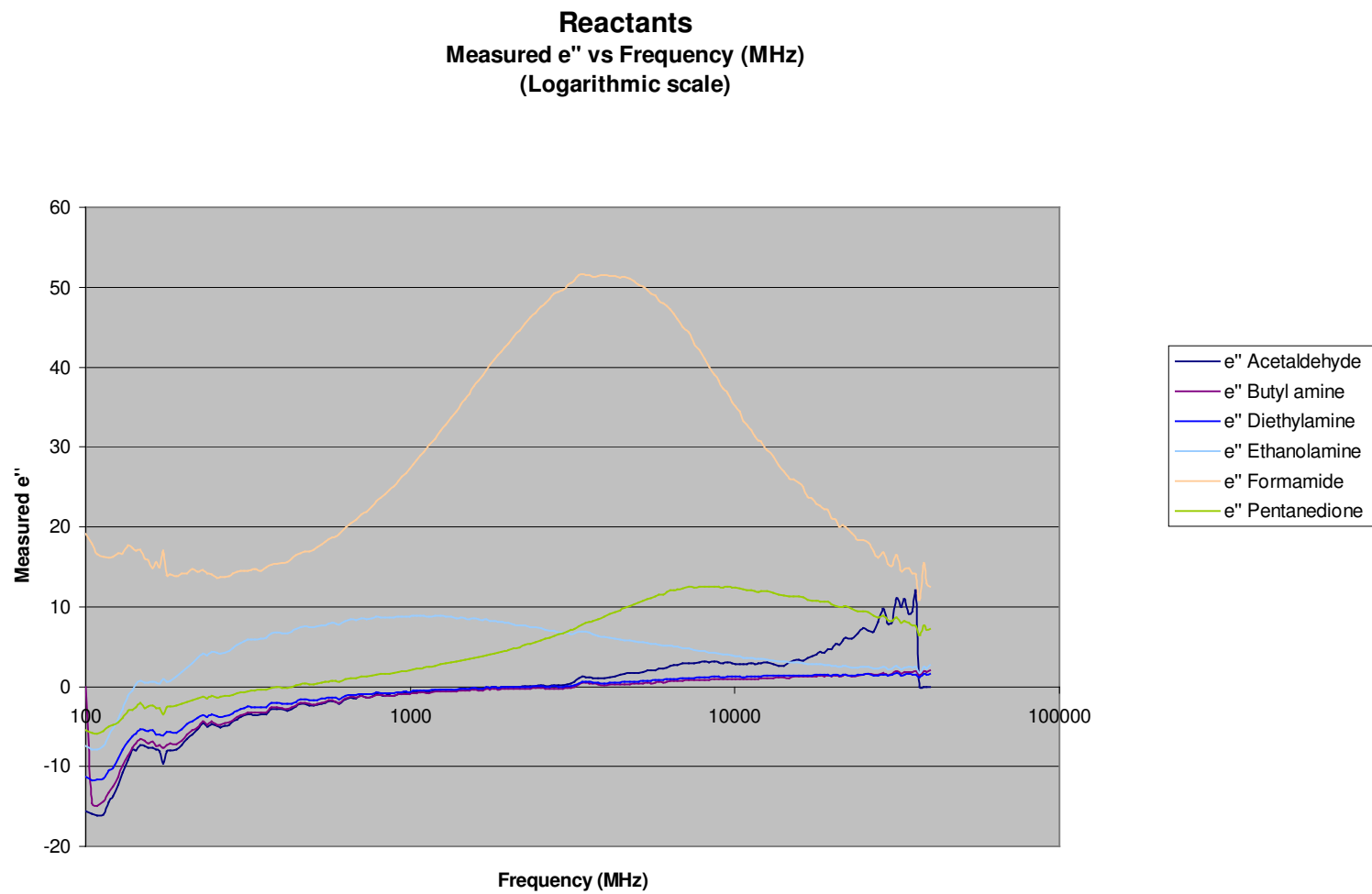


Figure 11. Measured ϵ'' vs Frequency (MHz) for reactants on a logarithmic frequency scale.

Loss Factor' (e'') measurement of chemicals at frequencies from 0.1 to 40 GHz

Chemicals; **Acetaldehyde, Acetic Acid, Acetone, Acetonitrile**, n-Butylamine, Cyclohexanol, DCM, Diethylamine, Digol, DMF, DMSO

Ethanol, Ethanolamine, Ether, Ethyl Acetate, Formamide, Isopropanol, Nitromethane, Pentanedione, Pyridine and THF

loss factor' - e'' related to power dissipation in the solvent

Frequency (Hz)	Frequency (MHz)	Frequency (GHz)	e'' Acetaldehyde	e'' Acetic acid	e'' Acetone	e'' Acetonitrile
10000000	100	0.1	-15.5422	-1.1149	-2.0799	-2.5218
104318759	104.318759	0.104318759	-15.8875	-1.3512	-2.2952	-2.5394
108637517.9	108.6375179	0.108637518	-16.0897	-0.8946	-1.8877	-2.2329
112956276.9	112.9562769	0.112956277	-15.9785	-0.9291	-2.0326	-2.0757
117275035.9	117.2750359	0.117275036	-14.5125	-0.9581	-1.6695	-1.9304
121593794.8	121.5937948	0.121593795	-13.6776	-0.9282	-1.5766	-1.8624
125912553.8	125.9125538	0.125912554	-12.3184	-0.8421	-1.5426	-1.6809
130231312.7	130.2313127	0.130231313	-10.7151	-0.5332	-1.1173	-1.2822
134550071.7	134.5500717	0.134550072	-9.2071	-0.3563	-1.209	-1.2933
138868830.7	138.8688307	0.138868831	-7.8285	-1.0338	-1.6668	-1.3991
143187589.6	143.1875896	0.14318759	-8.0144	-0.3424	-0.9719	-1.4204
147506348.6	147.5063486	0.147506349	-7.361	-0.2832	-1.3123	-1.4059
151825107.6	151.8251076	0.151825108	-7.3905	-0.1314	-1.4716	-1.6582
156143866.5	156.1438665	0.156143867	-7.6451	-0.3189	-1.3399	-1.6391
160462625.5	160.4626255	0.160462625	-7.6397	-0.4951	-1.6891	-1.794
164781384.4	164.7813844	0.164781384	-7.8444	-0.5293	-1.7923	-2.0018
169100143.4	169.1001434	0.169100143	-8.0583	-0.6931	-2.1197	-2.1789
173418902.4	173.4189024	0.173418902	-9.6762	-0.5905	-3.1423	-3.4143
177737661.3	177.7376613	0.177737661	-8.0591	-0.2911	-1.8362	-2.1541
182056420.3	182.0564203	0.18205642	-8.0399	-0.6526	-1.9261	-2.0026
189918998.3	189.9189983	0.189918998	-7.8956	-0.4729	-1.4599	-1.8905
197781576.2	197.7815762	0.197781576	-7.3651	-0.6813	-1.7723	-1.8916
205644154.2	205.6441542	0.205644154	-6.5306	-0.2335	-1.1025	-1.2723
213506732.2	213.5067322	0.213506732	-5.9859	-0.2283	-0.7612	-0.9596
221369310.2	221.3693102	0.22136931	-5.3126	-0.1238	-0.5671	-0.6481
229231888.1	229.2318881	0.229231888	-4.5655	-0.0418	-0.4281	-0.4972
237094466.1	237.0944661	0.237094466	-5.0395	0.0066	-0.4123	-0.4912
244957044.1	244.9570441	0.244957044	-4.6414	0.0621	-0.4546	-0.3485
252819622	252.819622	0.252819622	-4.8519	0.0584	-0.5017	-0.5993
260682200	260.6822	0.2606822	-5.0772	0.1975	-0.5134	-0.7465
268544778	268.544778	0.268544778	-4.93	-0.0307	-0.9087	-0.9733

Frequency (Hz)	Frequency (MHz)	Frequency (GHz)	e" Acetaldehyde	e" Acetic acid	e" Acetone	e" Acetonitrile
276407355.9	276.4073559	0.276407356	-4.74	-0.0616	-0.9847	-1.1515
284269933.9	284.2699339	0.284269934	-4.4066	-0.0119	-1.1407	-1.1979
292132511.9	292.1325119	0.292132512	-4.1278	0.0359	-1.0614	-1.2414
299995089.9	299.9950899	0.29999509	-3.8518	0.055	-0.9396	-1.0793
307857667.8	307.8576678	0.307857668	-3.6332	0.1201	-0.8524	-0.9684
315720245.8	315.7202458	0.315720246	-3.4904	0.1862	-0.6684	-0.7749
323582823.8	323.5828238	0.323582824	-3.4947	0.2923	-0.5748	-0.665
331445401.7	331.4454017	0.331445402	-3.5496	0.2594	-0.4892	-0.4576
345759729.7	345.7597297	0.34575973	-3.5173	0.3287	-0.3091	-0.216
360074057.7	360.0740577	0.360074058	-3.4694	0.2935	-0.2485	-0.1945
374388385.7	374.3883857	0.374388386	-2.7644	0.4642	-0.3016	-0.2004
388702713.7	388.7027137	0.388702714	-2.7665	0.4725	-0.4228	-0.3899
403017041.7	403.0170417	0.403017042	-2.8489	0.4876	-0.5996	-0.6515
417331369.7	417.3313697	0.41733137	-3.0035	0.4468	-0.6767	-0.792
431645697.7	431.6456977	0.431645698	-2.83	0.4246	-0.5798	-0.6091
445960025.7	445.9600257	0.445960026	-2.5061	0.6007	-0.3352	-0.3385
460274353.7	460.2743537	0.460274354	-2.1516	0.6543	-0.0541	0.0031
474588681.7	474.5886817	0.474588682	-2.127	0.6776	-0.0506	0.0845
488903009.7	488.9030097	0.48890301	-2.3547	0.7283	-0.0995	0.0006
503217337.7	503.2173377	0.503217338	-2.374	0.7524	-0.2563	-0.167
517531665.7	517.5316657	0.517531666	-2.2251	0.762	-0.3306	-0.3508
531845993.7	531.8459937	0.531845994	-2.1175	0.6963	-0.4498	-0.4403
546160321.7	546.1603217	0.546160322	-2.017	0.7521	-0.3198	-0.3033
560474649.7	560.4746497	0.56047465	-1.8135	0.7541	-0.2238	-0.1064
574788977.7	574.7889777	0.574788978	-1.795	0.7951	-0.1043	0.0691
589103305.7	589.1033057	0.589103306	-1.9471	0.8336	-0.0524	0.1099
603417633.7	603.4176337	0.603417634	-2.1257	0.8714	-0.0743	0.1421
629477786.8	629.4777868	0.629477787	-1.544	0.8869	-0.1118	0.0117
655537939.9	655.5379399	0.65553794	-1.3412	0.9024	-0.1761	-0.0621
681598093.1	681.5980931	0.681598093	-1.4488	0.9257	-0.073	0.089
707658246.2	707.6582462	0.707658246	-1.205	1.0186	0.1547	0.3802
733718399.4	733.7183994	0.733718399	-1.3519	1.0456	0.0434	0.2801
759778552.5	759.7785525	0.759778552	-1.2948	1.0279	-0.0682	0.049
785838705.6	785.8387056	0.785838706	-0.9871	1.0348	-0.0381	0.1432
811898858.8	811.8988588	0.811898859	-1.0784	1.0881	0.129	0.3446
837959011.9	837.9590119	0.837959012	-1.157	1.161	0.2064	0.4829

Frequency (Hz)	Frequency (MHz)	Frequency (GHz)	e" Acetaldehyde	e" Acetic acid	e" Acetone	e" Acetonitrile
864019165.1	864.0191651	0.864019165	-1.0978	1.1494	0.0845	0.3376
890079318.2	890.0793182	0.890079318	-1.1421	1.1211	-0.0089	0.1945
916139471.3	916.1394713	0.916139471	-0.9298	1.1543	0.1036	0.3533
942199624.5	942.1996245	0.942199624	-0.9223	1.2109	0.2239	0.5597
968259777.6	968.2597776	0.968259778	-0.8449	1.2216	0.2712	0.5902
994319930.7	994.3199307	0.994319931	-0.8784	1.221	0.1607	0.4257
1020380084	1020.380084	1.020380084	-0.6855	1.2308	0.1183	0.3901
1046440237	1046.440237	1.046440237	-0.7011	1.2619	0.2192	0.5681
1072500390	1072.50039	1.07250039	-0.6746	1.2925	0.3431	0.7147
1098560543	1098.560543	1.098560543	-0.5586	1.2954	0.327	0.6845
1146004725	1146.004725	1.146004725	-0.6915	1.2776	0.1982	0.4952
1193448907	1193.448907	1.193448907	-0.5293	1.3624	0.4102	0.8378
1240893089	1240.893089	1.240893089	-0.4358	1.3148	0.3072	0.6405
1288337271	1288.337271	1.288337271	-0.4229	1.3631	0.3584	0.7816
1335781453	1335.781453	1.335781453	-0.4091	1.3461	0.4356	0.8484
1383225635	1383.225635	1.383225635	-0.452	1.3665	0.3619	0.7359
1430669817	1430.669817	1.430669817	-0.2693	1.3861	0.5282	1.0496
1478113999	1478.113999	1.478113999	-0.3283	1.3603	0.4364	0.8795
1525558181	1525.558181	1.525558181	-0.3623	1.3782	0.4593	0.9594
1573002363	1573.002363	1.573002363	-0.1895	1.3722	0.6224	1.1531
1620446545	1620.446545	1.620446545	-0.2447	1.3704	0.489	0.9819
1667890726	1667.890726	1.667890726	-0.2557	1.3888	0.6608	1.2791
1715334908	1715.334908	1.715334908	-0.1213	1.3617	0.5863	1.1501
1762779090	1762.77909	1.76277909	-0.1428	1.4004	0.6275	1.302
1810223272	1810.223272	1.810223272	-0.0866	1.3866	0.7401	1.4904
1857667454	1857.667454	1.857667454	-0.1421	1.3634	0.5827	1.2961
1905111636	1905.111636	1.905111636	-0.0817	1.3888	0.7548	1.567
1952555818	1952.555818	1.952555818	-0.0754	1.3454	0.6894	1.3725
2000000000	2000	2	-0.0882	1.3586	0.6786	1.3686
2086375179	2086.375179	2.086375179	-0.0928	1.3427	0.6671	1.2882
2172750359	2172.750359	2.172750359	-0.0711	1.3471	0.8647	1.5659
2259125538	2259.125538	2.259125538	0.0238	1.3562	0.8852	1.6141
2345500717	2345.500717	2.345500717	0.0348	1.35	0.801	1.4694
2431875896	2431.875896	2.431875896	0.0739	1.3523	0.952	1.645
2518251076	2518.251076	2.518251076	0.1477	1.3574	1.1303	1.9453
2604626255	2604.626255	2.604626255	0.0696	1.3603	1.0144	1.8045

Frequency (Hz)	Frequency (MHz)	Frequency (GHz)	e" Acetaldehyde	e" Acetic acid	e" Acetone	e" Acetonitrile
2691001434	2691.001434	2.691001434	0.0798	1.3328	0.9693	1.7428
2777376613	2777.376613	2.777376613	0.1596	1.3185	1.1905	2.1785
2863751793	2863.751793	2.863751793	0.125	1.3257	1.214	2.4218
2950126972	2950.126972	2.950126972	0.1337	1.3054	1.0468	2.4043
3036502151	3036.502151	3.036502151	0.3126	1.293	1.2236	2.7457
3122877330	3122.87733	3.12287733	0.3646	1.3228	1.4642	2.977
3209252510	3209.25251	3.20925251	0.5578	1.3222	1.4524	2.681
3295627689	3295.627689	3.295627689	1.0366	1.3072	1.4889	2.4322
3382002868	3382.002868	3.382002868	1.2467	1.3197	1.7644	2.7993
3468378048	3468.378048	3.468378048	1.2118	1.3375	1.8599	3.0302
3554753227	3554.753227	3.554753227	1.1342	1.2828	1.6055	2.6747
3641128406	3641.128406	3.641128406	1.0857	1.2587	1.5877	2.703
3798379965	3798.379965	3.798379965	1.0181	1.2562	1.6063	2.8267
3955631525	3955.631525	3.955631525	1.0842	1.2778	2.0377	3.5457
4112883084	4112.883084	4.112883084	1.2051	1.2097	1.9546	3.2578
4270134644	4270.134644	4.270134644	1.3114	1.1785	1.6347	2.8347
4427386203	4427.386203	4.427386203	1.4649	1.2486	2.1398	3.6841
4584637762	4584.637762	4.584637762	1.573	1.2351	2.2731	3.8602
4741889322	4741.889322	4.741889322	1.6719	1.1521	1.9152	3.2301
4899140881	4899.140881	4.899140881	1.7154	1.2132	2.3091	3.9695
5056392441	5056.392441	5.056392441	1.6939	1.262	2.8062	4.8777
5213644000	5213.644	5.213644	1.8284	1.1626	2.3507	4.0434
5370895559	5370.895559	5.370895559	1.9999	1.1459	2.1941	3.7947
5528147119	5528.147119	5.528147119	2.0229	1.2431	3.0414	5.2296
5685398678	5685.398678	5.685398678	2.0513	1.1948	2.9795	5.0515
5842650238	5842.650238	5.842650238	2.2827	1.1403	2.5021	4.2962
5999901797	5999.901797	5.999901797	2.2603	1.2038	3.0771	5.4115
6157153356	6157.153356	6.157153356	2.4005	1.1963	3.4189	5.9282
6314404916	6314.404916	6.314404916	2.6156	1.1674	3.0717	5.2022
6471656475	6471.656475	6.471656475	2.6596	1.1977	3.2097	5.3211
6628908035	6628.908035	6.628908035	2.6877	1.2461	3.8268	6.2115
6915194595	6915.194595	6.915194595	2.9044	1.1612	3.5598	5.6404
7201481155	7201.481155	7.201481155	2.944	1.1876	3.6305	5.6786
7487767714	7487.767714	7.487767714	2.9613	1.1893	4.1765	6.5323
7774054274	7774.054274	7.774054274	3.0565	1.1345	3.771	5.7616
8060340834	8060.340834	8.060340834	3.0922	1.1798	3.8977	6.1007

Frequency (Hz)	Frequency (MHz)	Frequency (GHz)	e" Acetaldehyde	e" Acetic acid	e" Acetone	e" Acetonitrile
8632913954	8632.913954	8.632913954	3.0879	1.1481	3.9386	6.228
8919200514	8919.200514	8.919200514	2.9841	1.1765	4.1943	6.804
9205487074	9205.487074	9.205487074	2.9088	1.0938	4.4234	7.1568
9491773634	9491.773634	9.491773634	3.0287	1.1392	4.0955	6.5623
9778060194	9778.060194	9.778060194	2.9075	1.1331	4.415	7.1347
10064346754	10064.34675	10.06434675	2.8397	1.0708	4.5613	7.2624
10350633314	10350.63331	10.35063331	2.7562	1.1234	4.112	6.4458
10636919874	10636.91987	10.63691987	2.7622	1.0524	4.432	7.0836
10923206433	10923.20643	10.92320643	2.8204	1.0393	4.5224	7.2181
11209492993	11209.49299	11.20949299	2.8758	1.0924	4.1675	6.6618
11495779553	11495.77955	11.49577955	2.8534	1.0227	4.7269	7.8231
11782066113	11782.06611	11.78206611	2.9035	1.0194	4.6688	7.8185
12068352673	12068.35267	12.06835267	2.9097	1.0502	4.4646	7.5083
12589555736	12589.55574	12.58955574	3.0275	1.0106	5.205	9.0162
13110758799	13110.7588	13.1107588	2.7792	1.0172	5.072	8.84
13631961861	13631.96186	13.63196186	2.5959	1.069	4.4605	7.824
14153164924	14153.16492	14.15316492	2.6249	0.9666	4.9697	8.9934
14674367987	14674.36799	14.67436799	3.0322	0.988	5.7747	10.6441
15195571050	15195.57105	15.19557105	3.2107	0.9408	5.391	10.2683
15716774113	15716.77411	15.71677411	3.4043	0.8981	5.6611	10.9399
16237977175	16237.97718	16.23797718	3.3024	0.9724	6.4683	12.2276
16759180238	16759.18024	16.75918024	3.5522	1.0167	5.7985	10.7544
17280383301	17280.3833	17.2803833	3.753	0.994	5.704	10.9545
17801586364	17801.58636	17.80158636	3.974	0.9507	7.0677	13.8843
18322789427	18322.78943	18.32278943	4.3739	0.9978	7.2651	14.0869
18843992489	18843.99249	18.84399249	4.2383	1.0035	6.3781	12.0355
19365195552	19365.19555	19.36519555	4.699	0.9062	7.1159	13.82
19886398615	19886.39861	19.88639861	4.7293	0.8779	7.6881	14.8588
20407601678	20407.60168	20.40760168	5.3017	0.6406	6.2813	11.6409
20928804741	20928.80474	20.92880474	5.2127	0.5495	6.9137	13.1981
21450007803	21450.0078	21.4500078	5.8122	0.7323	9.0339	19.7773
21971210866	21971.21087	21.97121087	6.1538	0.7142	8.6335	19.5801
22920094505	22920.0945	22.9200945	5.9814	0.8792	10.4815	21.5814
23868978143	23868.97814	23.86897814	6.6729	0.7804	9.3342	17.9312
24817861782	24817.86178	24.81786178	7.3517	0.7752	9.1279	16.9449
25766745421	25766.74542	25.76674542	6.973	0.7619	8.0753	13.2169

Frequency (Hz)	Frequency (MHz)	Frequency (GHz)	e" Acetaldehyde	e" Acetic acid	e" Acetone	e" Acetonitrile
26715629059	26715.62906	26.71562906	6.8532	0.8519	9.8152	17.6516
27664512698	27664.5127	27.6645127	8.1457	0.93	12.7618	20.4476
28613396336	28613.39634	28.61339634	9.7444	0.9151	13.5359	24.7994
29562279975	29562.27998	29.56227998	7.9231	0.7157	8.6963	14.1666
30511163614	30511.16361	30.51116361	8.0745	0.825	9.2723	14.8413
31460047252	31460.04725	31.46004725	11.0789	0.9285	12.2764	0
32408930891	32408.93089	32.40893089	9.9468	0.8595	11.7626	0
33357814530	33357.81453	33.35781453	10.9967	0.894	12.7824	0
34306698168	34306.69817	34.30669817	9.0494	0.9062	12.3301	0
35255581807	35255.58181	35.25558181	9.428	0.8318	11.4813	0
36204465445	36204.46545	36.20446545	11.8093	0.8526	11.2546	0
37153349084	37153.34908	37.15334908	0	0.6682	5.8814	0
38102232723	38102.23272	38.10223272	0	1.0014	0	0
39051116361	39051.11636	39.05111636	0	1.0163	0	0
40000000000	40000	40	0	0.9047	0	0

Loss Factor' (e'') measurement of chemicals at frequencies from 0.1 to 40 GHz

Chemicals; Acetaldehyde, Acetic Acid, Acetone, Acetonitrile, *n-Butylamine, Cyclohexanol, DCM, Diethylamine, Digol, DMF, DMSO*

Ethanol, Ethanolamine, Ether, Ethyl Acetate, Formamide, Isopropanol, Nitromethane, Pentanedione, Pyridine and THF

loss factor' - e'' related to power dissipation in the solvent

Frequency (GHz)	e'' n-Butylamine	e'' Cyclohexanol	e'' DCM	e'' Diethylamine	e'' Digol	e'' DMF	e'' DMSO	e'' Ethanol
0.1	0	-3.6626	-1.0576	-11.2987	3.0827	-0.4578	-0.5049	2.1271
0.104318759	-14.5802	-4.0719	-1.0855	-11.7354	3.2751	-0.5029	-0.4292	2.2181
0.108637518	-14.9328	-4.3142	-0.9129	-11.6036	3.8663	-0.4177	-0.1699	2.7138
0.112956277	-14.4305	-4.2862	-0.8829	-11.4856	4.0816	-0.1433	0.2037	2.711
0.117275036	-13.2876	-3.5731	-0.8549	-10.51	4.2734	-0.1274	0.0382	2.7748
0.121593795	-12.5231	-3.1504	-0.7695	-10.1402	4.4634	-0.0685	0.1814	2.949
0.125912554	-11.3489	-2.5228	-0.6321	-8.9316	4.6199	-0.1025	0.0903	2.9927
0.130231313	-9.8651	-1.8233	-0.5579	-7.914	5.0203	0.1098	0.3929	3.0407
0.134550072	-8.6325	-0.8424	-0.7085	-6.8515	4.9873	-0.0075	-0.2398	2.9171
0.138868831	-7.6312	-0.2326	-0.8512	-6.2186	5.0296	-0.2727	0.0397	2.635
0.14318759	-7.0968	0.1821	-0.469	-5.8771	5.225	-0.1659	0.0251	3.1432
0.147506349	-6.5976	0.3709	-0.6083	-5.363	5.1913	-0.6076	-0.107	3.1344
0.151825108	-6.7899	0.0252	-0.7386	-5.4494	5.2686	-0.4979	-0.2761	3.3113
0.156143867	-7.1584	0.027	-0.6737	-5.5772	4.9757	-0.3766	-0.3265	2.9706
0.160462625	-6.8759	0.0239	-0.8416	-5.4259	5.1041	-0.5524	-0.5411	3.0064
0.164781384	-7.4002	-0.3299	-0.7343	-5.9893	5.3865	-1.0376	-0.7976	3.082
0.169100143	-7.2981	-0.4546	-1.2393	-6.0542	4.9764	-1.1128	-0.7972	2.9711
0.173418902	-7.7001	-0.6095	-1.9177	-6.1543	5.7776	-2.0159	-1.1008	3.3507
0.177737661	-7.3519	-0.6374	-0.9001	-5.6368	5.5758	-0.8223	-0.7629	3.0733
0.18205642	-7.0592	-0.4609	-1.0011	-5.7036	5.5453	-0.8966	-0.6647	3.1864
0.189918998	-7.2296	-0.485	-0.8141	-5.7384	5.8503	-0.6175	-0.3922	3.5324
0.197781576	-6.7626	-0.3929	-1.0466	-5.3758	6.2359	-0.4772	-0.0666	3.6649
0.205644154	-6.0509	-0.0591	-0.6233	-4.7175	7.0705	-0.2075	0.3211	4.2295
0.213506732	-5.4896	0.0787	-0.5068	-4.4055	7.4607	0.1595	0.5745	4.4765
0.22136931	-5.0703	0.4378	-0.2324	-3.9217	7.807	0.2608	0.8919	4.8028
0.229231888	-4.3908	0.6295	-0.2614	-3.5634	8.1658	0.5721	1.2499	5.0466
0.237094466	-4.7939	0.2551	-0.3194	-3.7786	8.4577	0.6072	1.3327	5.3011
0.244957044	-4.3151	0.574	-0.1951	-3.4216	8.465	0.5472	1.2836	5.3592
0.252819622	-4.7564	0.1503	-0.3134	-3.6907	8.3905	0.4757	1.0478	5.4467
0.2606822	-4.8082	0.0314	-0.2509	-3.8311	8.4103	0.3504	1.0159	5.476
0.268544778	-4.6208	0.164	-0.4681	-3.669	8.298	0.144	0.7156	5.5548

Frequency (GHz)	e" Butyl amine	e" Cyclohexanol	e" DCM	e" Diethylamine	e" Digol	e" DMF	e" DMSO	e" Ethanol
0.276407356	-4.4421	0.1825	-0.539	-3.569	8.3218	-0.0599	0.6113	5.5228
0.284269934	-4.1927	0.3051	-0.6857	-3.3681	8.3816	-0.1989	0.6039	5.4641
0.292132512	-3.8333	0.4337	-0.622	-3.0047	8.4343	-0.2254	0.4444	5.5964
0.29999509	-3.5629	0.5326	-0.4904	-2.8524	8.5693	-0.1622	0.6685	5.6921
0.307857668	-3.448	0.6401	-0.4869	-2.7075	8.6758	-0.0072	0.7629	5.9498
0.315720246	-3.2443	0.7168	-0.3626	-2.523	9.0498	0.1449	0.9933	6.1959
0.323582824	-3.2995	0.6092	-0.3354	-2.6404	9.2427	0.3634	1.3049	6.4782
0.331445402	-3.2869	0.528	-0.3162	-2.6222	9.3782	0.5338	1.5099	6.6577
0.34575973	-3.2825	0.522	-0.1277	-2.5613	9.8274	0.823	1.8715	7.1688
0.360074058	-3.2874	0.4295	-0.1945	-2.5724	10.0049	0.8611	1.9937	7.3956
0.374388386	-2.6252	0.7205	-0.1601	-1.9967	10.0652	0.8424	1.9782	7.5308
0.388702714	-2.5673	0.7118	-0.2543	-2.0581	9.8723	0.5952	1.8146	7.591
0.403017042	-2.6735	0.577	-0.3292	-2.0945	9.7643	0.4331	1.602	7.6303
0.41733137	-2.7926	0.451	-0.383	-2.1649	9.5899	0.3114	1.4984	7.7051
0.431645698	-2.6364	0.477	-0.3145	-2.0949	9.8126	0.4952	1.7187	7.9905
0.445960026	-2.39	0.5604	-0.1864	-1.8964	10.0031	0.7926	2.1413	8.2935
0.460274354	-2.0469	0.7427	-0.0514	-1.6472	10.3239	1.115	2.5712	8.6651
0.474588682	-1.9987	0.7371	-0.0898	-1.5518	10.4305	1.2455	2.7692	8.8749
0.48890301	-2.2009	0.5454	-0.0537	-1.6918	10.2796	1.1905	2.7282	9.0047
0.503217338	-2.2656	0.4568	-0.1532	-1.7273	10.2327	1.0127	2.6179	9.0352
0.517531666	-2.1143	0.5038	-0.1784	-1.6759	10.0151	0.8833	2.4344	9.0503
0.531845994	-1.9919	0.5716	-0.29	-1.4968	9.8701	0.7579	2.3687	9.0605
0.546160322	-1.8992	0.5723	-0.226	-1.4719	9.8748	0.8895	2.5555	9.2843
0.56047465	-1.7318	0.6401	-0.1814	-1.3792	9.9951	1.0798	2.828	9.4509
0.574788978	-1.7078	0.629	-0.125	-1.327	10.0756	1.2859	3.1333	9.6672
0.589103306	-1.8763	0.4911	-0.0717	-1.4182	10.1667	1.4495	3.3292	9.8709
0.603417634	-2.0609	0.3408	-0.0818	-1.5514	10.083	1.4924	3.4154	9.9885
0.629477787	-1.4905	0.6666	-0.1434	-1.1365	9.927	1.3121	3.3392	9.9883
0.65553794	-1.3218	0.7251	-0.1751	-0.9947	9.7021	1.2558	3.3005	10.0664
0.681598093	-1.4114	0.586	-0.126	-1.0963	9.7639	1.4789	3.6592	10.271
0.707658246	-1.2013	0.6824	-0.0254	-0.9386	9.8466	1.7905	4.0901	10.5214
0.733718399	-1.3318	0.5975	-0.0557	-0.9776	9.6708	1.7529	4.1276	10.587
0.759778552	-1.2667	0.5851	-0.1423	-0.9264	9.4483	1.61	3.9806	10.5326
0.785838706	-1.0104	0.7401	-0.1349	-0.7267	9.3325	1.6631	4.1456	10.5858
0.811898859	-1.0658	0.6365	-0.0431	-0.7995	9.4074	1.9673	4.6018	10.8061
0.837959012	-1.1842	0.5534	-0.0049	-0.8537	9.3896	2.1614	4.8821	10.9485

Frequency (GHz)	e" Butyl amine	e" Cyclohexanol	e" DCM	e" Diethylamine	e" Digol	e" DMF	e" DMSO	e" Ethanol
0.864019165	-1.1264	0.5495	-0.0441	-0.8267	9.2416	2.0236	4.8324	10.874
0.890079318	-1.1495	0.5003	-0.0881	-0.8396	8.9842	1.8988	4.7537	10.7728
0.916139471	-0.971	0.5841	-0.0781	-0.6991	8.868	2.1008	5.017	10.8399
0.942199624	-0.9785	0.5514	0.0038	-0.6903	8.9545	2.3548	5.4108	10.9522
0.968259778	-0.9085	0.5738	0.0431	-0.6483	8.8154	2.4353	5.5573	10.9599
0.994319931	-0.9666	0.5319	-0.0179	-0.6892	8.5897	2.3047	5.4403	10.8229
1.020380084	-0.7819	0.629	-0.0617	-0.5396	8.393	2.2833	5.4805	10.749
1.046440237	-0.7958	0.5953	-0.0215	-0.539	8.4608	2.5203	5.8244	10.8306
1.07250039	-0.7598	0.5761	0.0664	-0.5206	8.4552	2.751	6.1755	10.8957
1.098560543	-0.6715	0.6361	0.0483	-0.4436	8.3936	2.7322	6.2081	10.82
1.146004725	-0.7999	0.5165	-0.0461	-0.5316	8.0062	2.6188	6.1927	10.6055
1.193448907	-0.6428	0.5898	0.0757	-0.4055	8.1253	3.0738	6.8676	10.7309
1.240893089	-0.5952	0.6034	0.0163	-0.3497	7.866	2.9465	6.7792	10.4968
1.288337271	-0.5552	0.5849	0.0193	-0.3409	7.6598	3.1819	7.1905	10.4536
1.335781453	-0.57	0.5448	0.0859	-0.3333	7.6214	3.3612	7.4836	10.379
1.383225635	-0.5988	0.5045	0.0211	-0.3499	7.4097	3.2958	7.5249	10.1813
1.430669817	-0.4439	0.5627	0.1104	-0.2562	7.3921	3.706	8.1172	10.1982
1.478113999	-0.4996	0.5353	0.0757	-0.265	7.1337	3.5559	8.0421	9.9539
1.525558181	-0.5362	0.46	0.0464	-0.3087	7.0075	3.7473	8.3601	9.847
1.573002363	-0.376	0.5542	0.1435	-0.1781	7.0588	3.9828	8.7875	9.7887
1.620446545	-0.447	0.4897	0.0625	-0.2284	6.7941	3.8612	8.7169	9.568
1.667890726	-0.46	0.4786	0.1469	-0.222	6.7778	4.258	9.3177	9.5593
1.715334908	-0.3086	0.5568	0.1348	-0.1041	6.6388	4.1498	9.2465	9.3373
1.76277909	-0.3549	0.506	0.1217	-0.1237	6.5214	4.3176	9.579	9.2361
1.810223272	-0.2922	0.5154	0.1869	-0.0889	6.4911	4.5628	9.9636	9.1713
1.857667454	-0.3684	0.4753	0.1109	-0.1285	6.2573	4.3878	9.8264	8.9297
1.905111636	-0.3029	0.4977	0.1694	-0.0779	6.2748	4.7915	10.4133	8.9262
1.952555818	-0.2773	0.4737	0.1709	-0.0638	6.2176	4.7267	10.3834	8.7376
2	-0.3108	0.4469	0.1364	-0.0813	6.0067	4.8707	10.6212	8.6245
2.086375179	-0.2872	0.4339	0.1506	-0.0672	5.9739	5.0161	10.8945	8.4094
2.172750359	-0.3025	0.407	0.2287	-0.0687	5.877	5.5102	11.6657	8.3078
2.259125538	-0.2644	0.4319	0.1982	-0.0141	5.6711	5.6698	12.0325	8.097
2.345500717	-0.2354	0.4084	0.1682	-0.0085	5.5093	5.5824	12.0739	7.8417
2.431875896	-0.207	0.4106	0.2517	0.0147	5.4681	5.9018	12.6131	7.7182
2.518251076	-0.1819	0.4236	0.2918	0.0533	5.3906	6.4133	13.3415	7.6072
2.604626255	-0.2652	0.3481	0.2398	-0.0021	5.168	6.3912	13.3633	7.3693

Frequency (GHz)	e" Butyl amine	e" Cyclohexanol	e" DCM	e" Diethylamine	e" Digol	e" DMF	e" DMSO	e" Ethanol
2.691001434	-0.2704	0.324	0.2397	-0.0061	5.0964	6.4563	13.5139	7.1865
2.777376613	-0.252	0.3224	0.3172	0.0251	5.1019	7.0224	14.267	7.1269
2.863751793	-0.3163	0.2783	0.3037	-0.0167	4.9552	7.2454	14.637	6.9614
2.950126972	-0.3134	0.2673	0.2428	-0.0108	4.8004	7.0654	14.5842	6.7322
3.036502151	-0.1959	0.3216	0.3182	0.0884	4.8082	7.4308	15.1556	6.685
3.12287733	-0.1945	0.3089	0.3867	0.0867	4.7287	7.9307	15.8144	6.6093
3.20925251	-0.0784	0.3603	0.3523	0.1733	4.5775	7.878	15.7889	6.3812
3.295627689	0.2759	0.5699	0.3714	0.4394	4.5652	7.8408	15.776	6.2533
3.382002868	0.4766	0.6786	0.4808	0.5963	4.6455	8.4274	16.4958	6.2478
3.468378048	0.4873	0.6705	0.507	0.6131	4.5555	8.7485	16.8534	6.1251
3.554753227	0.4101	0.6269	0.3977	0.5765	4.3497	8.4232	16.4938	5.9
3.641128406	0.3475	0.572	0.4165	0.5378	4.3596	8.5817	16.7133	5.8385
3.798379965	0.2319	0.4829	0.4155	0.459	4.1994	8.8793	17.1012	5.6489
3.955631525	0.1845	0.4424	0.5534	0.4388	4.1721	9.7511	18.1196	5.614
4.112883084	0.2286	0.4603	0.4801	0.4842	3.99	9.6477	18.0892	5.3939
4.270134644	0.2328	0.4336	0.3978	0.502	3.8732	9.4179	17.7903	5.1284
4.427386203	0.2402	0.4187	0.6154	0.5167	3.8672	10.5472	18.9732	5.1523
4.584637762	0.2842	0.4331	0.6572	0.5616	3.8408	10.9805	19.511	5.0746
4.741889322	0.3188	0.4348	0.4894	0.5957	3.6988	10.4214	18.891	4.8252
4.899140881	0.3427	0.4342	0.645	0.6202	3.6142	11.1344	19.4617	4.756
5.056392441	0.3624	0.4309	0.8703	0.6464	3.6206	12.2478	20.5488	4.7697
5.213644	0.4346	0.4618	0.6839	0.7139	3.5271	11.6994	20.026	4.5861
5.370895559	0.4595	0.4653	0.6129	0.7415	3.351	11.4662	19.5622	4.3945
5.528147119	0.4273	0.4249	0.9341	0.7271	3.409	12.9964	20.9589	4.446
5.685398678	0.479	0.4485	0.9273	0.7751	3.4344	13.128	21.1971	4.4263
5.842650238	0.552	0.4804	0.725	0.8217	3.2656	12.3794	20.3486	4.2114
5.999901797	0.5499	0.4544	0.9499	0.8274	3.2479	13.3266	20.9771	4.1175
6.157153356	0.6167	0.4903	1.1114	0.894	3.2884	14.0499	21.6253	4.1448
6.314404916	0.6696	0.511	0.9948	0.9384	3.2178	13.6039	21.2598	4.0776
6.471656475	0.6825	0.5045	1.0214	0.9373	3.1078	13.784	21.0521	3.9242
6.628908035	0.7036	0.5181	1.2356	0.9633	3.1643	14.7356	21.8212	3.9993
6.915194595	0.7229	0.4961	1.1204	0.993	3.1171	14.6401	21.7007	3.8561
7.201481155	0.8359	0.5402	1.1372	1.0901	2.9295	14.5657	21.1537	3.6651
7.487767714	0.791	0.5105	1.3255	1.081	2.9427	15.4991	21.7116	3.6457
7.774054274	0.8275	0.4984	1.1621	1.1263	2.8626	15.1884	21.3949	3.5401
8.060340834	0.8707	0.5074	1.2121	1.1811	2.7045	15.2241	20.7869	3.3598

Frequency (GHz)	e" Butyl amine	e" Cyclohexanol	e" DCM	e" Diethylamine	e" Digol	e" DMF	e" DMSO	e" Ethanol
8.632913954	0.9218	0.5021	1.2481	1.218	2.6437	15.8161	21.0412	3.2915
8.919200514	0.9406	0.4903	1.3385	1.2244	2.5359	15.9934	20.5611	3.1261
9.205487074	0.9087	0.4717	1.4533	1.2076	2.5981	16.6558	21.0546	3.1866
9.491773634	0.9579	0.511	1.3236	1.2647	2.4922	16.2898	20.5164	3.0391
9.778060194	0.9437	0.4964	1.4463	1.2588	2.4252	16.4542	20.1127	2.9641
10.06434675	0.9045	0.4565	1.5241	1.2313	2.5036	17.1144	20.6713	3.0023
10.35063331	0.9418	0.4765	1.335	1.2611	2.3437	16.3786	19.7168	2.8377
10.63691987	0.8826	0.4269	1.4722	1.2121	2.2653	16.5397	19.3567	2.7568
10.92320643	0.9216	0.4301	1.553	1.2278	2.3367	17.1102	19.8383	2.8482
11.20949299	0.9503	0.4491	1.3813	1.251	2.1441	16.3261	18.7933	2.6322
11.49577955	0.9477	0.4244	1.6072	1.2282	2.1838	16.9531	19.0182	2.6921
11.78206611	0.9696	0.4348	1.5643	1.2519	2.1881	17.3447	19.2999	2.6919
12.06835267	1.0483	0.4645	1.4596	1.3158	2.0465	16.6285	18.3062	2.5093
12.58955574	1.0719	0.4612	1.7526	1.3465	2.1625	17.6869	18.7822	2.61
13.1107588	1.0917	0.4377	1.6973	1.3428	2.1398	17.937	18.8199	2.5758
13.63196186	1.1088	0.4616	1.4234	1.3733	1.9033	16.7533	17.4263	2.3841
14.15316492	1.1178	0.4422	1.5776	1.3682	1.861	16.9013	17.0066	2.3093
14.67436799	1.0963	0.4114	1.9057	1.3487	2.0348	18.3014	17.9912	2.4899
15.19557105	1.2167	0.46	1.628	1.4075	1.8349	17.6398	17.1409	2.3585
15.71677411	1.2284	0.4545	1.6126	1.4222	1.7811	17.3594	16.4636	2.2179
16.23797718	1.2583	0.4474	2.0252	1.427	1.985	18.4306	17.2005	2.3043
16.75918024	1.2332	0.4314	1.7842	1.3982	1.7854	17.4786	16.4751	2.296
17.2803833	1.2314	0.4126	1.5534	1.3907	1.5031	16.5008	15.2139	2.0663
17.80158636	1.3025	0.4656	2.0582	1.4473	1.7405	17.9372	15.8449	2.1358
18.32278943	1.3358	0.4699	2.2402	1.472	1.8559	18.6035	16.5195	2.2979
18.84399249	1.3054	0.452	1.7068	1.4546	1.4752	16.879	15.0666	2.3272
19.36519555	1.38	0.4883	1.8324	1.4892	1.4816	16.951	14.6867	2.0327
19.88639861	1.3076	0.4423	2.2061	1.4239	1.7579	18.3964	15.7474	2.0365
20.40760168	1.3425	0.473	1.6337	1.4817	1.2803	16.2999	14.2578	1.9601
20.92880474	1.3025	0.454	1.4793	1.43	0.9656	15.3042	13.0562	1.906
21.4500078	1.4286	0.5354	2.032	1.5369	1.3966	17.8418	14.4918	1.7798
21.97121087	1.4504	0.5127	2.105	1.52	1.5638	19.4373	15.8658	1.8152
22.9200945	1.3217	0.4277	2.8516	1.4124	1.7808	19.2811	15.6021	1.9337
23.86897814	1.3914	0.4771	2.2883	1.465	1.3125	15.6223	12.686	1.8893
24.81786178	1.5396	0.5294	2.3603	1.526	1.3075	14.6127	11.9307	1.8738
25.76674542	1.5905	0.5143	2.8636	1.5658	1.412	15.0539	12.4456	1.869

Frequency (GHz)	e" Butyl amine	e" Cyclohexanol	e" DCM	e" Diethylamine	e" Digol	e" DMF	e" DMSO	e" Ethanol
26.71562906	1.4407	0.3928	3.4362	1.4323	1.7898	17.4532	14.3902	1.9255
27.6645127	1.4733	0.4157	3.3867	1.4096	1.7384	17.0313	13.5707	1.952
28.61339634	1.6888	0.5466	3.459	1.5364	1.6155	15.0907	11.7926	1.9068
29.56227998	1.4245	0.4579	2.8606	1.4247	1.1624	12.6871	10.2589	1.7381
30.51116361	1.6114	0.5444	3.2311	1.4921	1.3754	13.2668	10.8633	1.8131
31.46004725	1.9455	0.6326	3.8231	1.6548	1.7039	16.2776	12.8935	1.9007
32.40893089	1.616	0.4792	3.7088	1.397	1.4658	14.0541	11.0291	1.8297
33.35781453	1.7657	0.5625	3.9317	1.4961	1.5689	14.0803	10.7731	1.9057
34.30669817	1.8233	0.6301	3.9392	1.6331	1.5955	14.0638	11.0983	1.8878
35.25558181	1.792	0.6005	3.961	1.535	1.3885	12.8265	10.384	1.7977
36.20446545	1.903	0.5721	4.1149	1.5021	1.4117	12.2205	9.7567	1.867
37.15334908	1.3794	0.332	2.8287	1.1442	0.9269	9.5379	7.7925	1.5901
38.10223272	1.9739	0.5412	4.1058	1.5994	1.8271	17.1303	12.3134	1.9699
39.05111636	1.8222	0.5139	5.0518	1.4591	1.8332	14.2734	11.4227	1.9758
40	2.088	0.6972	4.7392	1.6252	1.5751	9.0835	7.7747	1.5352

Loss Factor' (e'') measurement of chemicals at frequencies from 0.1 to 40 GHz

Chemicals; Acetaldehyde, Acetic Acid, Acetone, Acetonitrile, n-Butylamine, Cyclohexanol, DCM, Diethylamine, Digol, DMF, DMSO
Ethanol, **Ethanolamine, Ether, Ethyl Acetate, Formamide, Isopropanol, Nitromethane**, Pentanedione, Pyridine and THF

loss factor' - e'' related to power dissipation in the solvent

Frequency (GHz)	e'' Ethanolamine	e'' Ether	e'' Ethyl acetate	e'' Formamide	e'' Isopropanol	e'' Nitromethane
0.1	-7.4347	-2.2005	-1.6955	19.0837	0.5305	-14.5159
0.104318759	-7.8568	-2.4593	-1.9784	17.8745	0.7066	-14.8697
0.108637518	-7.8616	-2.0268	-1.4307	16.5954	0.7342	-14.8902
0.112956277	-7.4435	-2.0816	-1.4452	16.2415	0.8769	-14.6328
0.117275036	-6.228	-2.1299	-1.4551	16.1843	1.3882	-13.4994
0.121593795	-5.221	-1.8765	-1.3468	16.262	1.8089	-12.8054
0.125912554	-4.0388	-1.6403	-1.3039	16.7134	1.9675	-11.3381
0.130231313	-2.7674	-1.3064	-0.9253	16.7458	2.4545	-9.9164
0.134550072	-1.1843	-1.4818	-1.1691	17.7146	3.5668	-8.3012
0.138868831	-0.4885	-1.651	-1.032	17.3059	3.4999	-7.8171
0.14318759	0.2784	-1.1417	-1.0031	17.039	3.9012	-7.1259
0.147506349	0.6827	-0.8597	-0.8254	17.1304	4.1217	-6.6241
0.151825108	0.4631	-0.884	-0.8983	16.0856	4.0959	-6.9413
0.156143867	0.4937	-1.5164	-1.1072	15.8562	4.1208	-6.9533
0.160462625	0.6371	-1.2928	-1.1706	14.8296	4.3705	-7.0755
0.164781384	0.4663	-1.3044	-1.3211	15.6449	4.3464	-7.3745
0.169100143	0.3871	-1.6193	-1.503	14.9476	4.4429	-7.4607
0.173418902	0.952	-1.9557	-2.0951	17.0016	5.3475	-8.8508
0.177737661	0.6217	-1.6228	-1.3107	13.979	4.7995	-7.3902
0.18205642	0.7495	-1.6259	-1.5225	14.0207	4.8396	-7.3457
0.189918998	1.2763	-1.4838	-1.1139	13.8412	5.3342	-7.1773
0.197781576	1.8465	-1.6116	-1.3327	14.2114	5.3907	-6.686
0.205644154	2.3598	-1.1974	-0.9677	14.1461	5.7607	-5.9018
0.213506732	2.9666	-0.9504	-0.7299	14.6629	6.0279	-5.4372
0.22136931	3.618	-0.6537	-0.5135	14.3854	6.3285	-4.9153
0.229231888	4.1014	-0.57	-0.3394	14.5852	6.4023	-4.3062
0.237094466	3.9127	-0.6122	-0.4543	14.187	6.4486	-4.6803
0.244957044	4.3341	-0.594	-0.4717	14.0114	6.801	-4.3692
0.252819622	4.1973	-0.5183	-0.5184	13.622	6.6057	-4.5822
0.2606822	4.142	-0.6438	-0.533	13.6967	6.7379	-4.6762
0.268544778	4.2732	-0.8458	-0.7382	13.7536	6.831	-4.5614

Frequency (GHz)	e" Ethanolamine	e" Ether	e" Ethyl acetate	e" Formamide	e" Isopropanol	e" Nitromethane
0.276407356	4.4991	-0.9028	-0.7995	13.8235	6.8927	-4.3308
0.284269934	4.8454	-0.9048	-0.8027	14.1642	6.9926	-4.0264
0.292132512	5.2223	-0.9299	-0.7323	14.384	7.2587	-3.6691
0.29999509	5.4712	-0.7614	-0.6664	14.5328	7.3159	-3.5008
0.307857668	5.6744	-0.8386	-0.653	14.5135	7.4171	-3.2865
0.315720246	5.8691	-0.6317	-0.5653	14.5207	7.5177	-3.1618
0.323582824	5.8798	-0.5491	-0.5095	14.6011	7.4916	-3.0961
0.331445402	5.872	-0.5389	-0.4135	14.711	7.5577	-3.1511
0.34575973	6.0326	-0.4584	-0.299	14.4811	7.7006	-3.1505
0.360074058	6.1382	-0.4031	-0.3144	14.8939	7.6356	-2.9786
0.374388386	6.6782	-0.3928	-0.2732	15.242	7.7547	-2.3919
0.388702714	6.8189	-0.436	-0.3033	15.3798	7.76	-2.3035
0.403017042	6.7061	-0.5492	-0.4608	15.4965	7.6793	-2.4475
0.41733137	6.7116	-0.6025	-0.535	15.5878	7.6157	-2.54
0.431645698	6.8969	-0.5691	-0.5052	15.9908	7.6728	-2.3971
0.445960026	7.2443	-0.3902	-0.2651	16.4473	7.6531	-2.0373
0.460274354	7.4798	-0.2548	-0.1362	16.7327	7.7219	-1.7445
0.474588682	7.5736	-0.3103	-0.1066	16.9178	7.7396	-1.7206
0.48890301	7.4202	-0.2599	-0.1861	16.929	7.6269	-1.9023
0.503217338	7.401	-0.3587	-0.2318	17.1866	7.5008	-1.9105
0.517531666	7.5074	-0.365	-0.3023	17.5086	7.4284	-1.7326
0.531845994	7.6841	-0.4386	-0.3662	17.8463	7.4583	-1.6326
0.546160322	7.7092	-0.4146	-0.2926	18.1611	7.3817	-1.5223
0.56047465	7.9128	-0.3272	-0.2379	18.4751	7.3285	-1.3387
0.574788978	7.9597	-0.2829	-0.1855	18.7129	7.3045	-1.3381
0.589103306	7.8361	-0.2783	-0.1747	18.8127	7.2502	-1.4818
0.603417634	7.7467	-0.2878	-0.1428	19.091	7.1106	-1.5599
0.629477787	8.2439	-0.2587	-0.1493	19.8448	7.0978	-1.0206
0.65553794	8.405	-0.2721	-0.1842	20.4288	7.0127	-0.8261
0.681598093	8.3058	-0.2667	-0.1759	20.9295	6.8232	-0.8953
0.707658246	8.5206	-0.1392	-0.0462	21.5333	6.7752	-0.6903
0.733718399	8.4656	-0.1895	-0.1146	21.8869	6.6336	-0.8271
0.759778552	8.5372	-0.2584	-0.1607	22.525	6.551	-0.7034
0.785838706	8.7904	-0.2443	-0.1539	23.1497	6.4649	-0.4096
0.811898859	8.6895	-0.1955	-0.0758	23.6616	6.3111	-0.5019
0.837959012	8.6203	-0.179	-0.0675	24.1307	6.1395	-0.5492

Frequency (GHz)	e" Ethanolamine	e" Ether	e" Ethyl acetate	e" Formamide	e" Isopropanol	e" Nitromethane
0.864019165	8.661	-0.1631	-0.0584	24.6224	6.0277	-0.5186
0.890079318	8.6246	-0.2214	-0.1076	25.123	5.9304	-0.5017
0.916139471	8.7453	-0.206	-0.0955	25.7581	5.8271	-0.2667
0.942199624	8.7542	-0.1622	-0.0377	26.2543	5.6732	-0.244
0.968259778	8.7839	-0.1193	0.0097	26.7684	5.6358	-0.1707
0.994319931	8.738	-0.1516	-0.016	27.2477	5.5213	-0.1678
1.020380084	8.8807	-0.1692	-0.0587	27.8627	5.4753	0.0304
1.046440237	8.8579	-0.1651	-0.0371	28.3705	5.3699	0.0381
1.07250039	8.8552	-0.1119	0.0202	28.9259	5.2603	0.0985
1.098560543	8.9016	-0.0851	0.0416	29.3866	5.2279	0.1871
1.146004725	8.7768	-0.165	-0.0425	30.2504	5.0243	0.1239
1.193448907	8.8605	-0.0808	0.053	31.0679	4.9031	0.2945
1.240893089	8.8408	-0.1132	0.0303	31.9743	4.8066	0.3908
1.288337271	8.777	-0.1192	0.0164	32.8	4.6613	0.4471
1.335781453	8.7133	-0.055	0.0914	33.6531	4.4901	0.4837
1.383225635	8.5805	-0.1057	0.0369	34.4264	4.3826	0.476
1.430669817	8.6918	-0.0382	0.12	35.329	4.2899	0.6724
1.478113999	8.5535	-0.0574	0.1078	35.9265	4.1981	0.6443
1.525558181	8.4374	-0.1188	0.0501	36.6753	4.0596	0.6438
1.573002363	8.5223	0.0069	0.1744	37.5774	3.9863	0.8195
1.620446545	8.3797	-0.0746	0.1059	38.2791	3.9083	0.8275
1.667890726	8.299	-0.023	0.1683	38.9712	3.7908	0.8627
1.715334908	8.3813	0.0058	0.1798	39.6673	3.7558	1.0218
1.76277909	8.2427	-0.0264	0.1453	40.2218	3.6534	1.0634
1.810223272	8.2326	0.0362	0.2208	40.8942	3.5679	1.1317
1.857667454	8.134	-0.0349	0.1627	41.4779	3.4927	1.1307
1.905111636	8.0889	0.0078	0.208	41.9045	3.4531	1.1846
1.952555818	8.0346	0.026	0.227	42.5306	3.3801	1.2154
2	7.9462	-0.0325	0.1749	42.9465	3.3298	1.2229
2.086375179	7.8056	0.0092	0.2179	43.8051	3.1885	1.2586
2.172750359	7.6637	0.0448	0.2713	44.5215	3.0698	1.3995
2.259125538	7.6327	0.0007	0.2353	45.4637	3.0112	1.6096
2.345500717	7.4888	0.0069	0.2235	46.2179	2.9088	1.6368
2.431875896	7.3914	0.0607	0.3042	46.8044	2.8062	1.7296
2.518251076	7.341	0.0626	0.3345	47.5409	2.7767	1.8938
2.604626255	7.1416	0.0258	0.2774	48.0304	2.6641	1.9125

Frequency (GHz)	e" Ethanolamine	e" Ether	e" Ethyl acetate	e" Formamide	e" Isopropanol	e" Nitromethane
2.691001434	7.0336	0.0404	0.293	48.5384	2.5808	2.1008
2.777376613	6.9927	0.077	0.3685	49.1565	2.5488	2.251
2.863751793	6.8224	0.0092	0.3188	49.4519	2.464	2.2433
2.950126972	6.7235	-0.0071	0.2687	49.6825	2.3881	2.264
3.036502151	6.7232	0.0616	0.3655	50.1597	2.3784	2.4986
3.12287733	6.6073	0.0846	0.4089	50.5358	2.3144	2.5908
3.20925251	6.6245	0.0831	0.3976	50.8091	2.2659	2.738
3.295627689	6.8696	0.1702	0.4645	51.4983	2.3194	3.2397
3.382002868	6.9328	0.2391	0.5658	51.6121	2.3266	3.5662
3.468378048	6.881	0.224	0.5783	51.4841	2.2861	3.6482
3.554753227	6.7557	0.1778	0.5028	51.5517	2.2303	3.6876
3.641128406	6.5972	0.1849	0.5197	51.3152	2.178	3.6682
3.798379965	6.3724	0.1467	0.5046	51.4167	2.0913	3.5885
3.955631525	6.2161	0.1875	0.5987	51.4856	2.0232	3.6663
4.112883084	6.1398	0.1777	0.5785	51.4467	1.9877	3.877
4.270134644	6.009	0.1456	0.518	51.3996	1.9148	4.0791
4.427386203	5.8854	0.2122	0.6401	51.2396	1.8715	4.3024
4.584637762	5.8401	0.2243	0.6828	51.2485	1.8468	4.5835
4.741889322	5.7596	0.1793	0.5999	51.0378	1.8129	4.7813
4.899140881	5.6683	0.2141	0.6759	50.7266	1.7765	4.9811
5.056392441	5.5912	0.2952	0.822	50.3228	1.7293	5.161
5.213644	5.5296	0.2444	0.7362	50.0806	1.7166	5.4494
5.370895559	5.4686	0.1936	0.6838	49.6487	1.6927	5.6657
5.528147119	5.3602	0.3029	0.8792	49.2128	1.6369	5.8899
5.685398678	5.3035	0.3225	0.9142	48.9998	1.6405	6.0731
5.842650238	5.2439	0.2537	0.791	48.3318	1.636	6.3344
5.999901797	5.1687	0.3221	0.914	48.0301	1.5677	6.4791
6.157153356	5.1608	0.3891	1.0147	47.6753	1.6106	6.6468
6.314404916	5.1253	0.3641	0.9476	47.2281	1.601	6.8505
6.471656475	5.045	0.3626	0.9672	46.681	1.5347	6.8293
6.628908035	4.9624	0.4711	1.151	45.9779	1.5402	6.8488
6.915194595	4.8362	0.4435	1.1265	45.0389	1.5033	7.11
7.201481155	4.7849	0.4411	1.1186	44.3332	1.4873	7.2503
7.487767714	4.6017	0.5278	1.2625	42.9517	1.4242	7.3174
7.774054274	4.4921	0.483	1.1936	42.1433	1.3904	7.5803
8.060340834	4.4221	0.4708	1.1689	41.0467	1.3582	7.6425

Frequency (GHz)	e" Ethanolamine	e" Ether	e" Ethyl acetate	e" Formamide	e" Isopropanol	e" Nitromethane
8.632913954	4.2248	0.4992	1.2365	39.1031	1.3222	7.9581
8.919200514	4.1451	0.5161	1.2649	38.2934	1.2747	8.0952
9.205487074	4.0121	0.591	1.3734	37.2954	1.2445	8.1574
9.491773634	4.0073	0.5431	1.2981	36.7276	1.2464	8.3127
9.778060194	3.8931	0.5887	1.3634	35.699	1.2057	8.3228
10.06434675	3.8092	0.6428	1.465	35.0578	1.173	8.4779
10.35063331	3.7512	0.5526	1.3351	34.4573	1.1752	8.4051
10.63691987	3.634	0.5851	1.3831	33.2456	1.1075	8.5108
10.92320643	3.5786	0.622	1.4496	32.7877	1.107	8.7392
11.20949299	3.5533	0.5266	1.3163	32.0702	1.098	8.796
11.49577955	3.4552	0.6007	1.4423	31.3506	1.0643	9.0132
11.78206611	3.4264	0.6044	1.4646	30.8185	1.056	9.2919
12.06835267	3.4347	0.5445	1.3841	30.6654	1.0716	9.3995
12.58955574	3.3621	0.6954	1.6007	29.6072	1.0784	9.964
13.1107588	3.2548	0.7162	1.642	28.8698	1.0257	10.4081
13.63196186	3.1803	0.5837	1.4602	27.745	1.0092	10.3739
14.15316492	3.1217	0.6313	1.5253	26.9889	0.9761	10.7963
14.67436799	3.0184	0.8098	1.7775	26.0821	0.969	11.4714
15.19557105	3.047	0.6927	1.6103	25.9085	0.9899	12.1992
15.71677411	2.9919	0.6777	1.5925	25.5567	0.9876	12.9074
16.23797718	2.9568	0.9364	1.8955	25.0071	0.9795	12.7253
16.75918024	2.8237	0.7911	1.6976	23.735	0.931	13.0252
17.2803833	2.8069	0.5789	1.4542	23.4971	0.9159	14.1365
17.80158636	2.7725	0.8519	1.7884	22.8717	0.9551	14.3639
18.32278943	2.7947	1.0051	1.9754	22.6683	0.9324	15.202
18.84399249	2.6723	0.641	1.5649	22.1562	0.9373	14.9684
19.36519555	2.7315	0.7028	1.6386	22.0449	0.957	15.6775
19.88639861	2.5625	0.9815	1.958	21.1371	0.9082	15.2625
20.40760168	2.6244	0.5545	1.4661	20.8459	0.8857	16.2371
20.92880474	2.4823	0.2893	1.2052	20.0077	0.885	15.9013
21.4500078	2.6334	0.7288	1.7061	20.177	0.9271	17.2369
21.97121087	2.561	0.8544	1.8572	20.0118	0.9527	17.8247
22.9200945	2.3865	1.1218	2.2091	19.1839	0.8714	17.2531
23.86897814	2.409	0.7881	1.76	18.3357	0.8595	18.0085
24.81786178	2.515	0.8548	1.7849	18.3535	0.9055	19.5724
25.76674542	2.4698	0.9411	1.8779	17.9727	0.928	18.7506

Frequency (GHz)	e" Ethanolamine	e" Ether	e" Ethyl acetate	e" Formamide	e" Isopropanol	e" Nitromethane
26.71562906	2.2133	1.3096	2.3366	16.9295	0.813	17.767
27.6645127	2.2114	1.3882	2.4637	16.1944	0.8584	19.7054
28.61339634	2.4401	1.3411	2.3978	16.8083	0.921	23.6163
29.56227998	2.174	0.8832	1.7887	15.3339	0.8235	18.8936
30.51116361	2.2769	1.1488	2.0728	15.1158	0.8852	19.9616
31.46004725	2.5999	1.4954	2.5724	16.5043	0.9617	0
32.40893089	2.1776	1.348	2.3196	14.5094	0.811	0
33.35781453	2.4032	1.4607	2.4635	14.6712	0.9518	0
34.30669817	2.4622	1.5483	2.5686	14.8448	0.9464	0
35.25558181	2.3827	1.3671	2.2956	14.1262	0.9132	0
36.20446545	2.5004	1.3625	2.2765	14.0935	0.9203	0
37.15334908	1.7083	0.8425	1.6936	10.8851	0.6807	0
38.10223272	2.5054	2.0596	3.0491	15.467	0.9222	0
39.05111636	2.2558	1.9894	2.9956	12.9303	0.9005	0
40	2.7117	1.7624	2.4176	12.5471	1.0749	0

Loss Factor' (e'') measurement of chemicals at frequencies from 0.1 to 40 GHz

Chemicals; Acetaldehyde, Acetic Acid, Acetone, Acetonitrile, n-Butylamine, Cyclohexanol, DCM, Diethylamine, Digol, DMF, DMSO
Ethanol, Ethanolamine, Ether, Ethyl Acetate, Formamide, Isopropanol, Nitromethane, **Pentanedione, Pyridine and THF**

loss factor' - e'' related to power dissipation in the solvent

Frequency (GHz)	e'' Pentanedione	e'' Pyridine	e'' THF
0.1	-5.4001	-2.3396	-0.8324
0.104318759	-5.8349	-2.6742	-0.661
0.108637518	-5.9076	-2.2372	-0.4326
0.112956277	-5.5983	-2.1656	-0.6806
0.117275036	-5.0645	-1.9714	-0.4707
0.121593795	-4.7935	-1.9736	-0.5182
0.125912554	-4.4315	-1.6861	-0.3894
0.130231313	-3.871	-1.4127	-0.2099
0.134550072	-3.0153	-1.2676	-0.2607
0.138868831	-2.9386	-1.8689	-0.7839
0.14318759	-2.5748	-1.208	-0.304
0.147506349	-2.0743	-1.3285	-0.547
0.151825108	-2.6759	-1.4334	-0.5288
0.156143867	-2.4718	-1.4007	-0.5642
0.160462625	-2.3479	-1.6914	-0.4593
0.164781384	-2.7424	-1.7401	-0.627
0.169100143	-2.6642	-2.0049	-0.8741
0.173418902	-3.4334	-2.8335	-1.4386
0.177737661	-2.6201	-1.8835	-0.5887
0.18205642	-2.461	-1.7987	-0.8993
0.189918998	-2.3582	-1.7831	-0.5975
0.197781576	-2.1036	-1.7621	-0.8362
0.205644154	-1.934	-1.2841	-0.3835
0.213506732	-1.7072	-1.0499	-0.4431
0.22136931	-1.512	-0.5358	-0.1675
0.229231888	-1.2356	-0.6566	-0.0711
0.237094466	-1.4487	-0.5529	-0.0708
0.244957044	-1.1562	-0.4553	-0.1617
0.252819622	-1.359	-0.711	-0.1607
0.2606822	-1.3145	-0.7288	-0.1012
0.268544778	-1.2014	-0.8529	-0.2389

Frequency (GHz)	e" Pentanedione	e" Pyridine	e" THF
0.276407356	-1.2006	-0.9463	-0.4978
0.284269934	-1.027	-1.0314	-0.5389
0.292132512	-0.8088	-0.9646	-0.4998
0.29999509	-0.7406	-0.9267	-0.4178
0.307857668	-0.691	-0.8182	-0.3885
0.315720246	-0.5736	-0.6442	-0.3302
0.323582824	-0.5371	-0.5724	-0.2358
0.331445402	-0.5388	-0.4448	-0.2141
0.34575973	-0.4281	-0.3755	-0.0269
0.360074058	-0.4315	-0.3515	-0.1752
0.374388386	-0.1223	-0.2672	-0.1218
0.388702714	-0.0944	-0.3192	-0.142
0.403017042	-0.1364	-0.4701	-0.2722
0.41733137	-0.1194	-0.6205	-0.3197
0.431645698	-0.0878	-0.5056	-0.2165
0.445960026	0.1103	-0.2606	-0.0974
0.460274354	0.2432	-0.0313	-0.0175
0.474588682	0.3704	-0.0251	0.005
0.48890301	0.3301	-0.0853	-0.035
0.503217338	0.2896	-0.2016	-0.0525
0.517531666	0.3936	-0.2621	-0.1099
0.531845994	0.477	-0.3286	-0.225
0.546160322	0.5682	-0.2512	-0.1742
0.56047465	0.6284	-0.1253	-0.1392
0.574788978	0.6912	-0.0607	-0.0807
0.589103306	0.6992	0.0027	-0.0377
0.603417634	0.6583	-0.0052	-0.0354
0.629477787	0.9639	-0.0411	-0.0714
0.65553794	1.0932	-0.0844	-0.1232
0.681598093	1.0904	-0.0011	-0.0773
0.707658246	1.2155	0.1891	0.0031
0.733718399	1.2789	0.1103	-0.0114
0.759778552	1.3794	0.0155	-0.0903
0.785838706	1.5413	0.0752	-0.0806
0.811898859	1.568	0.1769	-0.0038
0.837959012	1.5927	0.266	0.0339

Frequency (GHz)	e" Pentanedione	e" Pyridine	e" THF
0.864019165	1.6459	0.2163	0.002
0.890079318	1.7213	0.137	-0.039
0.916139471	1.844	0.2012	-0.027
0.942199624	1.8889	0.2947	0.0254
0.968259778	1.9726	0.3663	0.0517
0.994319931	2.0411	0.3018	0.014
1.020380084	2.1774	0.2496	-0.032
1.046440237	2.2342	0.337	-0.0001
1.07250039	2.2913	0.4423	0.0458
1.098560543	2.3901	0.4374	0.0616
1.146004725	2.4626	0.3285	-0.0209
1.193448907	2.6187	0.516	0.0681
1.240893089	2.7985	0.4377	0.0357
1.288337271	2.8911	0.4802	0.0283
1.335781453	3.0008	0.5731	0.0713
1.383225635	3.112	0.5212	0.0459
1.430669817	3.2627	0.6918	0.1063
1.478113999	3.3575	0.6264	0.0968
1.525558181	3.4502	0.6202	0.0585
1.573002363	3.6054	0.7906	0.1564
1.620446545	3.7066	0.6735	0.0859
1.667890726	3.7971	0.8177	0.1573
1.715334908	3.9631	0.7899	0.1474
1.76277909	4.0448	0.8053	0.1274
1.810223272	4.1571	0.9163	0.1882
1.857667454	4.2502	0.8243	0.141
1.905111636	4.3705	0.9467	0.171
1.952555818	4.4734	0.9337	0.1847
2	4.5883	0.902	0.1446
2.086375179	4.7433	0.9596	0.1551
2.172750359	4.944	1.0962	0.2268
2.259125538	5.1873	1.0942	0.2098
2.345500717	5.3749	1.068	0.1817
2.431875896	5.5754	1.192	0.2491
2.518251076	5.8076	1.3291	0.2909
2.604626255	5.9635	1.2597	0.2355

Frequency (GHz)	ϵ'' Pentanedione	ϵ'' Pyridine	ϵ'' THF
2.691001434	6.1389	1.2659	0.2368
2.777376613	6.377	1.4355	0.3146
2.863751793	6.5246	1.4346	0.2801
2.950126972	6.6845	1.3516	0.2257
3.036502151	6.9317	1.5167	0.3083
3.12287733	7.095	1.6677	0.3625
3.20925251	7.2624	1.641	0.3254
3.295627689	7.5813	1.6961	0.3533
3.382002868	7.8062	1.9206	0.4476
3.468378048	7.9651	2.005	0.4672
3.554753227	8.1128	1.8564	0.3933
3.641128406	8.2288	1.8982	0.421
3.798379965	8.4643	1.9344	0.4057
3.955631525	8.742	2.2036	0.5158
4.112883084	9.0435	2.1446	0.4568
4.270134644	9.3157	2.0408	0.3874
4.427386203	9.5786	2.4243	0.558
4.584637762	9.8401	2.5621	0.5892
4.741889322	10.115	2.3874	0.4554
4.899140881	10.3408	2.6447	0.5713
5.056392441	10.529	3.0557	0.7528
5.213644	10.7788	2.834	0.6238
5.370895559	10.9542	2.72	0.5707
5.528147119	11.1242	3.2513	0.8497
5.685398678	11.3414	3.2925	0.8519
5.842650238	11.4623	3.0281	0.7073
5.999901797	11.5115	3.3681	0.8851
6.157153356	11.8872	3.6303	1.0162
6.314404916	12.0456	3.4755	0.8921
6.471656475	12.0138	3.5017	0.8879
6.628908035	12.1215	3.9018	1.0992
6.915194595	12.3145	3.8181	0.9993
7.201481155	12.4852	3.8493	1.0002
7.487767714	12.3886	4.2026	1.1849
7.774054274	12.5133	4.0664	1.093
8.060340834	12.5056	4.0837	1.1426

Frequency (GHz)	e" Pentanedione	e" Pyridine	e" THF
8.632913954	12.5268	4.3048	1.16
8.919200514	12.5079	4.4058	1.1898
9.205487074	12.4309	4.6792	1.2943
9.491773634	12.487	4.5414	1.1819
9.778060194	12.3578	4.6894	1.2933
10.06434675	12.3615	4.9124	1.3998
10.35063331	12.2952	4.621	1.2555
10.63691987	12.127	4.7192	1.3368
10.92320643	12.0999	4.8804	1.3932
11.20949299	12.0612	4.5953	1.2439
11.49577955	11.92	4.8696	1.4335
11.78206611	11.8675	4.957	1.4201
12.06835267	11.9269	4.7613	1.3456
12.58955574	11.9417	5.2645	1.635
13.1107588	11.7813	5.3385	1.5911
13.63196186	11.5231	4.9215	1.3761
14.15316492	11.3522	5.0296	1.5128
14.67436799	11.3369	5.5788	1.8051
15.19557105	11.3239	5.3198	1.5731
15.71677411	11.3131	5.322	1.5256
16.23797718	11.2163	5.8507	1.8708
16.75918024	10.8944	5.498	1.6797
17.2803833	10.7757	5.0948	1.4698
17.80158636	10.7272	5.7074	1.8935
18.32278943	10.6384	6.047	2.0602
18.84399249	10.6033	5.4405	1.6174
19.36519555	10.5844	5.546	1.745
19.88639861	10.2597	6.0276	2.0789
20.40760168	10.1183	5.2214	1.5735
20.92880474	9.9218	4.9062	1.3837
21.4500078	9.9801	5.7745	1.873
21.97121087	10.1029	6.1744	1.967
22.9200945	9.7775	6.6831	2.5351
23.86897814	9.3982	5.6417	2.0497
24.81786178	9.3991	5.5824	2.1046
25.76674542	9.3338	5.5482	2.6033

Frequency (GHz)	e" Pentanedione	e" Pyridine	e" THF
26.71562906	8.884	6.2524	3.1351
27.6645127	8.7017	6.8387	2.929
28.61339634	8.8442	6.8028	2.9376
29.56227998	8.3246	4.9802	2.492
30.51116361	8.1777	5.3808	2.8113
31.46004725	8.6084	6.9245	3.2826
32.40893089	7.9562	6.1383	2.9794
33.35781453	8.1822	6.1536	3.2699
34.30669817	8.0439	6.2901	3.341
35.25558181	7.6333	5.5406	3.3536
36.20446545	7.5095	5.4107	3.4873
37.15334908	6.409	4.4374	2.4996
38.10223272	7.6412	7.2991	3.5157
39.05111636	7.0592	6.5475	4.1594
40	7.1637	4.7732	3.705