Signal Processing as a Probe to Study Dielectric Properties of Mouth Cancer Patient's Saliva

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ABSTRACT

Dielectric relaxation study of saliva of mouth cancer patient, normal person and tobacco, gutaka-chewing person has been carried out at sampling frequency 12.4 GHz and at temperature 37^0C. Time domain reflectometry (TDR) in reflection mode has been used as a technique. In TDR a fast rising step pulse of 25 ps is incident on the saliva kept in the cell. The reflected pulse from the cell is sampled with incident pulse in sampling oscilloscope. The sampled pulses are digitized. The time dependent data were processed to obtain complex reflection coefficient spectra $\rho^*(\omega)$ using Fourier transformation. The static dielectric constant (ε_0) and dielectric relaxation time (τ) of " saliva" were evaluated from complex reflection spectra.

KEYWORDS

Cancer, Saliva, Time domain reflectometry, Dielectric constant, Relaxation time, Fourier transformation, least- squares fit method.

1. INTRODUCTION

The microwave energy is nonionizing. It does not alter the molecular structure of the sample. It provides only thermal activation. In the study of microwave dielectric relaxation, [1,2,3] the static dielectric constant (ε_0) and relaxation time (τ) for saliva of mouth cancer patient and normal person at 12.4 GHz sampling frequency and at 37^0C temperature using time domain spectroscopy[4] are reported. The dielectric parameter provides information about saliva of mouth cancer patient and normal person.

2. MATERIALS AND METHODS

The saliva of normal persons and mouth cancer patients were obtained from government medical college, Aurangabad. Ethanol AR grade (Changshu Yangyuan Chemical, China) and Acetone AR grade (Qualigens Fine Chemicals, Mumbai) 99.9% purity were obtained commercially and used without further purification. The complex permittivity spectra were studied using time domain reflectometry.

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The Hewlett Packard HP 54750A-sampling oscilloscope with an HP 54754A TDR plug-in module was used. A fast rising step voltage pulse of about 25 ps rise time generated by a tunnel diode was propagated through a flexible coaxial cable. The saliva was placed at end of the coaxial line in the standard military application (SMA) coaxial cell of 3.5 mm outer diameter and 1.35 mm effective pin length.

All measurements were done under open load conditions. The change in pulse on reflection from the sample placed in cell was monitored by the sampling oscilloscope. The reflected pulse without sample $R_1(t)$ and with sample $R_x(t)$ were digitized in 1024 points and stored on disc.

The temperature controller system with a water bath and a thermostat has been used to maintain the constant temperature within the accuracy limit of $\pm 1^0$C. The sample cell was surrounded by an insulating container through which, the constant temperature water was circulated.

3. DATA ANALYSIS

The time dependent data were processed to obtain complex reflection coefficient spectra $\rho^*(\omega)$ using Fourier transformation (Samulon[4] ; Shannon[5]) as

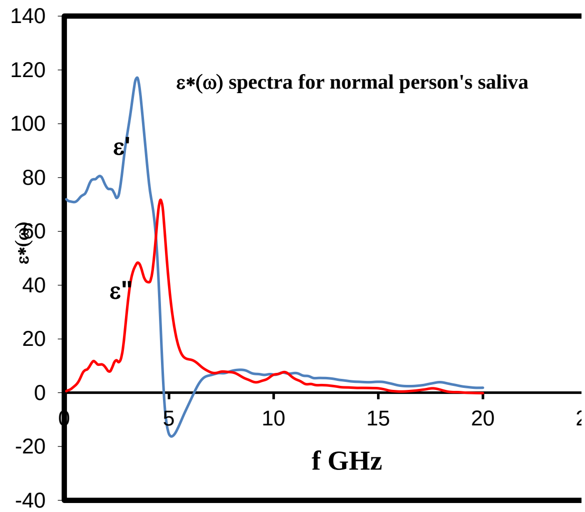
$$\rho^*(\omega) = \frac{c\, p(\omega)}{j\omega d\, q(\omega)}$$

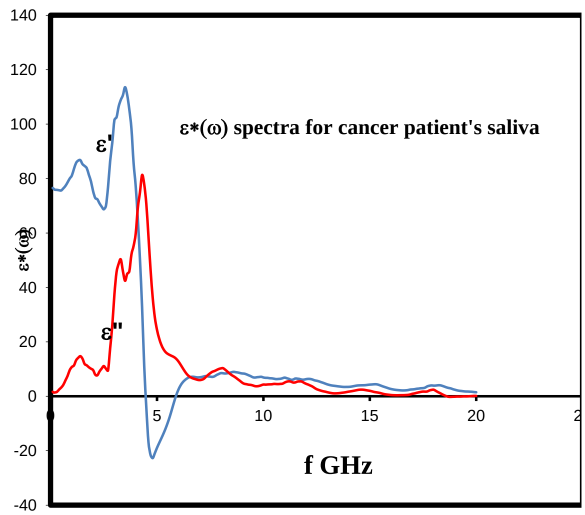
Where $p(\omega)$ and $q(\omega)$ are Fourier transforms of $(R_1(t)-R_x(t))$ and $(R_1(t)+R_x(t))$, respectively, c is the velocity of light, ω is the angular frequency, and d is the effective pin length.

The complex permittivity spectra $\varepsilon^*(\omega)$ were obtained from reflection coefficient spectra $\rho^*(\omega)$

by using the bilinear calibration method (Cole et al.[6]). Ethanol and Acetone were used as calibrating liquids.

The $\varepsilon^*(\omega)$ spectra for saliva's are shown in figure.





The experimental values of $\varepsilon^*(\omega)$ are fitted with the Debye equation (Havriliak and Negami[7]; Cole and Cole[8]; Davidson and Cole[9])

$$\varepsilon^*(\omega) = \varepsilon_\infty + \frac{\varepsilon_0 - \varepsilon_\infty}{(1 + j\omega\tau)}$$

with ε_0, ε_∞ and τ as fitting parameters. A nonlinear least- squares fit method (Bevington[10]) was used to determine the values of dielectric parameters.

4. FINDINGS

The static dielectric constant and relaxation time of saliva obtained at 37^0C by the least- squares fit method are listed in table1.

***Table* 1**: Dielectric relaxation parameters for saliva.

Sample No.	Cancer Patient's Saliva	
	ε_0	τ ps
1	81.68(66) [u]	13.29(97)
2	80.97(67)	13.44(10)
3	82.17(84)	13.31(12)
4	90.36(37)	13.86(55)
5	82.22(12)	13.52(16)
6	80.42(88)	13.61(12)
7	80.56(10)	13.45(14)
8	80.79(82)	13.51(11)
9	80.42(93)	13.03(73)
10	82.12(11)	13.07(15)

Sample No.	Habited Person's Saliva	
	ε_0	τ ps
1	79.06(78)	12.11(11)
2	79.12(73)	12.75(10)
3	79.71(83)	12.31(11)
4	78.79(80)	12.03(12)
5	79.28(82)	12.17(11)
6	78.85(83)	12.77(11)
7	78.79(97)	12.16(11)
8	78.53(84)	12.18(12)
9	79.86(95)	11.68(13)
10	78.91(90)	12.74(12)

Sample No.	Normal Person's Saliva	
	ε_0	τ ps
1	76.57(81)	11.38(11)
2	76.68(85)	12.06(12)
3	76.58(77)	10.95(11)
4	76.49(78)	11.71(11)
5	76.16(69)	11.81(10)
6	77.98(80)	11.57(11)
7	74.91(57)	11.39(85)
8	73.21(68)	11.33(10)
9	72.82(91)	10.80(14)
10	68.51(10)	8.97(16)

[u] Numbers in brackets indicate uncertainty. e.g., 81.68(66) means 81.68 ± 0.66.

5. RESULTS AND CONCLUSION

An attempt is made to determine dielectric parameters of mouth cancer patient's saliva at 37^0C using Ethanol and Acetone as calibrating liquids. The values of dielectric constant $\boldsymbol{\varepsilon_o}$ and relaxation time $\boldsymbol{\tau}$ for cancer patient's saliva are greater than normal person's saliva. This raise in dielectric constant $\boldsymbol{\varepsilon_o}$ is due to increase in effective dipole moment per unit volume of molecules in saliva. Relaxation time $\boldsymbol{\tau}$ of biological material can be related to the size of molecule, mobility of molecules, molecular volume, viscosity, and temperature. Increase in relaxation time $\boldsymbol{\tau}$ can be correlated to increase in size of molecule as well as to decrease in mobility of molecules. The saliva of mouth cancer patient becomes sticky, so its viscosity increases.

REFERENCES

1. Grant E.H., *Dielectric Behavior of Biological Molecules in Solutions.* Clarendon Press Oxford (1978).
2. Froblich H., *Theory of Dielectrics.* Oxford University Press London (1949).
3. Debye P., *Polar Molecules*. The Chemical Catalog Co., New York (1929).
4. Samulon H.A. Spectrum analysis of transient response curves, *Proc. IRE* 1951,39,175-186.
5. Shannon C.E., Communication in the presence of noise, *Proc. IRE* 1949,37,10.
6. Cole R.H.; Berbarian J.G.; Mashimo S.; Chryssikos G.; Burns A.; Tombari E. Time domain reflection methods for dielectric measurements to 10 GHz, *J. Appl. Phys*. 1989,66,793-802.
7. Havriliak S. & Negami S. A complete plane analysis of α-dispersion in some polymer systems *J. Polym. Sci. Polym. Symp*. 1966,99-117.
8. Cole K.S. & Cole R.H. Dispersion and absorption in dielectrics, *J.Chem. Phys*. 1941,9,341-345.
9. Davidson D.W.; Cole R.H. Dielectric relaxation in Glycerin, *J. Chem. Phys*. 1950,18,1417.
10. Bevington P. R., *Data reduction and error analysis for the physical sciences*; McGraw Hill: New York, 1969.