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Effect of Electrets Property on Artificially Removed Human Renal Stone Mineral Compositions

G. Kanchana, P. Sundaramoorthi*, G.P. Jeyanthi

Department of Bio-chemistry, Avinashilingam University for Women, Coimbatore, India.
**Department of Physics, Thiruvalluvar Govt. Arts College, Rasipuram, Namakkal, India-637401.*

(Ph.No.-04286-266313 (off.) Fax- 04286-266323 , MailID-moorthi.sundara@gmail,com)

ABSTRACT

Electrical and thermal conductivity studies play a vital role in the field of science and technology. According to the conductivity terms, materials can be classified in to good conductors, bad conductors, semiconductors and super conductors. In the free electron theory, electron only acts as carrier and carries its energy from one point to another point either natural or forced. In the present investigation, five renal stones are collected from the poor hard working males who are affected with mineral deposition in the urinary tracts. The stones are collected from the hospital by Lithotropic treatment process. Using two- probes method, the electrical conductivities are measured at different temperatures. The thermal conductivity and temperature coefficients are calculated. The results are reported and discussed.

Key Words*: Mineral processing, Sampling, Process instrumentation, Bio-oxidation, Ion exchange*

1. INTRODUCTION

The conductivity of many biomaterials has been reported [1]. The applied problems, such as thrombogenesis and enzymatic activity of cytochrome oxides, have been dealt with either semi conductivity or electrets behavior of different biomaterials. In the present study, both these aspect have been attempted on the same materials, namely renal stones or renal calculi. The study of electrets behaviors and conductivity becomes essential in order to find an inhibitor for renal stones or prevent its growth. The electrets behavioral of the renal stone material were studied through TSD, TSP [2-4]. Here the investigators report the D.C conductivity of kidney stones as a function of temperature and applied electric field and its interpretations.

2. MATERIALS AND METHODS

Kidney stones are removed from the affected patients by Litho tropic process in the Rasi stones diagnosing center in Rasipuram, Namakkal, India, and are used in the present investigations. These stones constituents are analyzed by biochemical analysis process. Table 1 represents the chemical composition present in the renal stones

Table 1. Chemical composition present in the renal stones

Stones	***Chemical constituents***
A	Calcium phosphate.
B	Calcium oxalate, mono di-hydrate.
C	Calcium oxalate monohydrate with Phosphates.
D	Calcium oxalate mono, di-hydrate, Phosphate,
E	Calcium oxalate monohydrate

Figure 1. Stone A

Figure 2. Stone B.

Stone samples are prepared for conductivity measurement initially. The bloodstains and other impurities are removed from the surfaces of the sample and dried naturally. Then the sample surfaces are smoothened by using very thin grain grinder. The renal stone samples are placed in between two aluminum probes with deep contact. The sample holders with the sample are kept inside the micro oven, which is automatically heated with electronic temperature monitor and controller (the accuracy is 2^oC). The D.C conductivity is studied at the temperature (T) from 295 K to373K at irregular temperature intervals. The electric field applied to the probes starts from 1V to 12V and the corresponding currents are measured. The entire samples are kept at a particular temperature at least 15 minutes to reach the saturation. Then the measurements are started. At higher voltage and higher temperature the current settling time are observed. The transient current of the sample mainly depends upon the presence of carriers in a sample according to the Curie-Von-Schweidlar law. The conductivity has been reported for polymer samples [6-8] and ionic materials [9-10].

Figure 3. Stone C.

Figure 4. Stone D.

Figure 5. Stone E.

3. RESULTS

The approximate area of each samples are measured by using graph sheet. The temperatures are varied from 295K to 373 K. The applied voltage (V), corresponding current measurements (I), resistance (R), resistivity (ρ), conductivity (σ) and current density (J) of each sample at a particular temperature are reported in Tables 2 to 16.

Table 2. Electrets properties of renal stone A at 33°C, $A=30x10^{-6}$ m^2, $L=5x10^{-3}$m

S.NO	Voltage applied in Volts (V).	Current measured in micro -amperes (I).	Resistance 10^6 (Ohm).	Resistivity in Ohm. m (ρ).	Current density (J) x 10^{-4} Amp/m^2
1	2	3	0.667	3960	0.5052
2	4	3	1.333	7980	0.5013
3	6	4	1.500	9000	0.6670
4	8	5	1.600	9600	0.8333
5	10	6	1.667	1002	0.9999
6	12	8	1.500	9000	1.3333
			1.378	8257	0.8060

Co efficient of electrical conductivity (σ) = $1.211x10^{-4}$ mho.m-1

Table 3. Electrets properties of renal stone A at 62°C, $A=30x10^{-6}$ m^2, $L=5x10^{-3}$m

S.NO	Voltage applied in Volts (V).	Current measured in micro -amperes (I).	Resistance in 10^6 (Ohm).	Resistivity in Ohm. m (ρ).	Current density (J) x 10^{-4} Amp/m^2
1	2	2	1.000	6000	0.3333
2	4	2	2.000	12000	0.3333
3	6	3	2,000	12000	0.3333
4	8	4	2.000	12000	0.3333
5	10	5	2.000	12000	0.3333
6	12	6	2.000	12000	0.3333
			2.000	11000	0.3333

Co efficient of electrical conductivity (σ) =$0.909x10^{-4}$ mho.m-1

Table 4. Electrets properties of renal stone A at 96^oC, A=30x10^{-6} m^2, L=5x10^{-3}m

S.NO	Voltage applied in Volts (V).	Current measured in micro -amperes (I).	Resistance 10^6 (Ohm).	Resistivity in Ohm. m (ρ).	Current density (J) x 10^{-4} Amp/m^2
1	2	2	1.000	6000	0.3333
2	4	2	2.000	12000	0.3333
3	6	3	2.000	12000	0.5000
4	8	3	2.667	16002	0.4999
5	10	4	2.580	15000	0.6670
6	12	4	3.000	18000	0.6667
			2.208	13167	0.3888

Co efficient of electrical conductivity (σ) =0.759x10^{-4} mho.m-1

Table 5. Electrets properties of renal stone B at 32^oC, A=30x10^{-6} m^2, L=6x10^{-3}m

S.NO	Voltage applied in Volts (V).	Current measured in micro -amperes (I).	Resistance 10^6 (Ohm).	Resistivity in Ohm. M (ρ).	Current density (J) x 10^{-4} Amp/m^2
1	2	5	0.4000	1600	1.2500
2	4	6	0.6667	2668	1.4999
3	6	8	0.7500	3000	2.0000
4	8	10	0.8000	3200	2.5000
5	10	12	0.8333	3332	3.0000
6	12	14	0.8571	3428	3.5000
			0.7176	2871	2.2900

Co efficient of electrical conductivity (σ) =3.483 x10^{-4} mho.m-1

Table 6. Electrets properties of renal stone B at 64^{o}C, A=30x10^{-6} m^2, L=6x10^{-3}m

S.NO	Voltage applied in Volts (V).	Current measured in micro -amperes (I).	Resistance 10^6 (Ohm).	Resistivity in Ohm. m (ρ).	Current density (J) x 10^{-4} Amp/m^2
1	2	4	0.500	2000	1.0000
2	4	4	1.000	4000	1.0000
3	6	5	1.200	4800	1.2500
4	8	6	1.333	5332	1.5000
5	10	8	1.250	5000	2.0000
6	12	10	1.200	4800	2.5000
			1.091	4322	1.5420

Co efficient of electrical conductivity (σ) =2.313 x 10^{-4} mho.m-1

Table-7 Electrets properties of renal stone B at 99^{o}C, A=30x10^{-6} m^2, L=6x10^{-3}m

S.NO	Voltage applied in Volts (V).	Current measured in micro -amperes (I).	Resistance 10^6 (Ohm).	Resistivity in Ohm. m (ρ).	Current density (J) x 10^{-4} Amp/m^2
1	2	3	0.667	2668	0.7490
2	4	3	1.333	5320	0.7200
3	6	4	1.500	6000	1.0000
4	8	4	2.000	8000	1.0000
5	10	5	2.000	8000	1.2500
6	12	6	2.000	8000	1.5000
			1.583	6331	1.0370

Co efficient of electrical conductivity (σ) =1.579 x 10^{-4} mho.m-1

Table-8 Electrets properties of renal stone C at 33^{o}C, A=25x10^{-6} m^{2}, L=5x10^{-3}m

S.NO	Voltage applied in Volts (V).	Current measured in micro -amperes (I).	Resistance 10^{6} (Ohm).	Resistivity in Ohm. m (ρ).	Current density (J) x 10^{-4} Amp/m^{2}
1	2	10	0.200	1000	2.0000
2	4	12	0.333	1665	2.4000
3	6	13	0.462	2310	2.6000
4	8	15	0.533	2665	3.0000
5	10	17	0.588	2940	3.4000
6	12	20	0.600	3000	4.0000
			0.453	2263	2.9000

Co efficient of electrical conductivity (σ) =4.418 x 10^{-4} mho.m-1

Table-9 Electrets properties of renal stone C at 64^{o}C, A=30x10^{-6} m^{2}, L=6x10^{-3}m

S.NO	Voltage applied in Volts (V).	Current measured in micro -amperes (I).	Resistance 10^{6} (Ohm).	Resistivity in Ohm. m (ρ).	Current density (J) x 10^{-4} Amp/m^{2}
1	2	9	0.222	1110	1.8000
2	4	10	0.400	2000	2.0000
3	6	13	0.462	2310	2.5800
4	8	13	0.615	3075	2.6010
5	10	14	0.714	3570	2.8000
6	12	14	0.857	4285	2.8000
			0.545	2725	2.4300

Co efficient of electrical conductivity (σ) =3.669x 10^{-4} mho.m-1

Table-10 Electrets properties of renal stone C at 95°C, $A=25x10^{-6}\ m^2$, $L=5x10^{-3}m$

S.NO	Voltage applied in Volts (V).	Current measured in micro -amperes (I).	Resistance 10^6 (Ohm).	Resistivity in Ohm. m (ρ).	Current density (J) x 10^{-4} Amp/m^2
1	2	6	0.333	1650	1.2000
2	4	6	0.666	3330	1.2000
3	6	7	0.857	4285	1.4000
4	8	7	1.143	5715	1.3999
5	10	7	1.429	7145	1.3999
6	12	8	1.500	7500	1.6000
			0.988	4938	1.3670

Co efficient of electrical conductivity (σ) =2.025x 10^{-4} $mho.m^{-1}$

Table-11 Electrets properties of renal stone D at 34°C, $A=12x10^{-6}\ m^2$, $L=6x10^{-3}m$

S.NO	Voltage applied in Volts (V).	Current measured in micro -amperes (I).	Resistance 10^6 (Ohm).	Resistivity in Ohm. m (ρ).	Current density (J) x 10^{-4} Amp/m^2
1	2	16	0.126	252	7.9400
2	4	18	0.222	444	9.0000
3	6	24	0.250	500	12.0000
4	8	28	0.286	572	13.9900
5	10	32	0.313	626	15.9700
6	12	35	0.343	686	17.4900
			0.257	513	12.9300

Co efficient of electrical conductivity (σ) =19.493x 10^{-4} $mho.m^{-1}$

Table-12 Electrets properties of renal stone D at 65°C, A=12x10^{-6} m^2, L=6x10^{-3}m

S.NO	Voltage applied in Volts (V).	Current measured in micro -amperes (I).	Resistance 10^6 (Ohm).	Resistivity in Ohm. m (ρ).	Current density (J) x 10^{-4} Amp/m^2
1	2	10	0.200	400	5.0000
2	4	12	0.333	666	6.0060
3	6	16	0.375	750	8.0000
4	8	16	0.500	1000	8.0000
5	10	17	0.588	1176	8.5000
6	12	20	0.600	1200	10.0000
			0.433	865.33	7.5840

Co efficient of electrical conductivity (σ) =11.556x 10^{-4} mho.m-1

Table-13 Electrets properties of renal stone D at 99°C, A=12x10^{-6} m^2, L=6x10^{-3}m

S.NO	Voltage applied in Volts (V).	Current measured in micro -amperes (I).	Resistance 10^6 (Ohm).	Resistivity in Ohm. m (ρ).	Current density (J) x 10^{-4} Amp/m^2
1	2	6	0.333	666	3.0000
2	4	6	0.667	1334	2.9000
3	6	7	0.857	1714	3.5000
4	8	7	1.143	2286	3.4900
5	10	7	1.428	2856	3.5000
6	12	10	1.200	2400	5.0000
			0.938	1876	3.5800

Co efficient of electrical conductivity (σ) =5.33x 10^{-4} mho.m-1

Table-14 Electrets properties of renal stone E at 35^{o}C, A=15x10^{-6} m^{2}, L=3x10^{-3}m

S.NO	Voltage applied in Volts (V).	Current measured in micro -amperes (I).	Resistance 10^{6} (Ohm).	Resistivity in Ohm. m (ρ).	Current density (J) x 10^{-4} Amp/m^{2}
1	2	8	0.250	1250	1.6000
2	4	8	0.500	2500	1.6000
3	6	9	0.667	3350	1.8100
4	8	9	0.889	4445	1.7800
5	10	11	0.909	4545	2.2000
6	12	11	1.091	5455	2.1900
			0.718	3590	1.8600

Co efficient of electrical conductivity (σ) =2.785x 10^{-4} mho.m-1

Table-15 Electrets properties of renal stone E at 65^{o}C, A=15x10^{-6} m^{2}, L=3x10^{-3}m

S.NO	Voltage applied in Volts (V).	Current measured in micro -amperes (I).	Resistance 10^{6} (Ohm).	Resistivity in Ohm. M (ρ).	Current density (J) x 10^{-4} Amp/m^{2}
1	2	7	0.286	1430	1.3990
2	4	8	0.550	2500	1.6000
3	6	8	0.750	3750	1.6000
4	8	9	0.889	4445	1.7999
5	10	10	1.000	5000	2.0000
6	12	10	1.200	6000	2.0000
			0.771	3854	1.7300

Co efficient of electrical conductivity (σ) =2.594x 10^{-4} mho.m-1

Table-16 Electrets properties of renal stone E at 98°C, $A=15x10^{-6}$ m^2, $L=3x10^{-3}m$

S.NO	Voltage applied in Volts (V).	Current measured in micro -amperes (I).	Resistance 10^6 (Ohm).	Resistivity in Ohm. m (ρ).	Current density (J) x 10^{-4} Amp/m^2
1	2	5	0.400	2000	3.6000
2	4	5	0.800	4000	7.2000
3	6	6	1.000	5000	10.8000
4	8	6	1.333	6665	14.4000
5	10	7	1.429	7145	18.0000
6	12	7	1.714	8570	21.6000
			1.112	5563	12.6000

Co efficient of electrical conductivity (σ) =1.798 x 10^{-4} mho.m-1

4. RESULT AND DISCUSSION

The measurement of hall coefficient of the renal stones is very difficult. The stones containing collagens like micro-protein and apatite also have some organic matrix like protein at 5% of the total weight [13]. The protein matrix is clearly visible under a scanning microscope. The D.C electrical conductivity of the renal stones are compared and calculated with the standard ionic conductors [11] and semiconductors [12].

The ionic conduction for the renal stone is

$$\sigma=\sigma_1 exp^{(A/KT)}+\sigma_2 exp^{(-B/KT)}$$

Where σ_1,σ_2 are the zero field conductivity, A and B are constants. The two exponential terms are nature of normal conductors.

In semiconductors the conductivity

$$\sigma=\sigma_0 exp^{(-Eg/2KT)}$$

Here σ_0 is the zero field conductivity and Eg is the activation energy of the conductors at a particular temperature (T). Because of practical inconvenience of electron microscope (SEM), a fine powder of kidney stone was observed under a high resolution optical microscope and shows fibrils of protein. Thus renal stones can be regarded as a mixture of semi conducting materials like N type and P type, but totally it behaves like N type material or conductors. Hence, conductivity of a kidney stone shows it may be interpreted in terms of a partially compensated semiconductor.

Available mechanism for conduction of renal stones may be sought with the help of various scattering mechanism of conductors and semiconductors [14]. The conductivity of samples depends upon the scattering by lattice vibrations. In conductor the curve between conductivity and temperature should be straight line, but in semiconductor, it is not in usual [15].

The TSP, TSD data of kidney stones also give added information about its conduction mechanism [2, 3]. For the TSP, TSD conductivity of a sample, the changing current is composed of three components, which are conduction, polarization and depolarization. When temperature increases, the conductivity of a samples is increased, the polarization and depolarization peaks merge in the conduction current or only a part of it is observable [16]. The voltage dependence of conductivity decreases with rise of temperature (T). The current density decreases, which shows the conduction is in non-ohmic. This change suggests a warm electron effect [17]. At higher temperature, the current density is directly proportional to voltage and gives the ohmic behaviors. This is clear that for a sample at higher temperature, the thermal energy difference between the charge carriers and lattices are relatively low or due to asymmetric effect [18] formed in inside the crystals of calcium oxalates and calcium phosphates. All the calculated renal stone parameters are tabulated in the following tables.

Table-17 Electrical parameters of renal stone samples

SNo	Stones	Temperature in degree Celsius	R in 10^6 ohms	ρ Ohm-meter	J $\times 10^{-4}$ Ampere/met^2
1	A	33	1.378	8257	0.8060
		62	1.833	11000	0.3333
		98	2.208	13167	0.3888
2	B	32	0.718	2871	2.2990
		64	1.091	4322	1.5420
		99	1.583	6331	1.0370
3	C	33	0.453	2263	2.9000
		64	0.545	2725	2.4300
		98	0.988	4958	1.3670
4	D	34	0.256	513	12.9300
		65	0.433	865.3	7.5840
		99	0.938	1876	3.5800
5	E	35	0.718	3590	1.8600
		64	0.771	3853	1.7300
		98	1.112	5563	12.6000

Table-18 Thermal conductivity of renal stones at different temperature.
[Loraznts constant (L_z)= 2.44x 10^{-8} wΩk^{-2}]

SNo	Name of the Stone samples	Conductivity (σ) X10^{-4} mho.m-1	Temperature in degree Celsius	Thermal conductivity $K= \sigma L_z T$ X10^{-9} W/MK
1	A	1.211	33	0.904
		0.909	62	0.743
		0.759	98	0.687
2	B	3.483	32	2.592
		2,313	64	1.902
		1.579	99	1.433
3	C	4.418	33	3.298
		3.669	64	3.016
		2.025	98	1.833
4	D	19.49	34	14.60
		11.56	65	9.530
		5.333	99	4.838
5	E	2.785	35	2.093
		2.594	64	2.133
		1.798	98	1.619

Table-19 Temperature coefficient of the renal stone at different temperatures

Sample	Temperature minimum in degree Celsius	Temperature Maximum in degree Celsius	Temperature coefficient of the sample. $\alpha=(R_2-R_1)/(R_1T_2-R_2T_1)$
A	33	62	0.01825
	33	98	0.01334
B	32	64	0.03390
	32	99	0.04244
C	33	64	0.00841
	33	98	0.04556
D	34	65	0.09228
	34	99	0.10415
E	35	64	0.00279
	35	98	0.01253

5. CONCLUSION

All the renal stones thermal conductivity, electrical conductivity and temperature co-efficient are measured. At higher temperature, the thermal conductivity of all the samples is constant, but the electrical conductivity varied. All the stones are positive temperature coefficient materials. The entire samples are high conductivity at low temperature, but when the temperature increases, the conductivity decreases.

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