Effect of Fungicide Treatment on Dielectric Properties of a Coarse-Cereal (Indian Rice Variety)

Pooja Mishra[1], Bharat Mishra[1], Vishal Singh Chandel[2*] and Rajiv Manohar[3]

[1]Department of Physics, MGCG Vishwavidyalaya Chitrakoot, Satna , M. P., India
[2]Department of Physics, Integral University, Lucknow, U.P., India
[3]Department of Physics, Lucknow University, Lucknow, U.P., India

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Abstract - *Effect of fungicide treatment on dielectric properties of few coarse-cereals seeds, the Indian rice varieties namely Basmati, Gandhasala, Pusa and Sona Masuri at given moisture content and bulk densities were examined using Hewlett-Packard (HP-4194A) impedance/gain phase analyzer over the frequency rang of 0.01 to 10 MHz and temperature range of 30-45^{0}C likely to cover the temperatures range encountered during radio frequency heating process. Study showed that fungicide treatment cast considerable change in dielectric parameters namely the dielectric constant and dielectric loss factor as well as in temperature variation coefficient of these parameters. These changes can not be ignored when precise and accurate determination of dielectric parameters is required for agricultural technology.*

Key words: **Dielectric constant, Dielectric loss factor, Coarse-cereals, fungicides.**

1.INTRODUCTION

Dielectric properties of agricultural materials and products are finding increasing applications in various technologies. The interest in these properties of agricultural materials and products have been principally for ascertaining the behaviour of the materials subjected to electromagnetic heating and in their use for indirect, instantaneous, nondestructive and rapid methods of moisture content determination of grains and seeds. The knowledge of these properties are also useful for promise applications for precision farming operations. The techniques, employing these properties are much useful to control grain dryers and grain processing equipments for improving energy efficiency and improvement of product quality.

The dielectric properties of practical use that describe the interaction of a material with an electric field are the dielectric constant ε' , and the dielectric loss factor ε'' ; the real and imaginary part of the relative complex permittivity ε^* can be expressed by the given equation $\varepsilon^* = |\varepsilon^*| e^{-j\delta} = \varepsilon' - j\varepsilon''$, where $\delta = \tan^{-1}(\varepsilon''/\varepsilon')$ is the loss angle of the dielectric. The other parameter which are of importance in agricultural technology is the ac conductivity defined as: $\sigma = \omega\,\varepsilon_0\varepsilon'' = 55.63\times10^{-12}\,f\ \varepsilon''$, where $\omega = 2\,\pi\,f$, is the angular frequency and f is in Hertz.

The dielectric properties of most of the hygroscopic biological material, such as seed and grains are much dependent on moisture, temperature, bulk density and composition[1]. There is no universal physical model that adequately correlates the effective complex permittivity and physical properties of such a medium. A better understanding of such media can be attained through experimental approach.

Grain quality is an important parameter in commercial marketing as well as in seed industry. The moisture content is the single most important quality that determines the safe storage of grains and seeds. Grains and seeds with high moisture content are subjected to attack of by grain storage fungi and stored grain insets. These infections and infestations produce spoilage and loss of value in significant proportion. Moisture content and temperature determines the longevity and viability of seeds and grains during storage. Therefore, on-line, real time moisture content and other physical properties of wet seed and grain is crucial in agricultural industries where these properties are used as a quality control indicators for optimization of given process particularly when large quantities are involved.

Direct methods for moisture content determination of agricultural material are the oven drying method (ASAE standards[2]), chemical titration (Karl-Fisher). The major disadvantages of these methods are their destructive nature and time they required. Indirect method based on the measurement of property of material that is directly correlated with moisture content. Nuclear radiation, infrared and dielectric based sensors are commonly using indirect method. Nuclear radiation-based sensors are expensive and present potential hazards. Infrared sensors provide mainly surface moisture content. In contrast, with radio or microwave sensors, the spatial resolution of electromagnetic wave, provide information related to volume rather than just the surface of the material. Radio and microwave moisture sensors based on measurement of intrinsic properties of materials such as dielectric properties [3-5]. They can continuously provide parameters such as bulk density, moisture content and dry mass from non-destructive measurements of dielectric properties using appropriate correlation model and functions. Any error in determination of dielectric parameters would cause error in sensing of physical properties of the material

The protection of grain and seeds from the fugal and insect damages during harvesting, handling, transportation and storage are of increasing importance with trends towards processing and unit packaging at the time of harvest. For control of quality of seeds it is necessary to treat the seeds with appropriate fungicide to ward off diseases that infect, infest and damage the seeds and grains. For quality preservation during production, processing, storage and marketing of seeds the agro industries treat seed and grain lots with appropriate antifungal and insect repellent chemicals. These chemicals, though used in meager quantity, would be changing the dielectric parameters values of the seeds thereby causing error in accurate determination physical properties of seeds and grains if corresponding correction factor would not be addressed. On account of this, objective of present investigation is to explore the effect of fungicide treatment on dielectric parameters of seeds and grains of few coarse-cereals in the frequency range of 0.01 to 10 MHz. Our group has also reported studies ion dielectric properties of seeds and grains in different physical conditions[6-15].

2.MATERIAL AND METHOD

The certified grains of coarse-cereals, Indian rice varieties namely Basmati, Gandhasala, Pusa and Sona Masuri were obtained as cleaned and untreated from local market. Moisture content of each sample is determined by ASAE standard[2] by drying triplicate10g sample of the seed in forced air-oven at 130 ^{0}C[16]. The four fungicides, selected for present investigation are (1) thiram (75%WS), chemical name: tetramethylthiramdisulfide, chemical formula: $C_6H_{12}N_2S_4$, molecular weight: 240.44, specific gravity: 1.3,used to protect harvested crops from deterioration in storage and transport and also used as seed protestant and animal repellant. (2) carbendazim or bavistine) (50%WP), chemical name: methyl-benzimidazol-carbamate, chemical formula: $C_9H_9N_3O_2$, molecular weight: 191.2, specific gravity: 1.45- a systemic fungicide with protective and curative action used to control a wide range of fungal disease on cereals seeds. (3) Captan (50% WP), chemical name:N-(trichloromethylthio) cyclohex-4-ene-1,2-dicarboximide, chemical formula: $C_9H_8Cl_3NO_2S$, molecular weight: 300.6- the product is belonging to a wide spectrum fungicide and used on cereals seeds to control all kind of diseases. (4) Bagalol [MEMC 6% (Hg) SD], chemical name: 2-methoxy ethyl mercury chloride, chemical formula: $C_3H_7Cl_3HgO$, molecular weight: 295.11.This fungicide is used against surface born diseases, seed dressing against seed born diseases of cereal.

The standard recommended dose of fungicides is 200-250g per quintal for Indian environmental conditions[17]. Here, in present investigations treatment was done at the rate of 250g per quintal of seed by slurry treatment method. The slurry treatment method is the common method and is being used extensively in treatments of various coarse-cereal seeds. In this method the fungicide was applied to the seed in soup-like fungicide-water solution. Commercially no drying is done and can be bagged for storage. In this study after the slurry treatment the sample was put in sealed jar for at least two days at 2-4^{0}C for moisture equilibrate[18] within the seed kernel and any increment in moisture level caused due to water used in slurry treatment was measured and added to the initial moister to get the final moisture content. One more sample, called reference sample of same moisture level of same seed lot was also prepared and conditioned in similar fashion.

2.1 MEASUREMENT PROCEDURE

From an electrical viewpoint all biological materials can be treated as electrolytes contained in biological cells. These biological cells form the conducting medium, which exhibit electrical impedance when an electrode pairs is placed in contact with conducting medium[19]. The equivalent circuit concepts, where a dielectric material is represented for a given frequency by a parallel equivalent capacitance and resistance have been applied in many measurement techniques[20-22] including the present investigations, where dielectric properties are calculated from impedance or admittance measurements on dielectric material samples. The dielectric constant is calculated from the change in capacitance value of the sample holder due to the presence of sample material. Dissipation factor, which is the tangent of the loss angle δ, represents the angle between reactive component of current and total current for parallel equivalent circuit. Hewlett-Packard (HP-4194A) impedance/gain phase analyzer that was used in present investigations is one of such piece of equipment based on above principle. Values for capacitance and dissipation factor of the sample holder with or without sample were read from the screen of the impedance gain phase analyzer. The real permittivity of the sample in the sample holder was obtained from the change in capacitance value of the sample holder due to presence of sample material using equation:

$$\varepsilon' = \frac{\Delta C}{C_g} + 1$$

where C_g is the geometrical capacitance of the sample holder. $\Delta C = C_p - C_0$ is the change in capacitance of the sample holder and C_p is the capacitance of the sample holder with sample and C_o is the capacitance of empty sample holder. Loss factor, $\tan\delta$, and conductivity σ, were evaluated using expression $\delta = \tan^{-1}(\varepsilon''/\varepsilon')$ and $\sigma = \omega\varepsilon_0\varepsilon'' = 55.63\times10^{-12} f\ \varepsilon''$.

2.2 SAMPLE HOLDER

A coaxial cylindrical sample holder was designed and fabricated for use with impedance analyzer for dielectric measurement[23, 24]. The coaxial cylindrical sample holder was made of brass with effective geometrical capacitance 2.085 pF. All the conducting parts of sample holder were silver plated to reduce conduction losses. An open circuit termination for the sample holder was provided by brass cap. This termination confines the electric field, prevents radiation from an open end and also eliminates edge effects due to field fringing. Measurements on the benzene and n-butyl alcohol were conducted to check the reliability of the method. The n-butyl alcohol was selected because it has dielectric constant and loss factor of about of the order of magnitude as those for grains and seeds.

2.3 MEASUREMENT PROCEDURE

The coaxial sample holder was filled evenly with fungicide treated sample seed sample by consistent filling to maximize material to air volume ratio. The sample holder was then placed inside the temperature-controlled chamber. Connections to impedance analyzer were made through short and well separated thin wires to avoid capacitance effect between the two pairs. Capacitance and dissipation factors were measured at various discrete frequency, over the frequency range of 0.01 to 10 MHz, at various discrete frequencies and at given moisture content and density, over the temperature range of 30– 45^{0}C likely to cover the temperatures range encountered during radio frequency heating process .Similar measurements were also made for the reference (untreated) sample keeping the density and moisture content same as that of the treated on to check the moisture and density effect. Moisture determinations were made before and after each series of measurement to detect any change in moisture content. Investigation were made for Indian rice varieties namely Basmati, Gandhasala, Pusa and Sona Masuri at the moisture content 9.8%,8.9%,12.9%,12.5%; and bulk density: 0.795, 0.673, 0.632 and 0.824, respectively. Here the moisture content is reported in percent and wet basis (w.b.) and bulk density is in gm cm^{-3}.

3.RESULT AND DISCUSSION

The effective complex permittivity is a measure of the ability of a material to polarize when subjected to an electric field. At radio and microwave field dipolar polarizability plays a major role in polarization phenomena. In seeds and grains the water molecules bound to the matrix acts like a dielectric dipole and rotate to align them with alternating electric field giving rise to molecular polarization. As frequency of applied field increases the dielectric constant ε' and dielectric loss factor ε'' decreases with increase in frequency due to the dispersion. Comparison of change in dielectric constant and in dielectric loss factor with frequency showed that the variations with frequency in loss factor are less regular than that of dielectric constant. The irregular behaviour of loss factor may be due to complex dispersion phenomena and unknown nature of surface conductivity. In other studies[25] on wheat, corn and soybean over the frequency range 1 to 200 MHz range similar types of behaviour have been reported.

The change in dielectric constant ε' , dielectric loss factor ε'' of Indian rice varieties namely Basmati, Gandhasala, Pusa and Sona Masuri seeds at given moisture content and bulk density and at 30 ^{0}C and in mean temperature coefficient per unit of moisture content due to treatment of different fungicides are reported in table 1 and table 2 respectively for the frequencies 0.01 and 10 MHz. The mean temperature coefficient per unit of moisture content is defined as:(value of mean temperature coefficient of the parameter at M_2-value of mean temperature coefficient parameter at M_1)/(M_2-M_1) where the mean temperature coefficient is given by (value of the parameter at temperature T_2-value of mean temperature coefficient parameter at temperatureT_1)/(T_2-T_1).Here, T is temperature in ^{0}C and M is moisture content in percent (w.b.).

Analysis of data of table1 for dielectric constant, dielectric loss factor of different selected coarse-cereals showed that considerable changes occurred in these parameters due to the fungicide treatment. The changes are high at low frequencies but become less pronounced at higher frequencies.Furthe it is observed that different fungicides cast different magnitude of change in dielectric parameters of different coarse-cereal seeds. Amongst four cereals bagalol cast maximum change in ε' of the sorghum seed followed by thiram, carbendazim and captan at 0.01 MHz frequency but at 10 MHz maximum change cast by bagalol followed by carbendazim, thiram and captan in absolute term. In case of ε'' of the sorghum seed maximum changes at lower frequency (0.01MHz) cast by bagalol followed by thiram, carbendazim and captan in absolute term whereas at higher frequency (10MHz) the sequence is different. In case of other cereals seeds i.e. maize, barley and pearl millet, the magnitude of the effect is different for different species for different fungicide at different frequencies. These changes are quite high and can not be neglected when accurate and precise measurements are necessitated for determination of any extensive physical properties of grains and seeds, and for other purposes, useful in agricultural technologies. Similarly considerable change in mean temperature coefficient per unit of moisture content of ε' and ε'' are also noticed (table 2) for different cereals seed at different frequencies for different fungicides. However change in mean temperature coefficient per unit of moisture content in both ε' and ε'' are generally small and negligible at higher frequencies except pearl millet. Both positive and negative chang were seen in such coefficient of ε' and ε'' . Study showed that one can not anticipate any common and generalized changes in dielectric parameters due to fungicide treatment on any particular seed species of coarse-cereals. All fungicides affect different dielectric parameters of different seeds in different proportions and modes. These could be due to difference in composition, nature of the surface, shape and size of the kernel, moisture adsorption characteristics. The change in the magnitude of dielectric parameters and temperature coefficient of the seeds due to fungicide treatment could also be attributed to the structural difference of constituent molecules of the seed species and the applied fungicide, thus giving frequency dispersion of different nature. Due to structural difference, the energetic status of the molecules would be different, and hence the change in mean temperature coefficient of the dielectric parameters is obvious. One cannot rely fully on the dielectric and other chemical properties of fungicide alone to see the effect of fungicide treatments on the dielectric parameters of the seeds. The physical and chemical properties of seeds are having their own contributions in treatment impacts on dielectric properties. Further, it is inferred that a meager fungicide treatment casts considerable change in the values of the dielectric parameters in the frequency range of 0.01to10 MHz and temperature range 30-45^{0}C. More exhausted study of changes in dielectric due to a fungicide treatment on dielectric parameters of seeds could be useful in assessing the degree of impact of fungicides on cereal seeds, which is always a matter of concern for plant pathologist. Amongst all coarse-cereals the dielectric properties of pearl millet and barley are more prone to fungicide treatments.

4.CONCLUSIONS

Study showed that fungicide treatment cast considerable change in dielectric parameters as well as in temperature variation coefficient of these parameters. One cannot rely fully on the dielectric and other chemical properties of fungicide alone to see the effect of fungicide treatments on the dielectric parameters of the seeds. The physical and chemical properties of seeds are having their own contributions in treatment impacts on dielectric properties. These changes cannot be ignored and should be addressed when precise and accurate determination of dielectric parameters is required for agricultural technology. More exhausted study of changes in dielectric due to a fungicide treatment on dielectric parameters of seeds could be useful in assessing the degree of impact of fungicides on seeds and grains.

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Table1. Percentage change in dielectric constant and dielectric loss factor due to fungicide treatment, over the frequency range of 0.01 to 10 MHz and at 30 ⁰C

CEREALS	Basmati		Gandhasala		Pusa		Sona Masuri	
FUNGICIDE	$\Delta\varepsilon'_{0.01}$	$\Delta\varepsilon'_{10}$	$\Delta\varepsilon'_{0.01}$	$\Delta\varepsilon'_{10}$	$\Delta\varepsilon'_{0.01}$	$\Delta\varepsilon'_{10}$	$\Delta\varepsilon'_{0.01}$	$\Delta\varepsilon'_{10}$
Thiram	13.2	7.1	4.4	-0.64	12.5	-6.57	-4.2	-6.7
Carbendazim	5.6	-13.4	14.1	6.15	10.6	-1.88	-17.6	-8.1
Captan	1.9	0.99	6.1	1.51	1.9	2.35	-27.8	-10.6
Bagalol	41.1	25.7	31.2	11.3	26.6	6.7	21.1	-8.6
	$\Delta\varepsilon''_{0.01}$	$\Delta\varepsilon''_{10}$	$\Delta\varepsilon''_{0.01}$	$\Delta\varepsilon''_{10}$	$\Delta\varepsilon''_{0.01}$	$\Delta\varepsilon''_{10}$	$\Delta\varepsilon''_{0.01}$	$\Delta\varepsilon''_{10}$
Thiram	28.9	12.3	10.8	-3.83	9.6	12.3	-0.94	7.8
Carbendazim	-11.7	0.62	27.7	10.5	0.18	20.8	-33.7	-5.5
Captan	7.8	23.8	4.6	-21.6	1.90	2.4	-44.6	-20.8
Bagalol	41.9	25.7	70.7	14.3	50.5	29.7	42.8	13.9

Table 2. Change in mean temperature coefficient per unit of moisture content for dielectric constant and dielectric loss factor due to fungicide treatment, over the frequency range of 0.01 to 10 MHz

FUNGICIDE	FOR DIELECTRIC CONSTANT							
	Basmati		Gandhasala		Pusa		Sona Masuri	
	0.01MHz	10MHz	0.01MHz	10MHz	0.01MHz	10MHz	0.01MHz	10MHz
Thiram	0.007	NS	0.001	NS	0.009	0.001	-0.020	NS
Carbendazim	-0.001	0.003	0.002	NS	0.007	NS	-0.029	0.001
Captan	0.007	NS	NS	NS	0.003	NS	-0.027	0.001
Bagalol	0.010	0.003	0.008	NS	0.013	NS	0.016	0.002
	FOR DIELECTRIC LOSS FACTOR							
Thiram	0.012	NS	0.003	NS	0.002	NS	-0.008	-0.001
Carbendazim	-0.003	NS	0.005	NS	0.011	NS	-0.042	NS
Captan	0.006	NS	0.001	NS	0.017	NS	-0.037	NS
Bagalol	0.012	NS	0.034	0.001	0.178	0.001	0.343	NS

NS: Not Significant