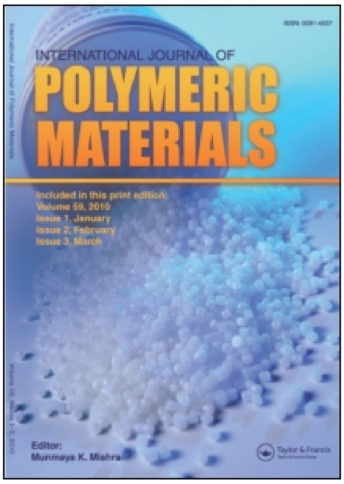

International Journal of Polymeric Materials
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713647664

Effect of γ-Radiation on the Dielectric Behaviour of Some Agricultural Wastes

G. Turky[a]; H. El-boohy[b]; A. M. A. Nada[c]
[a] Microwave Physics Dept., National Research Centre, Cairo, Egypt [b] Polym. Dept., National Centre for Radiation and Technology, Cairo, Egypt [c] Cellulose & Paper Dept., National Research Centre, Cairo, Egypt

To cite this Article Turky, G. , El-boohy, H. and Nada, A. M. A.(2000) 'Effect of γ-Radiation on the Dielectric Behaviour of Some Agricultural Wastes', International Journal of Polymeric Materials, 46: 1, 157 — 167
To link to this Article: DOI: 10.1080/00914030008054850
URL: http://dx.doi.org/10.1080/00914030008054850

Intern. J. Polymeric Mater., 2000, Vol. 46, pp. 157–167
Reprints available directly from the publisher
Photocopying permitted by license only

Effect of γ-Radiation on the Dielectric Behaviour of Some Agricultural Wastes

G. TURKY[a], H. EL-BOOHY[b] and A. M. A. NADA[c,*]

[a] *Microwave Physics Dept., National Research Centre, Dokki, Cairo, Egypt;*
[b] *Polym. Dept., National Centre for Radiation and Technology, Cairo, Egypt;*
[c] *Cellulose & Paper Dept., National Research Centre, Dokki, Cairo, Egypt*

(Received 8 October 1998)

Dielectric properties of some agricultural wastes *e.g.*, cotton stalks, Cs, rice straw, Rs and bagasse, B, are studied. The chemical constituents as well as the morphology of these material play a big roll on their dielectric properties. The effect of γ-irradiation on the dielectric properties of these lignocellulosic materials is also investigated. Grafting of these raw materials with acrylamide using γ-irradiation at dose of 20 M rad is also studied. Dielectric properties of these grafted materials and its complexes with Co^{++} is clarified. The mechanism of the interaction of γ-radiation with the investigated samples is also studied.

Keywords: Dielectric properties; agricultural wastes; γ-radiation

INTRODUCTION

Paper sheet may consider a good insulating material. It can be used as insulating material in telephone, radio and electrical wires. Lignocellulosic material is the raw material for paper production. Wood is the most abundant one that can be used for paper production. In Egypt agricultural wastes *e.g.*, bagasse [1] and rice straw [2, 3] are used for paper production. Cotton stalks also can be used as a good source for paper production [4, 5]. Chemical constituents as well fiber length of produced paper sheet have a high influence on the strength, physical and dielectric properties of the paper sheet. Chemical constituents of

*Corresponding author.

paper sheet depend mainly on pulping process (soda, kraft, sulfite and organosolv) as well as kind of raw materials.

The electrical properties of paper were investigated [6–9]. Dielectric properties of paper sheet can be improved by some treatments *e.g.*, impregnation in some resin solutions or addition of some insulating material during paper sheet formation [10]. Also, dielectric properties of lignin [11] and cellulose [12] that are the principal constituents of the lignocellulosic material are also recently investigated. The dielectric properties of lignocellulosic raw materials were also investigated [13].

In this study, the dielectric properties of different agricultural wastes as rice straw, bagasse and cotton stalks are studied. Also the effect of γ-irradiation, of different doses (0–40 M rad), on the dielectric properties of these materials is also interpreted on the basis of the molecular structure changes.

EXPERIMENTAL

The raw materials, which are used in this study are rice straw, Rs, Sugar cane bagasse, B, and braked cotton stalks, Cs. These raw materials were ground to 0.25 mm before use. 0.2 gm of the grounded raw material pressed at 5 ton/m^2 forming a tablet of 13 mm diameter and 1–2 mm thickness.

Analysis of the main constituents of Raw material, lignin [14], hemicellulose [15], α-cellulose [16] and ash content were estimated.

Raw material	Hemi cellulose%	α-Cellulose%	Lignin%	Ash%
Rice Straw	19.5	42.4	16.1	9.9
Bagasse	27.3	44.3	20.2	1.2
Cotton Stalks	25.4	43.2	27.3	1.3

Grafting Process

Raw material was grafted with acrylamide of ratio (1:1) using γ-irradiation of 20 M rad. Graft yield was calculated by the difference in weight of the used raw material before and after grafting.

Complex Formation

The grafted raw material was boiled with $CoCl_2$ (5%) for two hours. Dielectric properties of the samples under investigation were determined using AG-4311B RCL-meter (Ando-Japan) at frequencies varied among 100 Hz – 100 kHz. The used measuring cell consists of two parallel plates circular condenser made of copper of 12 mm diameter attached to movable micrometer. Dissipation factor ($\tan\delta$) and capacity of the condenser are measured directly by the RCL-meter. Using some standard samples of known dielectric constants, the dielectric constant ε' and then dielectric loss ε'' of the investigated sample could be determined.

The samples were irradiated by a Co-60 source of chamber 4000 A represented at the National Center for radiation and technology, Cairo.

RESULTS AND DISCUSSION

Agricultural wastes *e.g.*, Bagasse, rice straw and cotton stalks are considered as lignocellulosic materials. The constituents of these lignocellulosic materials like cellulose, hemicellulose and lignin are different for each of them. Also, the ratio of syringyl to guaiacyl lignin as well as the percent of their ash content are different.

Figure 1 clarified the dielectric constant (ε') and dissipation factor ($\tan\delta$) as a function of frequency for raw materials of cotton stalks, rice straw and bagasse. From this figure it is seen that the dielectric constant as well as dissipation factor are decreased by increasing frequency for the three samples under investigation. Dielectric constant (Fig. 1a) of cotton stalks is higher than the other two lignocellulosic materials in the lower frequency range and decreased sharply with frequency increase. This means that the dispersion step, which directly related to the dipole moment since $\mu^2\alpha(\varepsilon_s - \varepsilon_\infty)$ as stated by Onsager [17], is high in case of cotton stalks than that in case of rice straw and bagasse. This can be attributed to the higher lignin content in case of cotton stalks which is more than that in case of rice straw and bagasse. The high lignin content causes an increase in the functional groups.

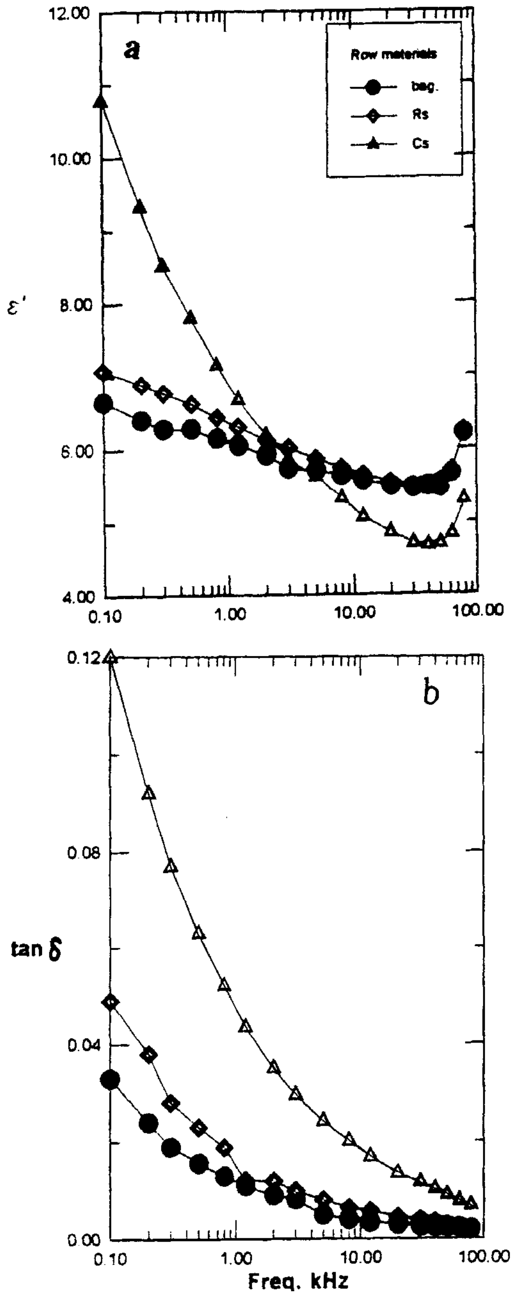

FIGURE 1 Dielectric constant ε' (a) and dissipation factor $\tan\delta$ (b) *vs.* frequency in kHz for bagasse, rice straw and cotton stalks raw materials.

Also the morphology structure of the three raw materials is taken into consideration. It is different in case of cotton stalks (woody structure) while the other two materials, (spongy structure) this may explain the higher dispersion step of cotton stalks than rice straw and bagasse.

Although the dielectric constant of bagasse and rice straw is lower than that of cotton stalks, it is more stable over the range of frequency as shown in Figure 1. Also, their dissipation factor is lower than in case of cotton stalks and within the range of good dielectric materials.

Effect of γ-radiation

The effect of different doses of γ-radiation on the dielectric constant ε' and dissipation factor $\tan\delta$ at spot point frequency 12 kHz of the three raw lignocellulosic materials Cs, B and Rs is shown in Figure 2. From this figure it is clear that the dielectric constant of irradiated raw material decreases by increasing the dose of irradiation and reaches its minimum value at about 5 M rad, then it began to increase till a maximum value at 30 M rad for Rs and Cs but for B at 20 M rad. This behavior can be explained by an increase in the cross linking between the constituents of lignocellulosic material at lower dose of irradiation which results a more condensed structure of lower polarity and hence decreases dielectric constant and dissipation factor. On the other hand, radiation doses above 5 M rad increase ε' for the three lignocellulosic materials. This can be explained by the predominating of the degradation process yielding smaller aggregates of high polarities. These fragments mainly highly oxyginating compounds and consequently this causes an increase in the dielectric properties. By increasing radiation dose more than 30 in case of Cs and Rs or 20 M rad in case of B, the dielectric constant decreases again. This can be explained by increase of the concentration of ash content and a formation of free radicals in the degraded material. These radicals take part into conduction process. This mechanism can be confirmed by considering the effect of γ-radiation on the dissipation factor Figure 2b. This figure shows also that the dissipation factor, $\tan\delta$, increases sharply by increasing dose after 20 M rad (at the beginning of the degradation process and the formation of radicals.

Generally, from Figure 2, the dielectric constant of bagasse in (a) increases by increasing the radiation dose as other two materials, but

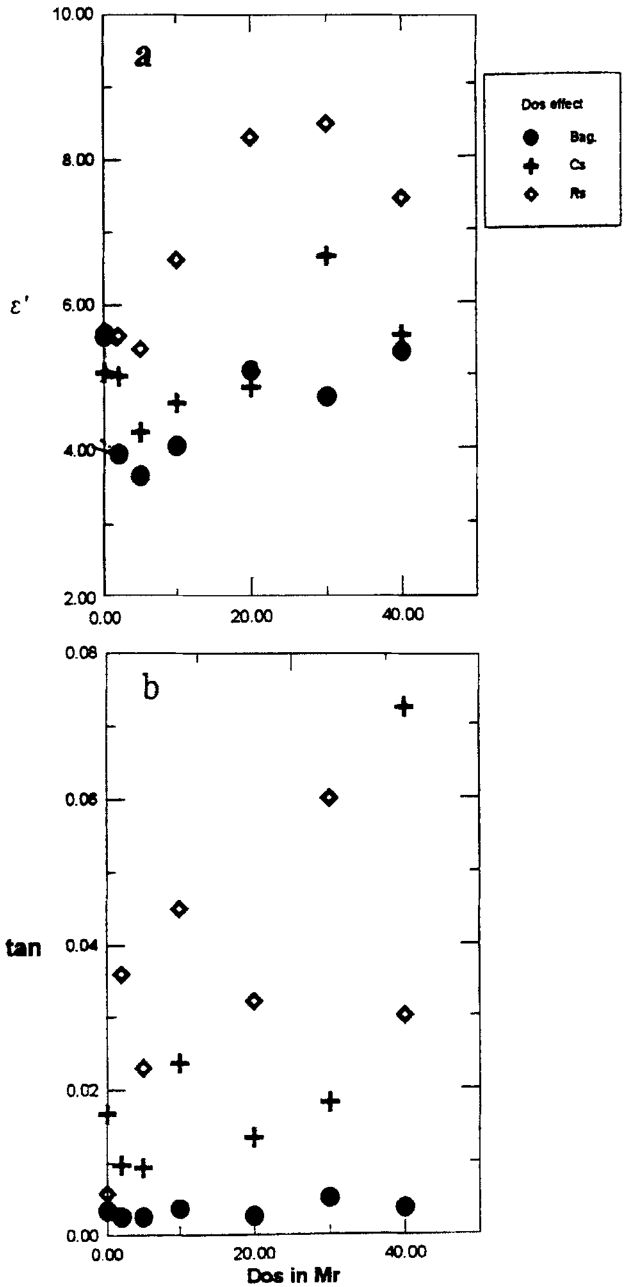

FIGURE 2 The effect of irradiation dose on the dielectric constant ε' (a) and dissipation factor $\tan\delta$ of the investigated materials.

its tan δ in (b) is stable within the range of irradiation doses used. In case of rice straw it is clear from the figure that, its tan δ increases by increasing the radiation dose, this can be attributed to the concentration of the ash content due to the degradation of the organic materials of lignocellulosic sample.

The dielectric constant of the irradiated lignocellulosic raw material is investigated and shows similar behavior over the frequency range, Figures 3a, b.

Dielectric Properties of Grafted Lignocellulosic Materials

Cotton stalks and rice straw are grafted with acrylamide by using γ-radiation at 20 M rad. These grafted materials are complexed with $CoCl_2$. The dielectric properties of these materials are discussed.

Table I shows the comparison of dielectric properties of the cotton stalks and rice straw and their grafted compounds at frequency of 2 kHz

From this table, it is clear that the dielectric constant of the cotton stalks decreases by radiation, grafting and complex formation. In case of rice straw, the radiation enhances the dielectric constant and at the same time decreases by grafting process. The complex of the grafted rice straw shows a slightly increase in the dielectric constant.

The higher dielectric constant of the irradiated rice straw than the irradiated cotton stalks is due to the low lignin content and the morphology of the two raw materials. On the other hand, the lignin content of the cotton stalks and the woody structure cause a lower graft yield (8%) than rice straw (11%). This high graft content causes a high value of the dielectric constant of rice straw. Complex formed of the grafted rice straw increases the dielectric properties more than cotton stalks.

In case of dissipation factor (tan δ), it is found that the treatment of rice straw and cotton stalks decreases tan δ which reaches its minimum values 0.009 and 0.007 in their complex, respectively.

The dielectric parameters ε' and tan δ of rice straw and cotton stalks raw materials, irradiated at 20 Mr, grafted and complexed samples are determined and illustrated *versus* frequency of range 0.1 to 100 kHz in Figure 4. It is shown from this figure that both of the dielectric properties (ε' and tan δ) decrease by increasing frequency. This is due

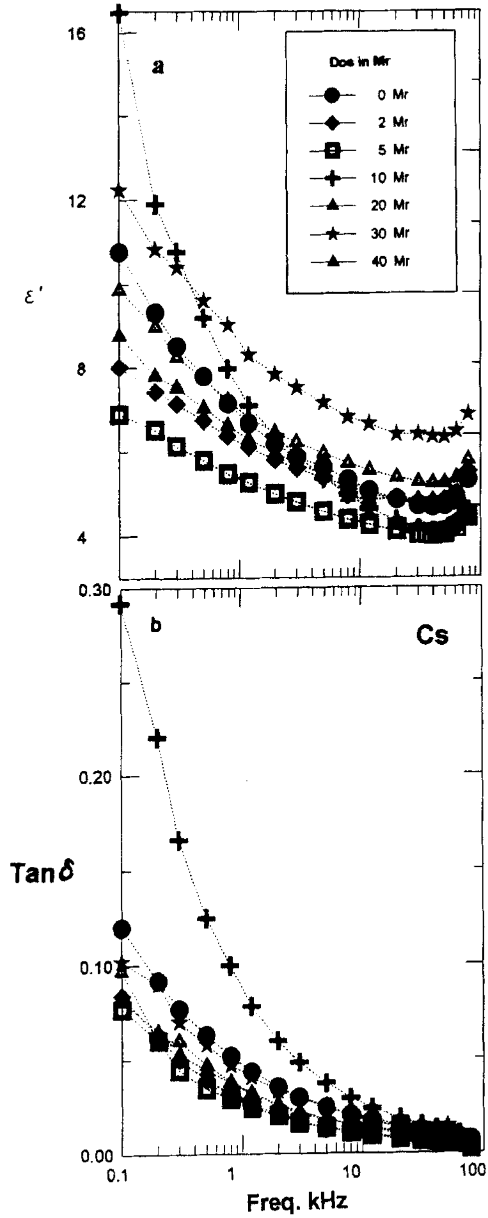

FIGURE 3 Dielectric constant ε' (a) and dissipation factor $\tan\delta$ (b) *vs.* frequency at different doses of irradiated cotton stalks.

TABLE I Dielectric constant and dissipation factor of treated Cs and Rs at 2 kHz

	Raw		*Irradiated*		*Grafted*		*Complexed*	
Material	*Cs*	*Rs*	*Cs*	*Rs*	*Cs*	*Rs*	*Cs*	*Rs*
ε'	6.19	6.13	5.97	10.54	5.35	5.59	4.54	6.43
$\tan\delta$	0.035	0.012	0.16	0.062	0.005	0.032	0.007	0.009

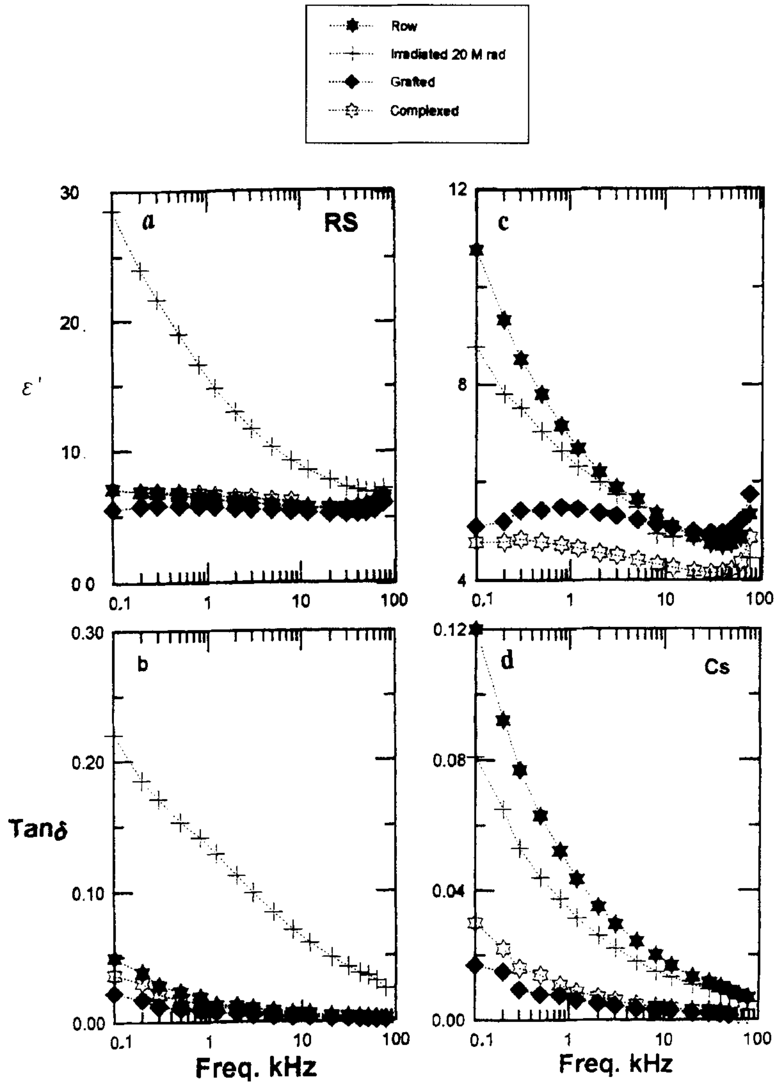

FIGURE 4 The effect of irradiation, grafting and complexing processes on the dielectric properties of rice straw and cotton stalks.

to the lag of molecular polarization behind the field of oscillation. In general the dielectric parameters of grafted material are lower than the irradiated one. This can be attributed to the degradation by irradiation in to small fragments of relative high mobility. While in case of grafted raw material, the monomer molecules attach with the cellulosic chains. This restrict the motion of the side and chain molecules. This cause a decrease of dielectric constant and dielectric loss. In case of cotton stalks, it is seen that the dielectric constant shows a marked decrease in cotton stalks than rice straw by boiling the grafted with $CoCl_2$ solution in the complex process.

CONCLUSION

1. The dielectric constant of the cotton stalks is higher than that of rice straw and bagasse raw material at lower frequencies.
2. The value of dielectric constant of bagasse is more or less stable over all frequencies.
3. Dielectric constant of these lignocellulosic materials increases by increasing radiation dose.
4. Dielectric constant of cotton stalks decreases by irradiation, grafting and complexes while as in case of rice straw increases by irradiation.
5. Grafting and complexing processes improve the dielectric properties of cotton stalks.

References

[1] Nada, A. M. A., Ibrahem, A. A., Fahmy, Y. and Abu-Yousef, H. E. (1995). *Res. and Ind.*, **40**, 273.
[2] Nada, A. M., Ibrahim, A. A., Saad, S. M. and Mohamed, H. T. (1990). *Cell. Chem. and Technal.*, **24**(4), 371.
[3] Nada, A. M. A., Fahmy, Y. and Abou-Yousef , H. E. (1996). *J. Scientific and Indst. Res.*, **55**(7), 316.
[4] El-Said, H. , Nada, A. M. A. and El-Ashmawy, A. E. (1989). *Patent*, 17677, Egypt.
[5] Nada, A. M. A., El-Said, H. and El-Ashmawy, A. E. (1986). *Holzforsch.*, **40**, 43.
[6] Tsutsumi, J. and Walanabe, H. (1965). *J. Jpn. Wood Res. Soc.*, **12**, 115.
[7] Venkaleswaran, A. and Tiwari, S. Y. (1964). *Tappi*, **47**, 25.
[8] Yousef, M. A., Shabaka, A., Nada, A. M. A. and Abdel-Nour, K. N. (1991). *Indian J. Appl. Pure Phys.*, **29**, 6.

[9] Nada, A. M. A., Badry, M. D. and Turky, G., Elastomers and Plastics "Submitted 1997".
[10] Nada, A. M. A., Yousef, E. A. and Abdel-Nour, K. N. (1997). *Pigment and Resin Techno.*, **26**(1), 17.
[11] Badry, M. D., Shabaka, A. A. and Nada, A. M. A. (1997). *4th Arab Int. Conf. of Polym. Sci. and Technol.*, 8–11 Sept., Egypt (Proc.).
[12] Badry, M. D. and Nada, A. M. A. (1994). *Cell. Chem. Tech.*, **28**(6), 604.
[13] Mounir, M., Ali, Ab. H. and Mobarak, F. (1996). *Proc. Int. Conf. Chem. and Technol. of Fibers and Textile*, 10–12 Dec., Egypt.
[14] Swedish Standards OCA9.
[15] Jayme, G. and Sarten, P. (1990). *Naturwiss*, **28**(52), 822.
[16] Markblatt IV 129 Zellecheming (*German Assoc. of Cellulose Chem. and Eng.*).
[17] Onsager, L. (1936). *J. Am. Chem. Soc.*, **58**, 1986.