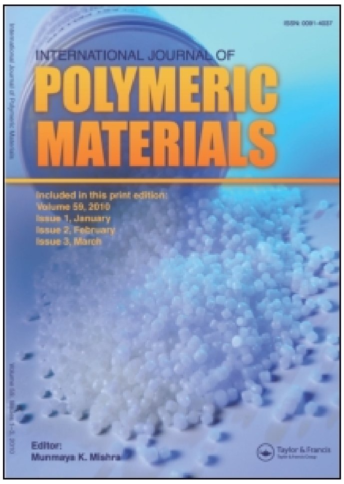

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Dielectric Properties of Bagasse and its Constituents

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Dielectric properties of bagasse raw material and its constituents, cellulose and lignin was studied. The effect of γ-radiation of different doses (0–40 M rad) on the dielectric properties of these investigated samples was also studied. However, the study of the grafting process of these materials with acrylamide initiating with γ-radiation (dose 20 M rad) was also clarified. The dielectric properties of these grafted materials were also investigated.

Keywords: Dielectric properties; bagasse material; cellulose; lignin; γ-radiation; acrylamide; grafting

INTRODUCTION

The electrical properties of dry, moist wood pulp and paper were investigated by many authors [1–4]. However information concerning agricultural residues pulp and paper as rice straw are scanty. Dielectric properties of produced paper sheets from some agricultural residues were investigated [5, 6]. Although pure cellulose possess high dielectric constant, yet the dielectric constant of paper is much lower [4]. This is due to the high percentage of air voids and pores in the paper sheet. Air has a comparatively low dielectric constant. Therefore, to increase the dielectric constant of paper it is common technique to decrease

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the air voids and porosity of paper. This can be carried out by coating the paper with resin [6, 7] or oils [8]. On the other hand the dielectric properties of the lignocellulosic constituents are studied [4]. The dielectric constant of lignin were also investigated. It has a good dielectric properties [9].

The aim of this work is to investigate the dielectric properties of bagasse and its constituents (lignin and cellulose). The effect of γ-radiation on the dielectric properties of these constituents are also studied. Grafting of these constituents and their dielectric properties are investigated.

EXPERIMENTAL

The material used in this study:

1. Sugar cane bagasse, B, delivered from Edfo paper mill, has the following analysis (lignin 20.2%, α-cellulose 45.1% and hemicellulose 27.4%).
2. Unbleached bagasse pulp, Bp, delivered from Edfo mill, has the following analyses (lignin 5.1%, α-cellulose 67.1% and hemicellulose 27.1%).
3. Dissolved bleached bagasse pulp, BB, prepared in the Cellulose and Paper Dept., NRC, Egypt and has the following analysis (α-cellulose 94%).
4. Kraft bagasse lignin, lig., precipitated from waste black liquor produced from pulping of bagasse with kraft pulping process.

These materials were irradiated with different doses 2–40 M rad of γ-radiation and grafted with acrylamide using γ-radiation at 20 M rad.

The grafting yield was calculated using the following equation:

$$\text{Graft yield} = \frac{W_1 - W_0}{W_0} \times 100$$

where,

W_1 is the weight after grafting and W_0 is the weight before grafting.

Dielectric Measurements

For dielectric measurements, samples were prepared in the form of discs of diameter 1.3 cm and a thickness ranging between 0.2 and 0.3 cm. The parallel surfaces of the samples were coated with graphite. The measuring cell consists of two parallel plates circular condenser made of copper of 1.2 cm diameter attached to a movable micrometer. The dielectric constant, ε' and dissipation factor, $\tan\delta$, were determined for the investigated samples in the frequency range 0.1 – 100 kHz using AG-4311B RCL-meter (Ando-Japan).

RESULTS AND DISCUSSION

The dielectric constant and dissipation factor of bagasse raw material **B**, bleached bagasse pulp **BB**, bagasse pulp **Bp** and lignin **Lig**. are shown in Figure 1. It is clear that the dielectric constant ε' of bagasse raw material is less than that of the bleached and unbleached bagasse pulp over all the used frequency range. This means that the decreasing of lignin content in the lignocellulosic material causing an increase in the dielectric constant from 8.5 to 19 at 100 Hz. However, the constituents of raw material: lignin, hemicellulose and α-cellulose have been linkage with each other through hydrogen bonds. However the pulping and bleaching processes of bagasse raw material cause a decrease in the lignin content and consequently the bond between the bagasse constituents decreases, *i.e.*, increase of the mobility of the functional groups of bagasse pulp. On the other hand, the dielectric constant of pure lignin is higher than that of the bagasse raw material. This can be attributed to that the functional groups of lignin are more free than in the presence of the raw material which the functional groups of its constituents is more restricted due to the presence of bonds which linkage the lignin with hemicellulose and cellulose. Figure 1a shows also that the dielectric constant of the bagasse raw material and lignin is more or less stable over the investigated range of frequency. This can be attributed to the increase of degradation of cellulosic chains as well as the decrease of the hydrogen bonds of the cellulosic chains during pulping and bleaching processes. This causes an increase of the mobility of the functional groups in the cellulosic chains. Also, the

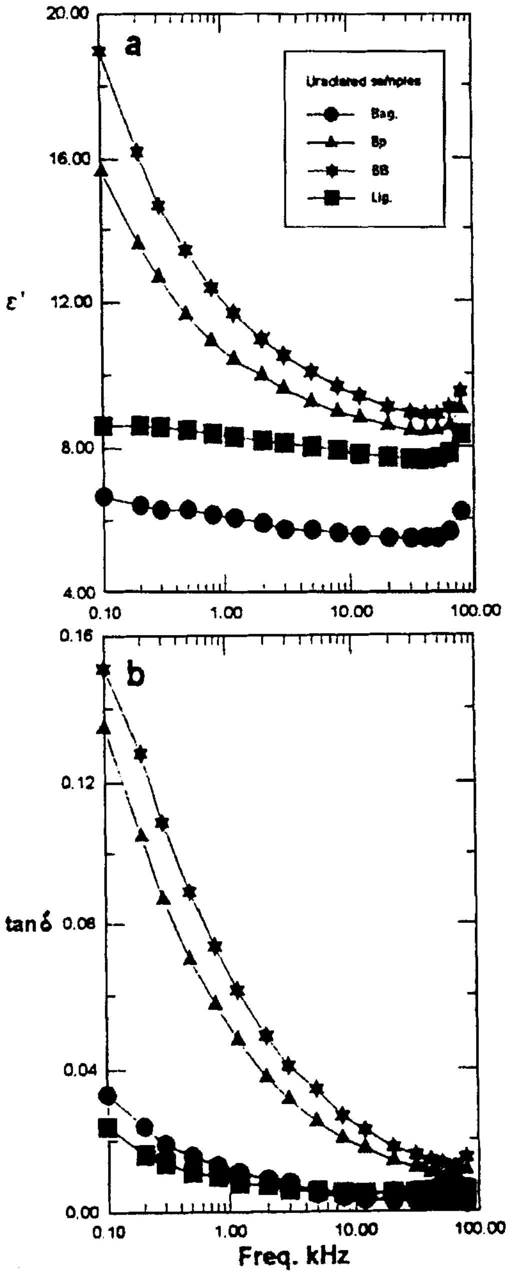
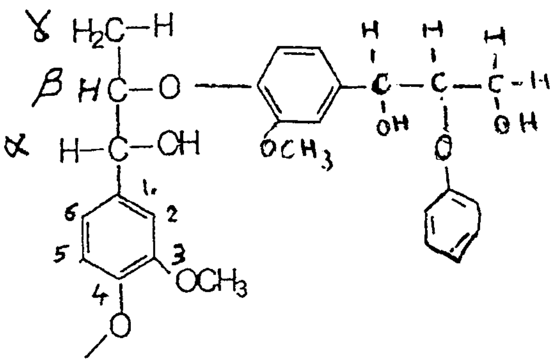


FIGURE 1 Dielectric constant, ε', and dissipation factor $\tan\delta$ *vs.* frequency for the raw materials.

presence of cellulose in straight chains whileas lignin molecules attached with each other in more than one direction with β-0-4 linkage, causes an increase in the dielectric constant of cellulose and decrease the dielectric constant of lignin. This can be confirmed by the high dissipation factor of bleached BB and unbleached bagasse pulp Bp than the bagasse raw material and lignin Figure 1b.



Dielectric Properties of γ-irradiated Bagasse and its Constituents

Dielectric constant ε' and dissipation factor $\tan\delta$ of **B**, **Bp**, **BB** and **Lig.** at 12 kHz for different doses of γ-radiation (0–40 M rad) are shown in Figure 2. From this figure it is clear that, the dielectric constant of the samples under investigation decreases sharply with increasing γ-dose tell 5 M rad. Increasing the dose more than this value the dielectric constant begin to increase. This can be attributed to that the low γ-radiation dose causes an accumulation of small cellulosic chains which decreases the dielectric constant. Decrystallization and degradation of cellulosic chains occur by the increase of γ-dose over 5 M rad. This causes an increase of the dielectric constant.

From Figure 2b it is seen that, $\tan\delta$ of bagasse raw material and lignin is slightly influenced by increasing radiation dose, while as its dielectric constant increases. This means that, γ-radiation improves the dielectric properties of bagasse. On the other hand, $\tan\delta$ of bagasse pulp (bleached and unbleached) have higher value than B and lig. This

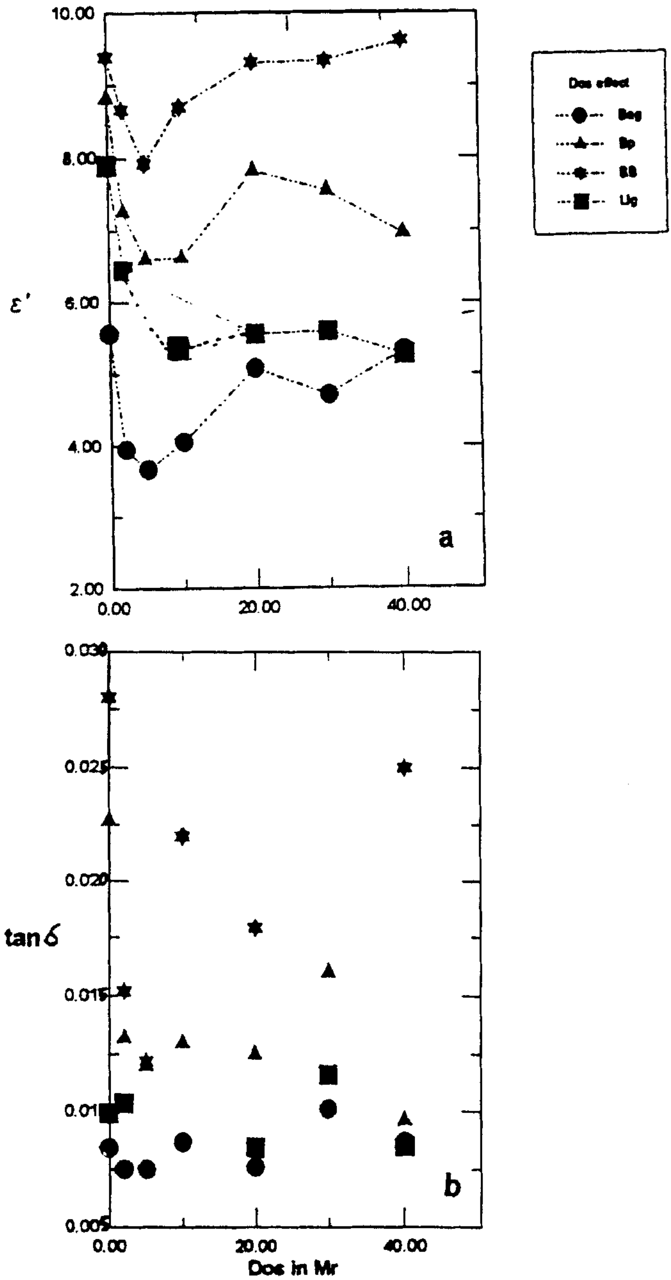


FIGURE 2 Effect of γ-irradiation of different doses on the dielectric properties of bagasse, bagasse pulp (unbleached and bleached) and lignin.

can be attributed to that, the γ-radiation has more effect on the degradation of cellulosic pulps (bleached and unbleached pulp) than that of bagasse raw material and lignin. Also it is seen that the unbleached bagasse pulp has a lower $\tan\delta$ than the bleached bagasse pulp. This means that, the presence of lignin with cellulose chain decreases the effect of γ-radiation on the degradation of cellulose.

The dielectric constant (ε') and the dissipation factor ($\tan\delta$) of irradiated B, Bp, BB and lignin in the frequency range under investigation are represented graphically in Figures 3 and 4. From these figures it is shown that, $\tan\delta$ decreases gradually with increasing frequency. The BB irradiated at 5 M rad shows stability of its dielectric constant with frequency while its $\tan\delta$ sharply decreases from about 0.09 to about 0.002. On the other hand the unbleached bagasse pulp irradiated at 5 M rad shows a stability than the other doses and its dissipation factor, $\tan\delta$, decreases from about 0.06 to 0.001. This means that the irradiation of Bp with 5 M rad improved its dielectric properties. This recommend that γ-irradiated bagasse pulp with 5 M rad is preferable for insulating papers.

Grafting of Bagasse Constituents with Acrylamide Using γ-irradiation

Bagasse raw material, bagasse pulp (bleached and unbleached) and lignin are grafted with acrylamide using γ-radiation of 20 M rad. Table I shows the graft% of these molecules.

From this table it is clear that the bleached bagasse pulp has the highest graft%. The graft of the different materials has the following sequence:

$$\mathbf{BB > Bp > B > Lig.}$$

This means that the presence of lignin in the bagasse decreases the grafting with acrylamide. This can be attributed to that the presence of hydrogen bond linkages between lignin and cellulose and hemicellulose. On the other hand, the γ-radiation causes a high free radicals, which increase the grafting process in bleached pulp more than the unbleached pulp.

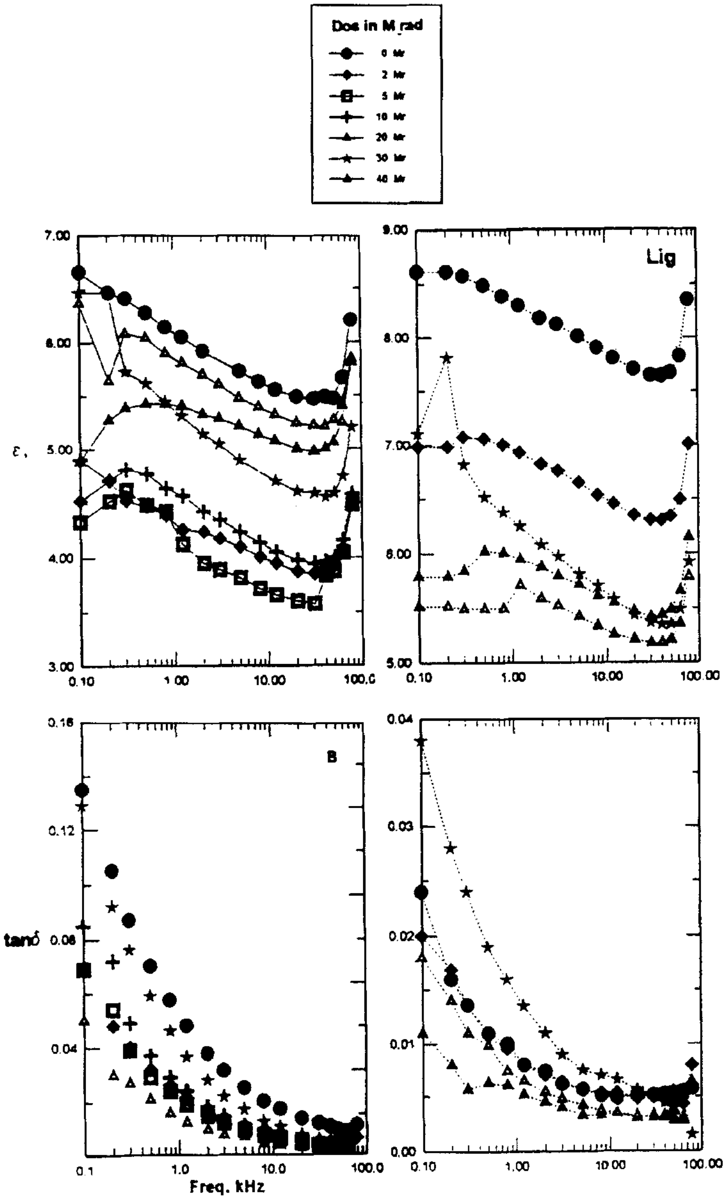


FIGURE 3 The dielectric constant, ε', and dissipation factor, $\tan\delta$, *vs.* frequency in kHz (semi log scale) for bagasse and lignin at different doses of γ-irradiation.

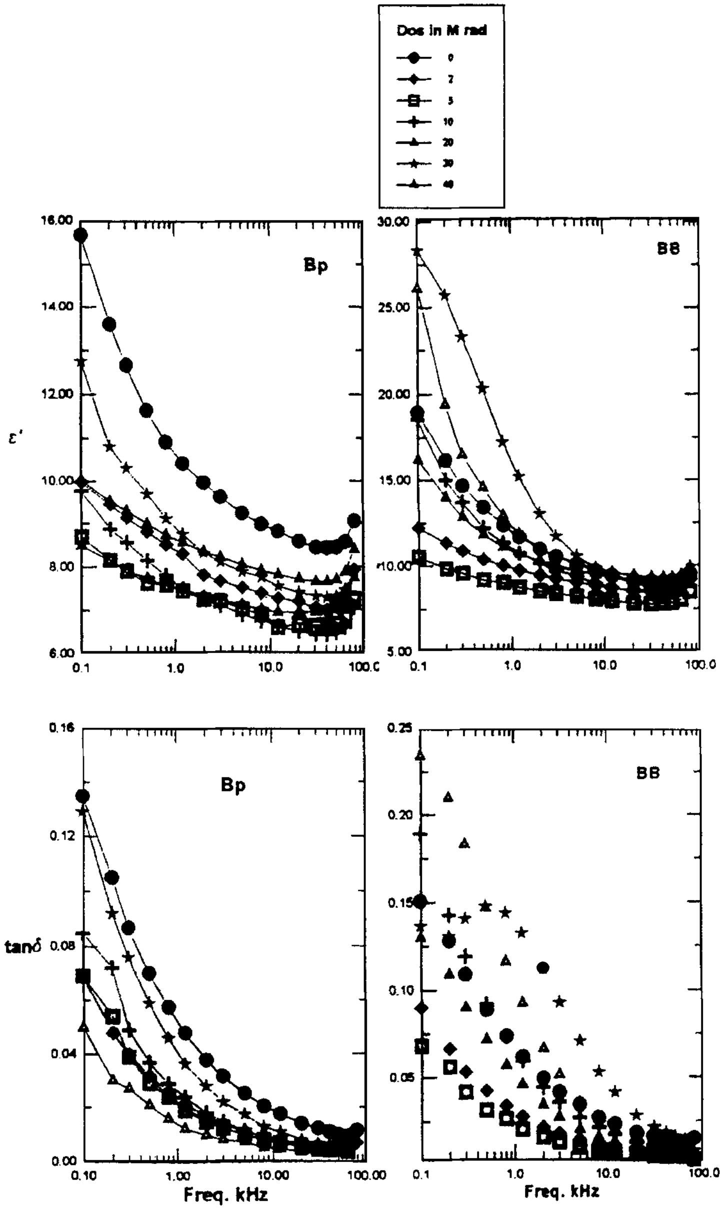


FIGURE 4 The dielectric constant, ε', and dissipation factor, $\tan\delta$, *vs.* frequency in kHz (semi log scale) for bagasse pulp (unbleached and bleached) at different doses of γ-irradiation.

TABLE I Effect of γ-radiation of 20 M rad dose on the grafting of bagasse

Material		*Yield%*
Bagasse raw material	**B**	15
Bagasse bleached pulp	**BB**	43
Bagasse unbleached pulp	**Bp**	28
Lignin	**Lig.**	0

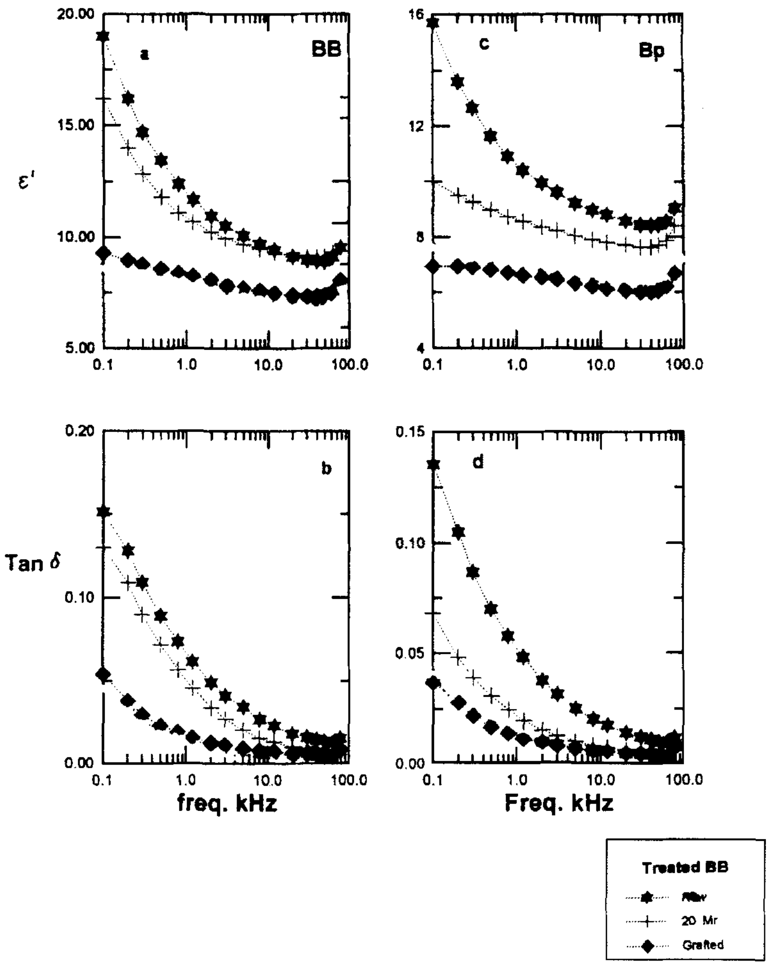


FIGURE 5 Effect of grafting process, irradiation at 20 M rad dose on the dielectric properties of bagasse pulp (bleached and unbleached).

Dielectric Properties of Grafted Bagasse Pulp

Figure 5 shows the dielectric constant, ε', and dissipation factor, $\tan\delta$, of ungrafted and grafted bagasse pulp. It is clear that, the dielectric constant of grafted bagasse pulp becomes lower and more stable as a function of frequency. Comparing the dielectric properties of grafted bagasse with ungrafted irradiated one at the dose used in the grafted process (20 M rad), it is found that the grafted pulp has a better dielectric properties than the ungrafted one. This can be attributed to that the grafting introduce an acrylamide group in the cellulose chain of bagasse pulp, which increases the mobility of the functional groups.

CONCLUSION

The dielectric constant of bagasse raw material is lower than bleached and unbleached bagasse pulp. On the other hand, the dielectric constant of bagasse raw material and lignin is more or less stable over the investigated range of frequency (0.1 – 100 kHz).

The irradiation of bagasse pulp with low dose of γ-radiation (5 M rad) is preferable for insulating papers.

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