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A dielectric study of cellulose fibres

It appears from the literature that little work has so far been reported on the dielectric properties of cellulose fibres. Cellulose is one of the most important organic substances and has been subjected to thorough analysis by various techniques [1-3]. The directional dependence of the properties of fibres is now of wide interest as a means of producing desirable properties by inducing preferred orientation. A study of the dielectric property is of importance as it provides a measure of the amorphous fraction of the material and is sensitive to orientation effects, mobility effects and to the number and interactions of the dipoles participating. In view of this we have extended our previous work on electrical anisotropy [4] to the case of cellulose fibres. The result of measurements along both the longitudinal and transverse directions of some natural cellulose fibres are reported.

Natural cellulose fibres of ramie, hemp and jute were chosen for this study. A study of its crystallinity defects, etc., has been reported [5]. These fibres were first purified and delignified. The samples were prepared in the same way as reported earlier [4]. Dielectric measurements were carried out on a precision capacitance bridge GR716 in the frequency range 10^5 Hz by applying a resonance curve method.

The results are illustrated in Figs. 1 to 3. It is found that the dielectric constant and loss factors are highest for jute, followed by hemp and ramie. All these fibres possess the same molecular structure, i.e. cellulose I structure. The difference is mainly due to differences in the amorphous and crystalline fractions in the fibres. Thus we can conclude that the amorphous fraction is the greatest in jute, followed by hemp and ramie.

The most interesting features of the results are a sharp increase of dielectric constant and a fall of loss factor along the fibre direction, i.e. the longitudinal direction compared to the transverse direction. This is certainly not due to an increase in amorphous fraction, as in that case the loss factors would also increase. It is an established fact that the crystallinity is greater along the fibre direction in these fibres, thus we can conclude that dipoles are arranged in these molecules along the longitudinal direction, i.e. the chain direction, and the higher mobility of the dipoles along the longitudinal direction compared to the transverse direction, is the cause of anisotropy in the fibres.

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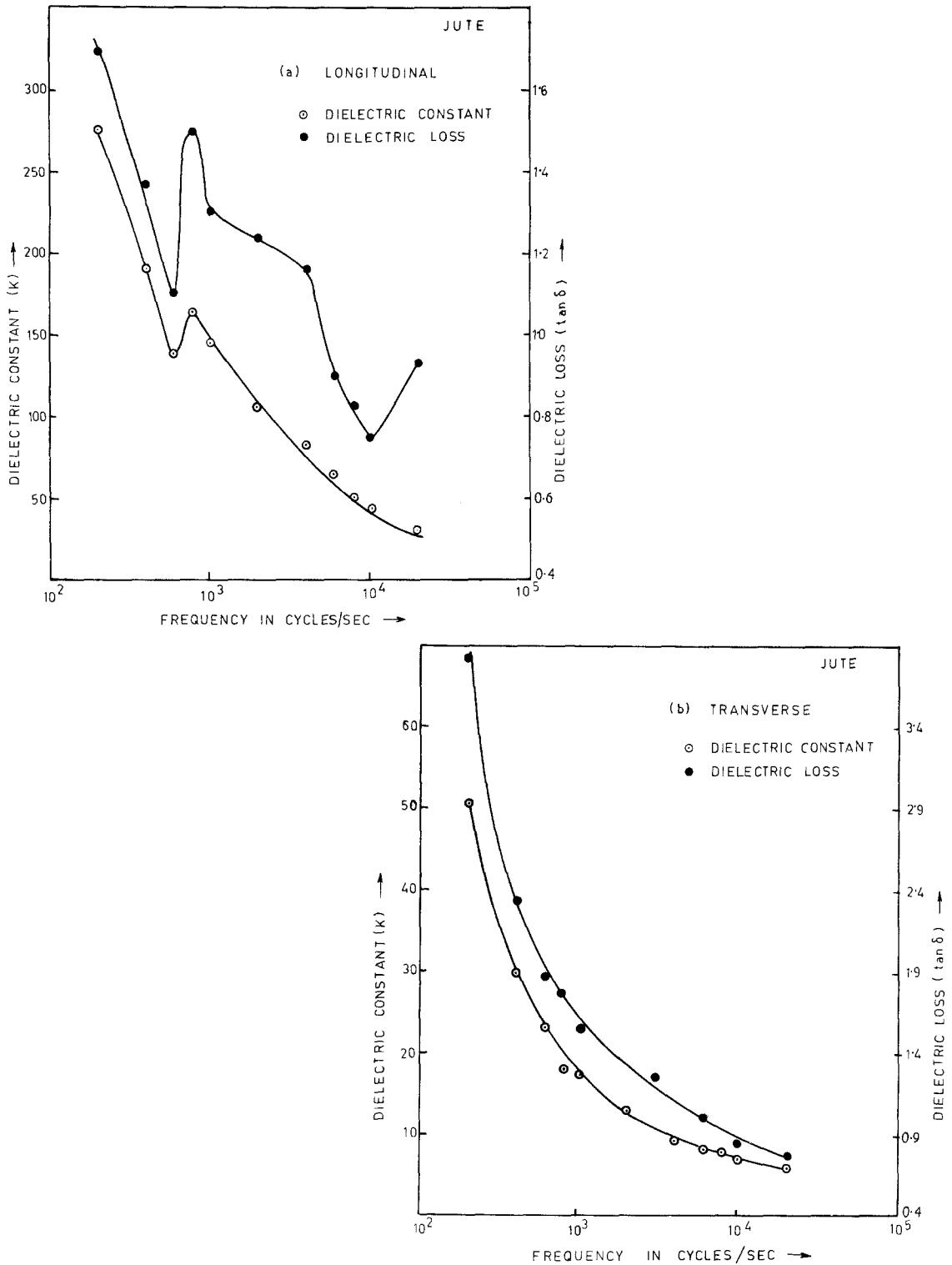


Figure 1 Variations of dielectric constants and dielectric losses of jute with frequency along (a) the longitudinal, and (b) the transverse directions.

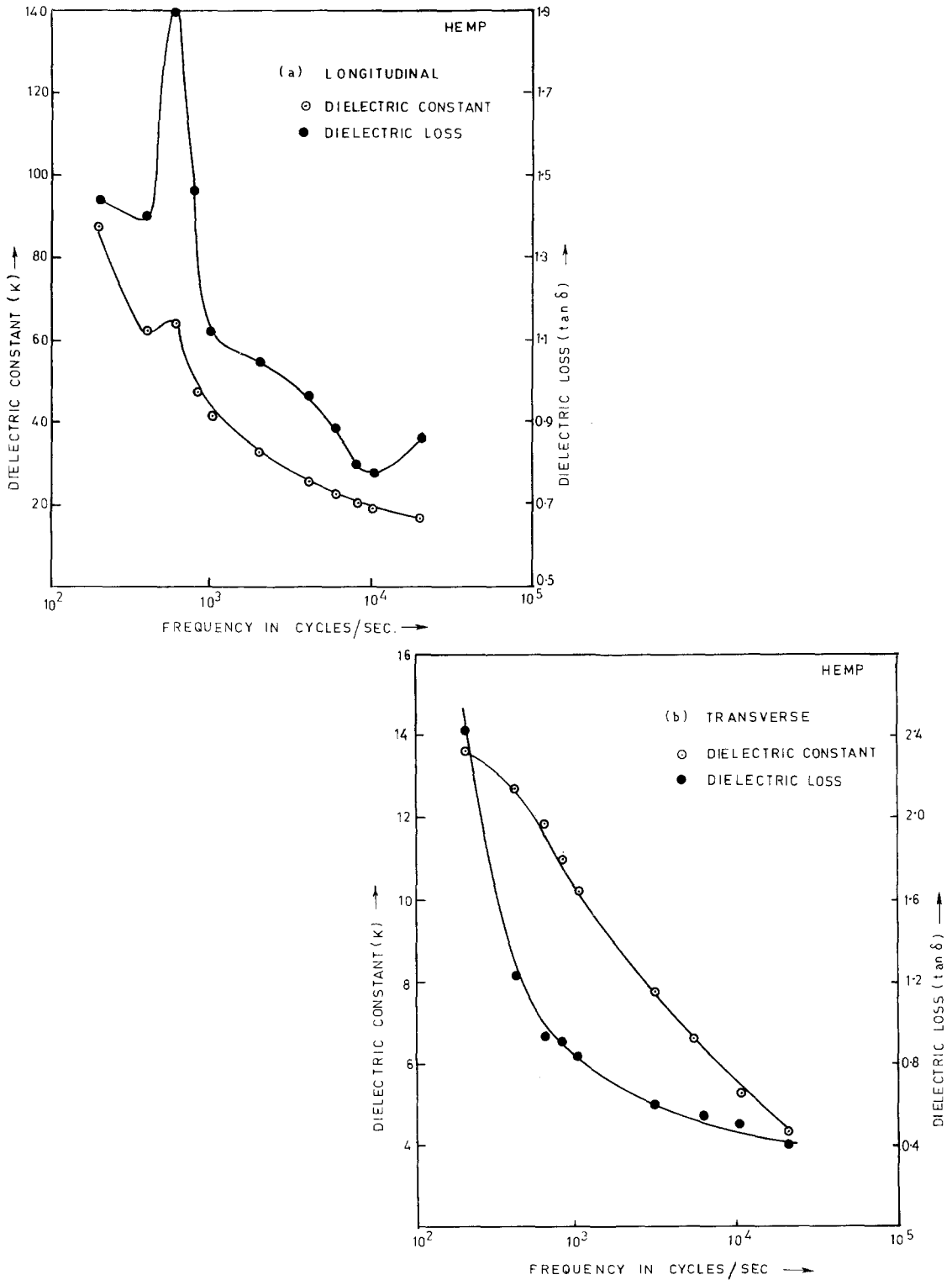


Figure 2 Variations of dielectric constants and dielectric losses of hemp with frequency along (a) longitudinal, and (b) the transverse directions.

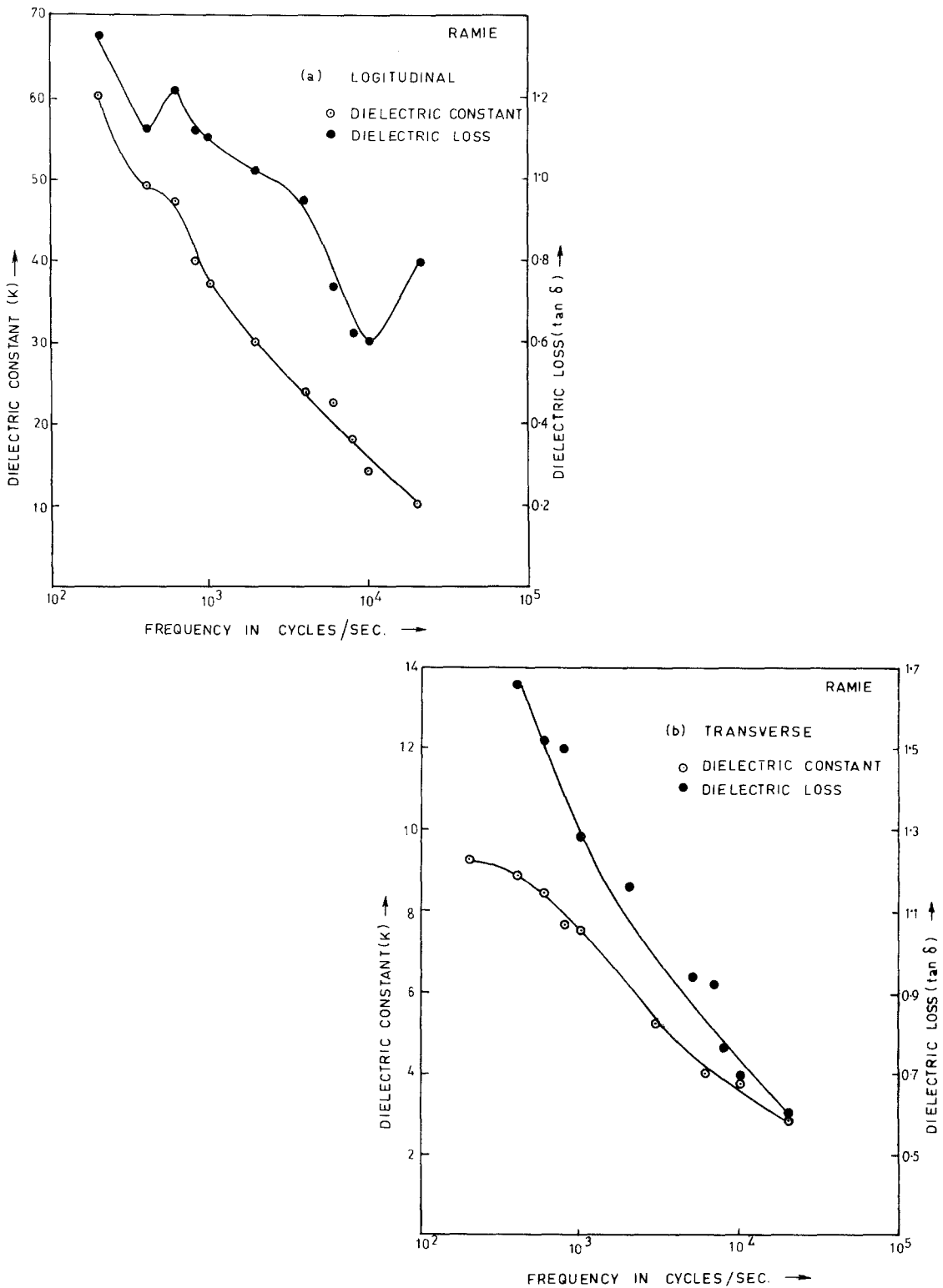


Figure 3 Variations of dielectric constants and dielectric losses of ramie with frequency along (a) the longitudinal, and (b) the transverse directions.

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Coating structure of metal-coated carbon fibres

Applications of coated fibres in preparation of metal matrix composites are growing at an increasing rate. To obtain a good composite the fibre should be wetted by the matrix to ensure good bonding. A coating on carbon fibre can promote this wetting by the matrix material and also helps in preventing surface damage during composite fabrication. Details of the coating of Cu, Ni and Co on to carbon fibres by the cementation process were described earlier [1, 2]. A tow of 1000 filaments, 20 cm long carbon fibres (PAN base) were heat treated in vacuum (10^{-5} Torr) at 700°C for 15 min to remove any coupling agents and adsorbed layer of gases. Heat-treated carbon fibres

were then treated in glacial acetic acid to activate the fibre surface.

These surface activated fibres were immersed in metal salt solutions of known amount and concentration. Displacing agents Zn for Cu coating and Mg for Co and Ni coating were added in the form of granules to displace the respective metals from their salt solutions by the cementation process. Coated fibres were tested individually in a universal testing machine (Instron). In each batch, 25 to 30 fibres were tested and average strength was computed. The present note reports the effect of the concentration of glacial acetic acid during coating on the structure of the coating formed on heat-treated carbon fibre as determined by scanning electron microscopy, and its effect on the strength of the coated fibre.

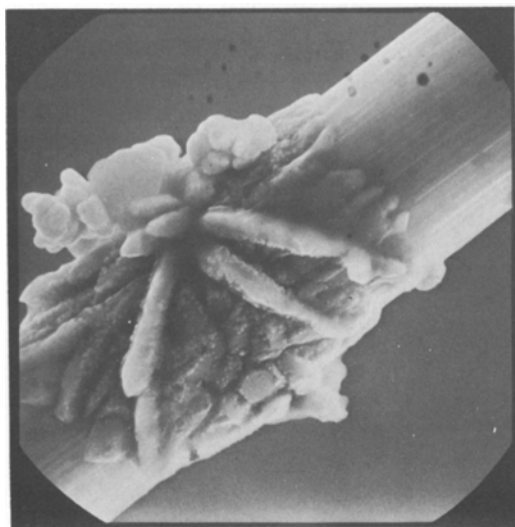


Figure 1 Isolated dendritic copper coating on non-heat-treated unactivated carbon fibre, $\times 4800$.

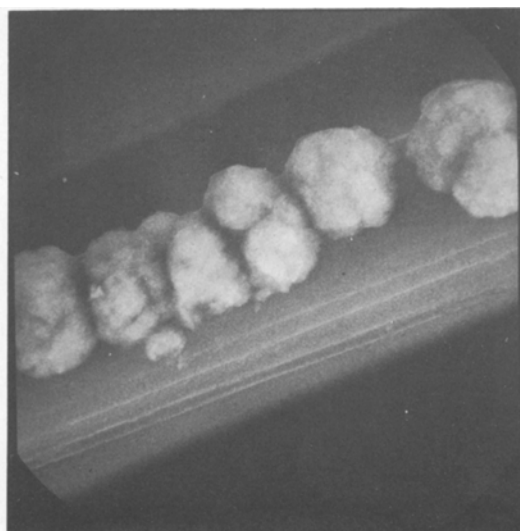


Figure 2 Isolated massive crystallite copper coating on carbon fibre, acetic acid concentration 2vol%, $\times 4800$.