Asian Journal of Chemistry Vol. 19, No. 2 (2007), 1277-1282

Destruction of Electron Radiation on The Appearance of Microwave Dried Fibers

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In this paper, the influences of electron radiation on the appearance of microwave-dried fibers were studied. Previously dried fibers with different properties are radiated by electron beam of electron microscope. Variable magnifications, processing time and voltage are applied. Using electron microscopy photographs, fibers inflations or deflations are measured precisely. It is observed that the electron energy can have significant effects on the fibers surface layer properties.

Key Words: Electron radiation, Microwave drying, Fibers.

INTRODUCTION

Scanning electron microscope (SEM) is one of the most complete tools for engineers and scientists in order to investigate the materials characteristics. The high magnification ranges of this instrument as well as its X-ray spectrometry can easily provide resolutions of defects on nano-scale ranges. The SEM can focuses at high magnification and play a key role in a variety of materials science studies[1]. Research with the scanning electron microscope consists of the study of a wide range of problems in instrumentation, theory, and applications. According to previous investigations by Gao Yu *et. al.*[2] the electron irradiation causes an increase in the tear resistance of the some polymers. However, the electron energy can changes adhesion properties[3] and strength and elongation in the some other polymers as well[4,5]. This is due to the similarity between internal atmosphere an electron microscope and space environment in the section of vacuumed and charged particles (*i.e.* electrons). Meanwhile, the effect of SEM electron beam on fiber is similar to the effect of irradiation of an accelerator on the polymer film. The objective of this study is to investigate the effects of beam radiation on different microwave dried fibers.

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Theory: In light microscopy, a specimen is viewed through a series of lenses that magnify the visible-light image. However, the scanning electron microscope does not actually view a true image of the specimen, but rather produces an electronic map of the specimen that is displayed on a cathode ray tube. The electron radiation in the SEM is produced by a thermoyonic effect, which is induced by a tungsten filament[6]. The electron waves have an extra acceleration and the electron wave length is calculated by the equation (1).

$$\lambda = \sqrt{\frac{150}{V + 10^{-6} V^2}} \qquad (1)$$

where; λ = Electron radiation wave length, V = The voltage of SEM

The amount of the energy of electron beam is being calculated by Plank equation:

$$E = \nu\, h \qquad (2)$$

where; E = Electron wave energy, ν h = Plank constant.

$$\nu = C/\lambda$$ where C = velocity of light

From (1) and (2) one can observe that an increase in SEM voltage may cause a decrease in electron radiation wave length. In view of the above, the diffusion depth is expected to increase as well[7].

It should be noted that the irradiation of electron beam causes elastic and inelastic diffraction in the sample. On the other hand, the energy of primary electrons are dispersed or transferred to sample electrons. All the kinetic energy is changed to heat and just a little of it is transferred to the former cathodoluminescence and secondary electron. These are based on the images of SEM displayed on a cathode ray tube and spots on the cathode ray tube mimic and the motion of electron beam on the sample. Hence, for a spot on the cathode ray tube sample and the size of it , is calculated by this equation for a 10 × 10 cm monitor.

$$P = \frac{10 \times 10}{M} \qquad (3)$$

where; M= Magnification.

Based on this relation, with increasing the magnification, the beam scanned area will be decreased.

EXPERIMENTAL

In this experiment, a commercial electron microscope Philips armored to (EAXE) detector. The characteristic of this microscope is presented in the Table-1.

TABLE-1
CHARACTERISTIC OF ELECTRON MICROSCOPE

Model	XL 30
The size of chamber	20 × 20
Filament	W-gun
Kind of pump	Oil diffusion pump
Max voltage	30 KeV

In order to compare the effect of irradiation on the fibers, four types of fibers are kindly provided by industrial sectors (*i.e.*, acrylic, polyester, cotton and viscose rayon).

At the end of drying process each fiber sample is glued to ample holder with carbon stick and then they are placed in the SME vacuum chamber and the electron gun is switched on. At the first stage each sample is observed by 12800 x magnification with various voltage namely; 12, 15, 20, 25, 30 KV, alter to get a steady state condition. The photographs are then taken from each sample and the size variations are measured.

At the second stage the samples size variations are measured after irradiation with respect to time.

RESULTS AND DISCUSSION

Fig. 1 shows the inflation or deflation of different fibers *vs.* different voltages. According to Fig. 1, increase of beam voltage causes some changes in the fibers diameter, but this change is different for each fiber. The most variation belongs to viscose fibre and the least variation belongs to acrylic fibre. The diameter variation is most likely for inflation of viscose, cotton and polyester, whilst as deflation for acrylic fibre.

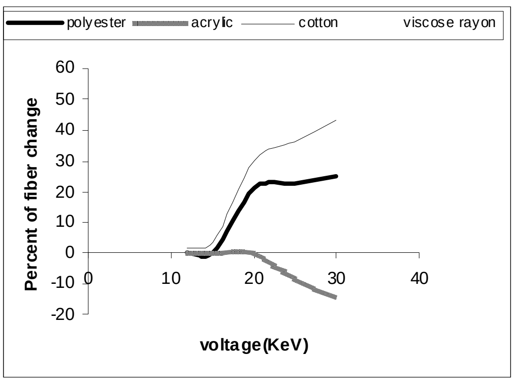

Fig. 1. Fiber diameter change *vs.* different voltage at 13000 x

Figs. 2-5 show diameter changes for polyester, acrylic, cotton and viscose rayon. It can be seen that with increasing the time of irradiation, the destruction of fibers increased significantly. For polyester, cotton and viscose fibers this destruction appears in the form of increase in the fiber diameter whilst for the acrylic fiber, this deformation appears as decrease of the fiber diameter.

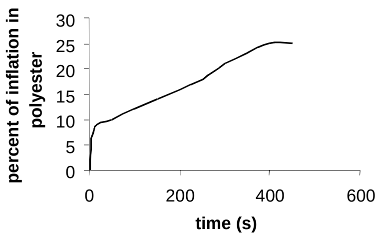

Fig. 2. Polyester fiber diameter change *vs.* time after irradiation at13000 x

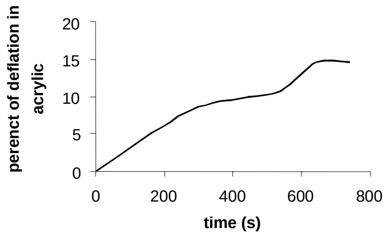

Fig. 3. Acrylic fiber diameter change *vs.* time after irradiation at13000 x

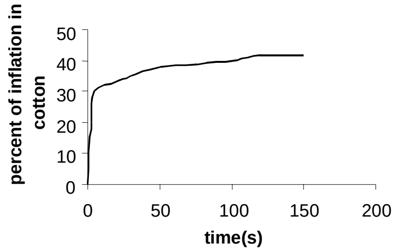

Fig. 4. Cotton fiber diameter change *vs.* time after irradiation at13000 x

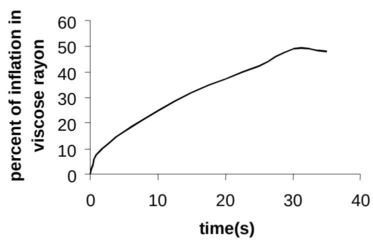

Fig. 5. Viscose fiber diameter change *vs.* time after irradiation at13000 x

The destruction depends on electron radiation in vacuum atmosphere and the formation on the surface of fibers is shown in the Figs. 6-9. Distruction of the polyester fiber is showed in the Fig. 6 where some sorts of fractures are seen on the surface of fiber. On contrast, in Fig. 7 the diameter decreased and the necking of fiber is obvious. In Fig. 8, it is clearly observed that the transverse bonding of cotton has broken[2,8]. In Fig. 9 the variation of viscose rayon is shown as bulging of fiber cross section.

Fig. 6. Electron micrograph of polyester

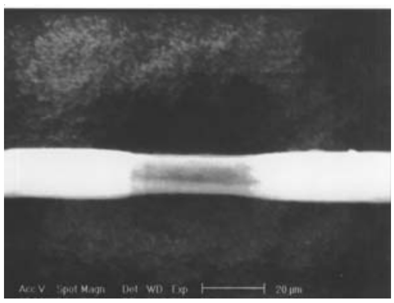

Fig. 7. Electron micrograph of acrylic

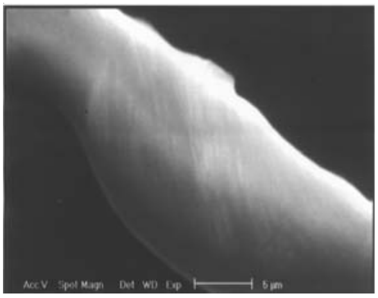

Fig. 8 Eelectron micrograph of cotton

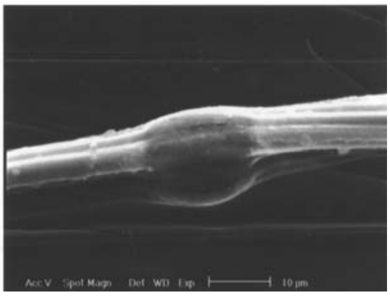

Fig. 9. Electron micrograph of viscose rayon

Conclusion

The radiation modification of fibers by means of the SEM electron beam was studied in this work. From the figures captured, it is observed that the proper selection of SEM radiation wavelength and time can have significant effects on the appearance of fibers studied. The effect of time on this variation is summarized in the Table-2. For the case of acrylic fiber it takes 640 s to get to a maximum deflation whilst this time for viscose rayon is as short as 30s.

TABLE-2
THE CHARACTERISTIC OF FIBER CHANGING

Kind of fiber	Maximum change in fiber diameter	Minimum time (s) for maximum change
Polyester	25.0	450
Acrylic	-14.5	640
Cotton	42.0	120
Viscose	48.7	30

It is concluded that electron irradiation has much faster effects on the viscose comparing to the other samples. Nevertheless, the rate and amount of changes for acrylic is least. It is expected that the irradiation of electrons break the chemical bonds with lower binding energies in the fibers surface layer. (*i.e.* the C-C , C-H , C-N and C-O bonds)[8]. Hence the tendency and range of changes in the materials depend on the amount of energy absorbed by materials. Meanwhile, as irradiation time increases, the amount of energy absorbed by the fiber will increase as well. This is due to the increase in the duration of surface scanning by electron probe. However, increase of voltage of beam causes decrease in the wavelength and for each case the fibers may absorb more energy. The electron energy may produce some defects and abrupt cross- link bonds. The effect of electron on the different fibers could depend on the length and the type of fiber bonds charges. The observed deformation in the samples is similar to deformation in the wool and silk fibre (Figs. 10 and 11).

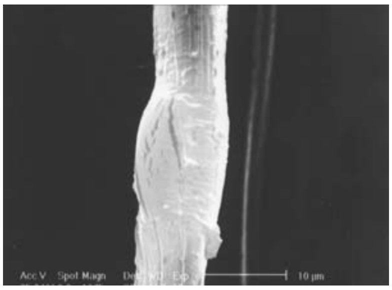

Fig. 10. Electron micrograph of silk

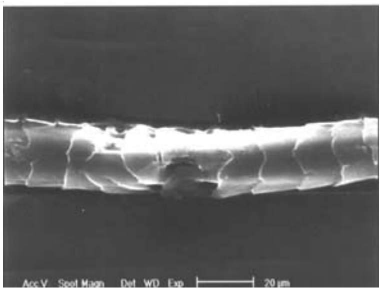

Fig. 11. Electron micrograph of wool

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(*Received*: 19 December 2005; *Accepted*: 8 September 2006) AJC-5088