Note

Effect of Grafting on the Tensile Properties of Jute Fiber

INTRODUCTION

Since the development of synthetic polymers considerable attention has been paid to the modification of textile fibers by the internal deposition of certain specific polymeric materials.[1] Although a vast amount of work on grafting onto cotton,[2] wool,[3] and synthetic fibers has been reported, very little work seems to have been done on lignocellulosic fibers. Barkakaty and Robson[4] reported increased extension at break of sisal at higher add-on of a few polymers while Trivedi and Mehta[5] obtained improvement in properties like light fastness and extensibility of jute by grafting of acrylonitrile. Majumdar and Rapson[6] studied the conditions of grafting of styrene onto jute while Ray[7] showed from his X-ray work that the fiber becomes more rigid on grafting.

In the present paper the effect of grafting of methyl methacrylate, ethyl acrylate, and acrylonitrile onto jute has been reported. Since the main interest of the work is to find out specific polymers which may improve the poor extensibility of jute, only the tensile properties of fibers are reported.

EXPERIMENTAL

Jute fibers were purified by dewaxing the fibers with alcohol benzene mixtures, 1:2 (v/v), followed by drying in air and then washing in alcohol and finally with distilled water and drying.

All the monomers were used fresh after distillation. Grafting experiments were carried out at 50°C with sample to liquor ratio 1:50 under nitrogen atmosphere in a thermostatically controlled bath following the procedure due to Trivedi and Mehta.[5] After the desired time of reaction, the unreacted monomers were removed using acetone or methanol (as required), and water and the homopolymers were removed by extracting the grafted fibers with acetone at 55°C for 24 h for poly(methyl methacrylate) and 50 h for poly(ethyl acrylate). However, in the case of acrylonitrile-grafted fibers the extraction with dimethylformamide caused no change in weight loss, and hence solvent extraction was not done in this case.

Tensile properties determined were single fiber tenacity and elongation at break at 65% RH and 28°C using Instron at 1 cm test length at a rate of extension of 5%/min.

RESULTS AND DISCUSSION

Choice of Initiator

A series of experiments was performed, and it was found (Table I) that, for methyl methacrylate (MMA) and ethyl acrylate (EA), $FeCl_3$—H_2O_2 redox system and, for acrylonitrile, ceric ammonium sulphate are the preferred initiators. The emulsion technique for water-insoluble monomers, which has been successfully used for cotton, was found to be ineffective in this case. In case of acrylamide monomer all possible initiators were tried, but no grafting occurred at all. Bleached fiber (upto 50% lignin removal) was also used, but still no grafting was observed. This is in agreement with the results on wood.[8]

Grafting of Methyl Methacrylate and Ethyl Acrylate onto Jute

The grafting experiments were carried out at 50°C with 2% monomer concentration. It can be seen from Table II that on grafting with methyl methacrylate the elongation at break does not increase much but the breaking tenacity increases significantly, while in case of ethyl acrylate there is an increase of more than 50% in elongation at break. The tenacity also increases but not to the extent obtained with methyl methacrylate. The difference in the extension property may be due to the

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TABLE I

Sample	Monomer	Initiator used	% Grafting
Dewaxed white jute	MMA in water	H_2O_2	8.9
		$FeCl_3—H_2O_2$	23.8
		$K_2S_2O_8$	3.5
		CAS soln	17.5
	MMA in emulsion	$FeCl_3—H_2O_2$	2.3
Dewaxed white jute	EA in water	$FeCl_3—H_2O_2$	33.9
		CAS soln	Extensive homopolymerization
		$K_2S_2O_8$	1.5
	EA in emulsion	$FeCl_3—H_2O_2$	2%
	EA in $H_2O—CH_3OH$ mixture	$FeCl_3—H_2O_2$	9.5%
Dewaxed white jute	Acrylonitrile in water	CAS soln	16.2
		$FeCl_3—H_2O_2$	9.5
		$K_2S_2O_8$	2.2
Dewaxed white jute	Acrylamide in water	CAS soln	nil
		$FeCl_3—H_2O_2$	nil
		$K_2S_2O_8$	nil
Jute fiber bleached up to 50%		CAS soln	nil
		$FeCl_3—H_2O_2$	nil
		$K_2S_2O_8$	nil

fact that poly(methyl methacrylate) is a rigid polymer and poly(ethyl acrylate) is a soft polymer. It can be seen from Table II that, though there are increases in elongation at break and breaking tenacities, the ratio of the two parameters, i.e., the slope of the load–elongation curves remains more or less unchanged, which indicate that the jute fiber matrix becomes only more homogeneous after grafting without an actual increase in the extensibility of the fiber.

The effect of various amounts of grafting was also studied using methyl methacrylate. Table III shows that the tenacity of the control jute fiber increases on grafting from 23.7 to 39.6 g/tex but the increase in add-on has no significant effect, which suggests that the initial grafting is sufficient to homogenize the fiber after which the further add-on has little effect. It can also be seen from Table III that jute preswelled with urea gives better results on grafting with methyl methacrylate. This

TABLE II
Stress–Strain Properties of Grafted Jute Fibers[a]

Monomer used	Initiator used	% Grafting	Breaking load (g)	Standard deviation	% Elongation at break	Standard deviation	Breaking tenacity (g/tex)
Control jute	—	—	71.5	20.02	1.97	0.508	28.17
MMA in water	H_2O_2	8.9	128.9	34.02	2.38	0.388	51.84
Acrylonitrile in aq soln	CAS	6.3	111.3	41.07	3.13	0.644	50.4
		16.2	101.4	27.38	2.88	0.94	38.52
EA in water methanol mixture	$FeCl_3—H_2O_2$	9.5	91.97	33.11	3.07	0.884	55.57
EA in water	$FeCl_3—H_2O_2$	33.9	108.35	35.21	3.11	0.80	34.6

[a] Reaction temp = 50°C; reaction time: 3 h; sample to liquor ratio: 1:50; grip length: 1 cm at 65% RH and 25–28°C. Test carried out on 50 fibers.

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