CENTRO DE CIÊNCIA E TECNOLOGIA TÊXTIL

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ENZYMATIC ENHANCED ADHESION OF CELLULOSIC WOVEN FABRICS COMPOSITES

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Introduction

Biotechnology applied to the textile processes has been an increase tendency during last years. Textile composites produced due to the enzymatic modification in the material's surface is a recent and increasing investigation's field and might be the complement or the alternative to the conventional process by applying polymeric matrices. However, there are few studies about composite fabrics produced with reinforced structures from natural fibres and biodegradable matrices using enzymes. The purpose of this work was to produce and characterize enzymatically treated fabric composites using different mixture of two commercial cellulase enzyme solutions in dosages of 0.1 and 0.5% in order to improve fabric's adhesion. Three cellulosic taffeta plain weave fabrics of 100% linen, cotton and bamboo viscose were used in different combinations. The properties of the woven fabrics and produced composites were characterized using several physical tests.

Experimental

Materials

The composites were conceived by combining three taffeta weaved woven fabrics: 100% linen, 177 g/m2; 100% cotton, 156 g/m2; 100% bamboo viscose, 133 g/m2. AlternaFuel® MAXTM (Dyadic International, USA) a liquid cellulase preparation produced from Myceliophthora thermophila. Dyadic Xylanase PLUS (Dyadic International, USA) a concentrated liquid acid-neutral endo-1,4-β-D-xylanase produced by Trichoderma longibrachiatum. All other reagents were analytical grade purchased from Sigma-Aldrich.

Enzymatic treatment process

Cleavage of the glycoside bonds of the polymers surfaces were achieved by hydrolysis with the two commercial cellulase preparations opportunely diluted in 0.1 M phosphate buffer. Fabrics of flax, cotton and viscose (3.16 g, 2.89 g, 2.41 g, respectively) with a dimension of 30 cm x 6 cm were incubated in a liquor rate of 1/20 and with two cellulase enzymatic dilutions of 0.1 and 0.5%. The solutions with the immerged fabrics were processed under continuous agitation at the temperature of 50 ºC for 30 minutes. After the treatment, each sample was rinsed in distilled water and dry at room temperature. Parameters of enzyme dosage preparations are outlined in Table 1.

Table 1: Table 1 Enzyme dosage (mg), sample mass (g) and volume of solution (mL) in a liquor rate of 1:20 for sample dimension of 30 x 6 cm

			AlternaFuel® MAX™		Dyadic® Xylanase PLUS	
			0.10%	0.50%	0.10%	0.50%
	Solution (mL)	Sample mass (g)	Enzyme dosage (mg)			
Linen	127	3.16	10.1	49.9	10.2	49.6
Cotton	116	2.89	11.7	50.0	10.4	49.1
Viscose	96	2.41	10.4	10.7	51.2	51.6

Adhesion of composites

The combinations of fabrics that were made for the development of textile composites can be seen in Table 2. All sample-composites have been pressed for 10 minutes after the enzyme treatment. Then, the adhesion was promoted by compression in a uniaxial hydraulic press under a load of 10 tonnes at 200 ºC for 60 seconds

Fabric characterization

The three woven fabrics were characterized by physical tests as per following standards: Determination of mass per unit area using small samples (NP EN 12127:1999); Determination of number of threads per unit length (ISO 7211-2: 1984 modified; NP EN 1049-2: 1995); Determination of crimp of yarns in fabrics (NP 4115: 1991); Determination of linear density of yarn removed from fabric (NP 4105: 1990); Determination of thickness of textiles and textiles products (NP EN ISO 5084: 1999); Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method, ASTM D5035: 93); Standard Test Method for Pilling Resistance and other Related Surface Changes of Textile Fabrics (Martindale Pressure Tester Method, ASTM D 4970 – 89).

Composite characterization

The composites were characterized by physical tests as per following standards: Determination of thickness of textiles and textiles products (NP EN ISO 5084: 1999); Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method, ASTM D5035: 93); Standard Test Method for Peel or Stripping Strength of Adhesive Bonds (ASTM D903: 93); Standard Test Method for Pilling Resistance and other Related Surface Changes of Textile Fabrics (Martindale Pressure Tester Method, ASTM D 4970 – 89).

Table 2: Enzyme and fabrics combinations for composite production and respective codex

Enzyme formulation	AlternaFuel® MAX™		Dyadic® Xylanase PLUS	
Dosage	0.10%	0.50%	0.10%	0.50%
Linen & Cotton	B	D	A	C
Linen & Viscose	F	H	E	G
Cotton & Viscose	J	L	I	K

Results

Table 3: Characterization of woven fabrics

	Linen	Cotton	Viscose
Mass per unit area [g/m²]	177.01±0.28	155.76±4.75	132.91±0.35
Number of threads (warp) [Nº/cm]	19.6±0.6	17.8±0.5	48.7±2.5
Number of threads (weft) [Nº/cm]	19.4±0.9	15.6±0.5	33.7±0.6
Crimp (warp) [%]	5.7±0.9	9.6±0.4	11.18±0.45
Crimp (weft) [%]	4.1±0.4	4.2±0.2	6.5±0.5
Linear density (warp) [tex]	45.1±4.6	30.9±2.2	14.6±1.2
Linear density (weft) [tex]	41.3±5.0	60.8±1.5	14.8±0.8
Thickness [mm]	0.37±0.02	0.47±0.01	0.27±0.01
Breaking Force (warp) [N]	390.6	164.1	233.3
Elongation (warp) [%]	24.05	11.17	24.05
Pilling resistance	5	4-5	4-5

Table 4 Characterization of flax & cotton composite

	Control	A	B	C	D
Thickness [mm]	0.46±0.02	0.55±0.03	0.52±0.02	0.53±0.04	0.50±0.03
Breaking Force (warp) [N]	371.6	295.2	339.6	348.4	352.4
Elongation (warp) [%]	9.33	8.13	8.93	9.55	8.60
Peel Strength [N]	0.18	0.18	0.18	0.08	0.08
Pilling resistance	4	5	4	4	5

Table 5 Characterization of flax & viscose composite

	Control	E	F	G	H
Thickness [mm]	0.40±0.02	0.45±0.02	0.44±0.02	0.44±0.03	0.42±0.04
Breaking Force (warp) [N]	372.8	395.6	424.0	474.0	372.4
Elongation (warp) [%]	8.48	10.27	9.60	10.33	9.20
Peel Strength [N]	1.325	0.825	1.175	0.925	1.075
Pilling resistance	4-5	5	5	5	5

Table 6 Characterization of cotton & viscose composite

	Control	I	J	K	L
Thickness [mm]	0.35±0.04	0.45±0.02	0.43±0.02	0.46±0.03	0.40±0.02
Breaking Force (warp) [N]	248.0	281.6	275.6	287.2	274.4
Elongation (warp) [%]	19.93	22.65	22.35	23.25	22.33
Peel Strength [N]	0.675	1.000	1.075	1.000	1.25
Pilling resistance	5	5	5	5	5

Conclusions

The combination cotton & linen did not work probably due to the relatively greater linear density of the yarns that may restrict the entanglement of the fibres and minimize the adhesion between components. The linen & viscose combination did not show peel strength improvement, however for Xylanase PLUS exhibit remarkable elongation and breaking force at the 0.5% dosage. The cotton & viscose composite appear to be the best combination exhibiting improved breaking force (0.5% of Xylanase PLUS™) and percentage of elongation at maximum force (0.1% of Xylanase PLUS™), as well as on the peel adhesion test (0.5% of AlternaFuel® MAX™). The abrasion resistance has been also slightly improved, based on the results of the evaluation of pilling resistance, despite of the good results on the control composites.

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COMPETE

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