677 BIO	6	7	7		B	l	C)	
---------	---	---	---	--	---	---	---	---	--

	Contributor contact details	xi
	Introduction	xv
	R S BLACKBURN, University of Leeds, UK	
1	Microbial processes in the degradation of fibers	1
	P M FEDORAK. University of Alberta, Canada	
1.1	Introduction	1
1.2	Background and terminology	1
1.3	Incubation conditions used for studying biodegradation	
	of fibers and films	8
1.4	Sources of microorganisms and enzymes for laboratory	
	incubations	12
1.5	Analytical methods used to assess biodegradation of	
	fibers and films	17
1.6	Examples of types of bonds that are susceptible to	
	enzymatic attack	24
1.7	Future trends	29
1.8	Acknowledgements	31
1.9	References	31
2	Bast fibres (flax, hemp, jute, ramie, kenaf, abaca)	36
	R KOZLOWSKI, P BARANIECKI and J BARRICA-BEDOYA. Institute of Natural Fibres, Poland	
2.1	Introduction	36
2.2	Flax	37
2.3	Hemp	51
2.4	Jute	60
2.5	Ramie	70
2.6	Kenaf	78
2.7	Abaca	81

V	Contents
V	Contenta

2.8 2.9	Comparison of fibre properties References	86 86
3	Alginate fibers	89
	J M MURI and P J BROWN, Clemson University, USA	
3.1	Introduction	89
3.2	The chemical nature of alginate materials	92
3.3	Physical properties of alginate-based materials	96
3.4	Industrial applications of alginates	100
3.5	Fabrication of alginates as useful flexible substrates in	
	medical textile-based products	101
3.6	Alginates in bioengineering	105
3.7	References	107
4	Cellulosic fibres and fabric processing	111
	D CIECHANSKA, Institute of Chemical Fibres, Poland and P Nousiainen, Tampere University of Technology, Finland	
4.1	Introduction	111
4.2	Life cycle assessment (LCA)	112
4.3	The mechanisms of enzymatic reactions on wood and	
	cellulose	120
4.4	Biodegradability of cellulose fibres in textile blends	131
4.5	Biotechnology for manufacture and modification of	10000
	cellulosic fibres	133
4.6	Enzyme applications in fabric and dyestuff processing	140
4.7	Hygienic and medical fibres	144
4.8	Future trends	150
4.9	References	151
5	Lyocell fibres	157
	P White, M Hayhurst, J Taylor and A Slater, $Lenzing^{(0)}$ Fibers Ltd, Derby, UK	
5.1	Introduction	157
5.2	Process description	159
5.3	Lyocell sustainability	165
5.4	Lyocell fibre properties	171
5.5	Lyocell in textiles	172
5.6	Lyocell – a versatile, high performance fibre for	
202	nonwovens	181
5.7	Marketing	187
5.8	Future trends	188
5.9	Sources of further information	188

6	Poly(lactic acid) fibers	191
	D W FARRINGTON, Consultant, UK, J LUNT, S DAVIES, NatureWorks LLC, USA and R S BLACKBURN, University of Leeds, UK	
6.1	Introduction	191
6.2	Chemistry and manufacture of PLA polymer resin	192
6.3	PLA fiber properties	197
6.4	Applications	200
6.5	Environmental sustainability	211
6.6	Future trends	218
6.7	References	219
7	Poly(hydroxyalkanoates) and poly(caprolactone)	221
	I CHODÁK, Polymer Institute of the Slovak Academy of Sciences, Slovakia, and R S BLACKBURN. University of Leeds, UK	
7.1	Introduction	221
7.2	PHA-based oriented structures	222
7.3	Poly(caprolactone)-based fibres	232
7.4	Structure of drawn fibres	235
7.5	Thermal properties	236
7.6	Enzymatic and hydrolytic degradation	237
/./	Other biodegradable and sustainable polyesters	238
7.8 7.0	Application of polyester-based biodegradable fibres	239
7.9	References	241
7.10	Kelefences	242
8	The route to synthetic silks	245
	F VOLLRATH and A SPONNER, University of Oxford, UK	
8.1	Introduction	245
8.2	Silk structures	245
8.3	Development of fibre: the feedstock	248
8.4	Development of fibre: spinning	255
8.5	Performance characteristics	256
8.6	Applications	262
8.7	Future trends	262
8.8	Acknowledgements	264
8.9	References and sources of further information	264
9	Biodegradable natural fiber composites	271
78.5515	A N NETRAVALI, Cornell University, USA	
9.1	Introduction	271
9.2	Biodegradable fibers	274
9.3	Biodegradable resins	279

viii Contents

9.4	Soy protein-based green composites	295
9.5	Conclusions and future trends	304
9.6	Acknowledgements	304
9.7	References	305
10	Biodegradable nonwovens	310
	G BHAT, University of Tennessee, USA and H RONG, Johnson Controls Inc., USA	
10.1	Introduction	310
10.2	Nonwoven fabrics	311
10.3	Fiber consumption in nonwovens	314
10.4	Web formation methods	315
10.5	Web bonding techniques	319
10.6	Technology and relative production rate	321
10.7	Recent research on biodegradable nonwovens	322
10.8	Applications of biodegradable nonwovens	336
10.9	Flushable nonwovens	337
10.10	Leading producers of nonwovens	338
10.11	Sources of further information and advice	338
10.12	References	340
11	Natural geotextiles	343
	C LAWRENCE, University of Leeds, UK and B COLLIER, University of Tennessee, USA	
11.1	Introduction	343
11.2	Fundamental aspects of geotextiles	344
11.3	Fibres used for natural geotextile products	345
11.4	Fibre extraction and preparation	351
11.5	Production of natural geotextile products	355
11.6	Measurement of the properties of natural geotextiles	362
11.7	References	365
12	Conversion of cellulose, chitin and chitosan to filaments with simple salt solutions	367
	H S WHANG, N AMINUDDIN, Fiber and Polymer Science Program, IJSA. M FREY, Cornell University, USA, S M HUDSON and J A CUCULO, Fiber and Polymer Science Program, USA	001
12.1	Introduction	367
12.2	Cellulose in liquid ammonia/ammonium thiocyanate	
	solutions	368
12.3	Fibers from chitin and chitosan	380
12.4	Future trends	393
12.5	Sources of further information	394

ix

12.6	References	395
13	Soya bean protein fibres – past, present and future	398
	M M BROOKS, University of Southampton, UK	
13.1	Introduction	398
13.2	The soya bean plant	398
13.3	Naming regenerated protein fibres	400
13.4	The need for new fibre sources	401
13.5	Generalised method for producing soya bean fibre in the	
	mid-twentieth century	413
13.6	Contemporary research into alternative protein fibre	
	sources	420
13.7	Contemporary methods for producing fibres from soya	
	bean protein	422
13.8	Fibre characteristics	425
13.9	Identifying soya bean protein fibres	428
13.10	Degradation behaviour	431
13.11	A truly biodegradable and ecological fibre?	434
13.12	Conclusion	434
13.13	Acknowledgements	435
13.14	References	435
Index		441