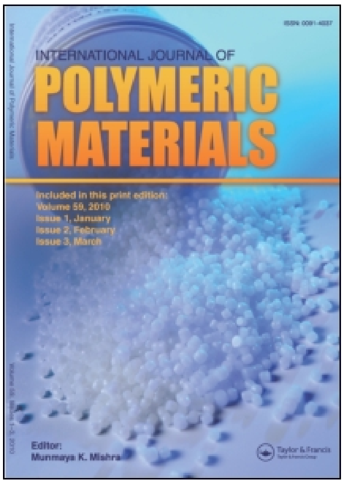

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Damage to Undyed Polymeric Substrates Caused by Weathering

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Damage to Undyed Polymeric Substrates Caused by Weathering

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This work concerns the damage to undyed fabrics caused by climatic conditions prevailing at an urban site in Egypt. Samples of unfinished cotton of different counts and densities were used. For comparison purposes, samples of nylon, polyester, taffeta and satin fabrics were included in the survey. These were subjected to unprotected outdoor exposure for 120 days. The different fibres showed significant variations in changes to physical properties arising from exposure. Thus, breaking strength losses range from 29 to 87% of the original value, while losses in elongation range from 26 to 85% of the initial elongation value. Losses were found to be least for the coarsest cotton fibre and highest for taffeta and satin. Nylon and polyester were both seriously attacked. With these a much greater loss of strength than of elongation was observed.

INTRODUCTION

Several authors (see Shah, C. D. and Srinivasan, R. (1975)[1]) have reported the photodegradation of fibres by means of sunlight. This is seen as progressive molecular chain scission at exposed surfaces and reduction in specific mechanical properties (Singleton, R. W., *et al.*, 1965).[2] We are particularly interested in the effects of weathering on various fabric types and composition during the Egyptian summer months.

EXPERIMENTAL

a) *Fabrics.* Details of the unfinished fabrics used in this work are given in Table I.

TABLE I

Characteristics of fabrics used in weathering experiments

Fabric	Nominal weight (gm/m^2)	Thread/cm		Linear density in text	
		Warp	Weft	Warp	Weft
1. Cambric	110.5	25	23	21	21
2. Lino	111.7	35	34	15	14
3. Poplin	143.2	20	19	33	33
4. Calico	144.8	23	19	32	29
5. Plain napped	234.5	19	19	36	80
6. Twill napped	240.6	30	19	41	38
7. Drill	323.5	30	20	62	62
8. Duck (Canavus)	478.6	19	14	105	105
9. Taffeta	125.3	44	30	14	14
10. Satin	135.3	54	25	13	16
11. Nylon	159.2	22	15	8	8
12. Polyester	186.6	10	6	17	17

Outdoor, unprotected exposure of samples was provided from May to August in Giza, Egypt. The samples were mounted in wooden frames (70 cm × 70 cm) on racks at 45° to the horizontal, facing south. At intervals of 15 days, two frames of each fabric were removed for testing.

The data of climatic conditions were recorded continuously by the Egyptian Meteorological Association, E.M.A., at the nearest meteorological station to the exposure site. Twenty-four hour means were calculated for the temperature, relative humidity and the incident solar energy of the surrounding area. Relevant data are given in Table II.

b) *Testing.* The samples were removed and conditioned at 23°C and 65% R.H. Exposed and unexposed (standard) strips of 5 cm (width) and 20 cm (length) were tested for their tensile strength and elongation on a C.R.T. Tensile Tester. Twenty samples of each fabric were tested.

RESULTS AND DISCUSSIONS

The results are presented in tabular form for convenience in Table III, for both tensile strength and elongation changes, as a result of exposure. Table IV gives the percentage decrease in each property on continuing exposure.

From Tables III and IV we see that the weathering of fabrics in Egypt produces serious and rapid losses in strength and elongation, particularly with light weight fabrics. The different fibres were found to lose strength at different rates, ranging from sensitive satin and taffeta to the apparently more resistant duck fibre which appears to withstand sunlight for long periods.

TABLE II

Climatic conditions pertinent to sample exposure

Days of exposure	Incident solar energy (Langleys)	Total sun hours	Temperature Range of maximum	Temperature Mean	Humidity Range	Humidity Mean
15 days		151.3	27.5–37.5	29.6	18.0–92.0	55.3
30 days	18612	326.8	31.0–42.2	35.6	9.0–88.0	47.23
45 days		478.2	30.5–43.4	32.3	13.0–88.0	47.9
60 days	37989	657.0	30.2–40.8	35.2	11.0–92.0	57.3
75 days		834.6	31.0–39.0	34.8	23.0–95.0	60.0
90 days	56469	1009.0	33.1–37.8	35.2	28.0–93.0	62.0
105 days		1181.8	34.8–38.2	34.4	23.0–96.0	61.5
120 days	75249	1354.1	32.2–39.4	34.7	12.0–93.0	62.3

TABLE III

Variation in tensile strength and elongation of various fabric types with increased exposure time (days)

Exposure (time in days)	—	15	30	45	60	75	90	105	120
	Tensile strength (kgf)								
Cambric	20.0	18.0	16.4	15.4	14.0	13.0	11.6	10.4	9.2
Lino	32.4	29.7	26.5	23.5	20.9	18.5	16.0	13.5	10.5
Poplin	39.9	32.0	30.5	28.0	26.0	23.5	21.5	19.0	17.0
Calico	39.0	34.1	31.0	29.0	25.0	22.0	19.0	16.0	13.5
Plain napped	45.0	41.0	36.5	33.5	31.0	28.0	24.0	21.0	18.0
Twill napped	40.0	37.0	33.5	30.5	26.0	23.0	20.5	17.0	14.0
Drill	113.7	107.0	103.0	97.5	91.0	86.0	81.5	77.0	72.0
Duck	170.0	161.1	155.0	149.0	144.0	139.0	132.8	127.0	121.0
Nylon	60.0	52.0	46.0	43.0	38.0	32.0	28.0	24.5	20.0
Polyester	54.0	49.0	44.0	40.5	37.0	32.5	29.5	26.0	22.0
Taffeta	41.0	37.0	34.0	30.0	25.5	20.0	17.5	13.5	10.0
Satin	59.2	55.0	48.7	39.5	33.9	27.0	22.0	14.0	8.0
	Elongation %								
Cambric	11.5	10.3	9.0	7.8	6.5	5.5	4.8	4.0	3.5
Lino	15.5	14.0	12.5	11.5	10.0	8.5	7.5	6.3	5.5
Poplin	16.9	15.5	14.2	12.5	11.0	9.5	8.0	7.0	6.5
Calico	18.5	16.5	15.5	14.5	13.5	12.0	10.5	9.5	8.8
Plain napped	18.5	17.0	15.5	13.5	11.5	10.0	9.0	8.3	7.8
Twill napped	8.0	7.0	6.0	5.0	4.0	3.0	2.6	2.4	2.0
Drill	20.5	19.5	18.5	17.5	16.3	15.0	13.8	13.0	12.5
Duck	31.5	30.0	29.0	27.8	26.5	25.5	24.9	24.0	23.2
Nylon	62.5	56.5	53.0	48.7	45.0	41.5	38.5	35.5	33.0
Polyester	100.0	92.0	85.8	80.7	75.5	70.3	65.0	60.1	55.5
Taffeta	21.5	19.3	16.8	14.3	11.8	9.3	7.0	5.0	3.3
Satin	14.5	12.5	10.5	9.0	7.5	6.3	5.0	4.0	3.0

TABLE IV

				Loss % in tensile strength					
Time in days	—	15	30	45	60	75	90	105	120
Cambric	—	10.0	18.0	23.0	30.0	35.0	42.0	48.0	54.0
Lino	—	8.3	18.2	27.5	35.5	42.9	50.6	58.3	67.6
Poplin	—	19.8	23.6	29.8	34.8	41.1	46.1	52.4	57.4
Calico	—	12.6	20.5	25.6	35.9	43.6	51.3	57.7	65.4
Plain napped	—	8.9	18.9	25.6	31.1	37.8	46.7	53.3	60.0
Twill napped	—	7.5	16.3	23.8	35.0	42.5	48.8	57.5	65.0
Drill	—	5.5	9.4	14.3	20.0	24.4	28.3	32.3	36.7
Duck	—	5.2	8.4	12.1	15.3	18.2	21.9	25.3	28.8
Nylon	—	13.3	23.3	28.3	36.7	46.7	53.3	59.2	66.7
Polyester	—	9.3	18.5	25.0	31.5	39.8	45.4	51.9	59.3
Taffeta	—	9.8	17.1	26.8	37.8	51.2	57.3	67.6	75.6
Satin	—	7.1	17.8	33.3	43.8	54.4	62.9	76.4	86.5
				Loss in Elongation %					
Cambric	—	10.8	21.7	32.6	43.5	52.5	58.7	65.2	69.6
Lino	—	9.7	19.4	25.8	35.5	45.2	51.6	59.7	64.5
Poplin	—	8.3	16.0	26.0	34.9	43.8	52.7	58.6	61.5
Calico	—	10.8	16.2	21.6	28.4	35.1	41.9	48.7	52.7
Plain napped	—	8.1	16.2	27.0	37.8	46.0	51.5	55.4	58.1
Twill napped	—	12.5	25.0	37.5	50.0	62.5	66.5	70.0	75.0
Drill	—	4.9	9.8	14.6	20.7	26.8	32.9	36.6	39.0
Duck	—	4.8	7.9	11.8	15.9	19.1	21.0	23.8	26.4
Nylon	—	9.6	15.2	22.1	28.0	33.6	38.4	43.2	47.2
Polyester	—	8.0	14.3	19.3	24.5	29.8	35.0	39.9	44.5
Taffeta	—	10.2	22.1	33.7	45.4	57.0	67.4	76.7	84.9
Satin	—	13.8	27.6	37.9	48.3	56.9	65.5	72.4	79.3

However, such results must be handled with caution. In considering the effects of any parameter on the properties of assembled fabrics, attention must be paid to the fabric construction. Thus a fabric assembled from a heavy nominal weight fibre having in addition a large fibre diameter, will present a markedly different total exposed surface than would a fabric assembled from a lighter yarn of narrow diameter. Hence the effective absorbed radiation dose will differ significantly in each case. Such an observation would explain the considerable variation in change of physical properties, resulting from the same incident intensity, experienced by fabric of identical chemical composition (i.e. fabrics 1 to 9 in Table I).

One might reasonably expect that the sample with the greatest exposed surface area would experience the most severe attack from sunlight. Manipulation of primary data of these types does not present a truly clear picture. Work will be undertaken involving model systems and calculation of exposed surfaces in assembled systems of the types used in these fabrics. Perhaps, then, a clear picture may emerge. Conclusions which can be drawn from this initial part of our work include the fact that the severe damage may be attributed to the following factors, bearing in mind the fact that exposure took place at Giza, Egypt;

a) the long daily sunny periods (mean 9–11 hours per day);

b) high solar energy values which range from 275–475 Langleys in winter and from 675–740 Langleys in summer;

c) high values of u.v. irradiation in the spectral energy distribution curve of daylight at Giza, which were found to be higher than in other countries (Wassef and Lawendy).[3]

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