ANALYSIS OF MECHANICAL AND PHYSICAL PROPERTIES ON GEOTEXTILES AFTER WEATHERING EXPOSURE

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Abstract: When geotextiles are exposed to solar rays for a short or long period of time, some level of UV degradation occurs. In this sense, variations in physical and mechanical properties may occur due to degradation by outdoor exposure. This paper presents results of mechanical and physical properties on 3 polyester PET non-woven geotextiles that were exposed to weathering for 720 and 1440 hours (1 and 2 months). Properties were evaluated according to the Brazilian standards (NBR). The results showed that the geotextiles presented some variations in tensile properties after exposure. Deformability decreases after all times of exposure. The samples became stiffer than fresh samples.

Keywords: geotextile, weathering, laboratory tests.

INTRODUCTION

Geotextiles (GT) may be exposed to UV radiation in many different ways. The time of exposure may cause some level of degradation on the materials since all the geosynthetics contain polymers in their formulation. All the geotextiles are sensitive to UV effects. Loss of properties (tensile resistance and deformability, for example) may occur in prolonged exposure. Generally, the polyester (PET) shows medium to good UV resistance. Thus, evaluation of the effects of outdoor exposure is very important.

The ASTM D5970 procedure is commonly used as a guide to evaluate geotextile products for outdoor exposure. Because, in outdoor testing, the effects of sunlight can take an extended period of time to become apparent, an accelerated method is desirable. Many methods of accelerated weathering of geotextiles are available (Baker 1997).

This paper presents results of mechanical and physical properties of 3 PET non-woven geotextiles (171, 280 and 450 g/m^2) that were exposed to weathering for 1 and 2 months. Properties were evaluated according to the Brazilian standards (NBR).

MATERIAL AND METHODS

Non-woven geotextiles (GT) were exposed according to ASTM D1435 and D5970. Samples were placed on a panel located in the east-west axis angled towards the sun (Figure 1). Three Polyester (PET) non-woven geotextiles were exposed and evaluated: 171, 280 and 450 (g/m^2). These will be referred to as PET 171, PET 280 and PET 450. The PET geotextiles were exposed for a total period of 2 months. Physical and tensile properties were evaluated and compared to intact (un-exposed) material. Tests were carried out in accordance with ABNT standards (Brazil standards): ABNT NBR 12568 (mass per unit area) and ABNT NBR 12824 (tensile properties).

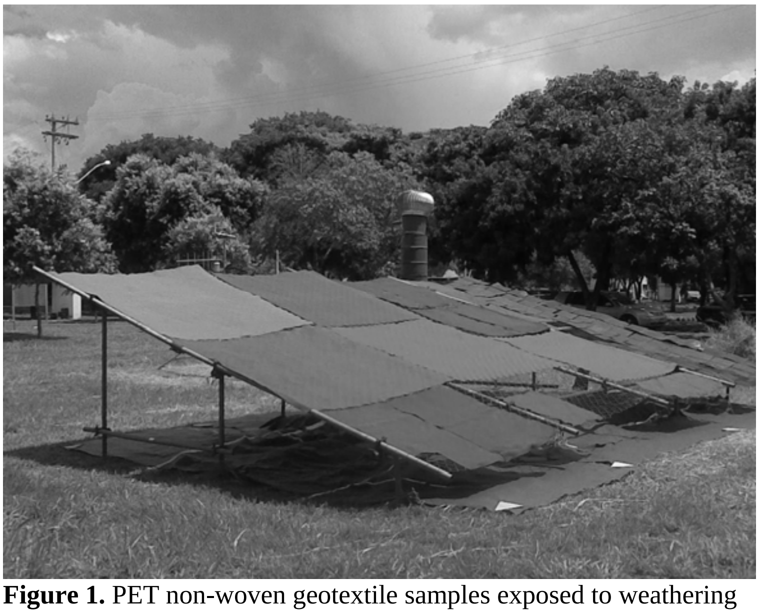


Figure 1. PET non-woven geotextile samples exposed to weathering

RESULTS AND DISCUSSION

During the periods of exposure, the average values recorded were 26°C (temperature), 59 mm (precipitation), 65% (relative humidity), and 0.9 (MJ/m^2)/day (intensity of global radiation). The cumulative UV radiation until the end of the period of exposure is about 52.10 (MJ/m^2).

Table 1 compares the results obtained for all 3 PET geotextiles (intact and after exposure). Table 2 shows the UV radiation values obtained during outdoor exposure.

Values of mass per unit area are presented in Figure 2. Figures 3 and 4 show the variations that occurred in tensile resistance and deformation versus the cumulative UV radiation.

Table 1. Comparison of results of properties obtained for PET non-woven geotextiles

Geotextile	Condition	Mass per unit area (g/m^2)	CV* (%)	Tensile Strength (kN/m)		CV* (%)		Elongation (%)		CV* (%)	
				MD	CMD	MD	CMD	MD	CMD	MD	CMD
PET 171	intact	171	7.48	3.73	7.65	16.32	13.8	104.3	83.76	6.97	6.78
	1 month	150	7.00	3.69	5.74	15.80	8.57	74.09	65.01	6.78	3.92
	2 months	150	7.00	2.35	3.56	21.48	0.95	62.29	49.04	4.75	3.18
PET 280	intact	280	9.88	10.2	12.83	9.55	13.7	76.10	82.21	5.40	4.70
	1 month	200	9.00	5.36	5.32	5.70	4.56	48.55	53.07	9.09	1.93
	2 months	200	8.00	5.29	6.15	9.34	5.31	41.39	52.82	13.1	5.47
PET 450	intact	450	12.1	18.5	22.06	12.03	7.61	71.14	74.89	5.85	7.07
	1 month	500	12.0	20.4	20.29	8.76	6.13	59.59	60.08	3.79	5.58
	2 months	400	10.0	14.7	13.62	6.66	9.95	49.11	49.08	2.11	4.76

* CV = Coefficient of variation; MD =longitudinal or machine direction; CMD =transverse or cross machine direction

Table 2. UV radiation values

Period	UV		
month	(MJ/m^2)/day	(MJ/m^2)/month	(MJ/m^2) (cumulated)
0	0.00	0.00	0.00
1	0.92	27.60	27.60
2	0.79	24.49	52.09

All of the geotextiles presented variations in mass per unit area after exposure. PET 280 presented the highest decrease (28.57%) after 1 and 2 months of exposure. PET 171 presented a variation of 12.28% (decrease). These variations in mass per unit area occur due to two main factors. The first factor is related to the loss of mass of the material when exposed to the solar rays: loss of antioxidants and carbon black. These additives have the function to improve the resistance to rays UV and to protect the material in case of exposure. Secondly, the geotextiles have a inherent variability in the mass per unit area due to the manufacturing process. Rigorous controls are required in selecting specimens for the tests so that this factor does not mask the apparent effects of UV exposure. Prior to weighing, the specimens were conditioned to the standard temperature and humidity

PET 171, 280 and 450 geotextiles all presented variations in the tensile strength. After the first month of ageing, one geotextile presented an increase in the value of the tensile strength: PET 450 (10.41%) in the MD (longitudinal direction). Note, however, that the mass of this sample appeared to increase and so it is probable that this result is an anomaly of the sampling. At the last period, all geotextiles presented a reduction of the tensile strength in the two directions. Some tensile strength reductions were more significant in the CMD (transverse direction) as, for example, PET 171 after 2 months (43.46%), PET 280 after 1 month (58.53%) and 2 months (52.07%). Analysing the average curves for both MD and CMD directions, it is observed that the trend of the behaviour of the tensile strength is characterised by decreases (eliminating the dubious result for the PET 450),

The deformability presented also decreased after two periods of exposure. After the final period, the reduction reached values of about 40% for PET 171 and 280 in the both directions. The largest variation for PET 450 occurred after the last period: decrease of about 30% in the MD (longitudinal direction). The average curves of deformation show decreases of the deformability after the exposure periods.

LABORATORY METHODS FOR ACCELERATED TESTING

According Baker (1997), to evaluate the effects of sunlight in outdoor testing, an accelerated method is desirable. During the 2 two month duration of this research, the cumulative UV radiation to the final exposure time is 52.10 (MJ/m^2)/month. It is proposed to consider the equivalent exposure that can be obtained in the laboratory. The laboratory weatherometer equipment in common use is the xenon arc lamp and the UV-A lamps

The radiant exposure in the UV range can be calculated by integration of the light energy for the wavelengths from 295 to 385 nm (xenon arc lamps) and 295-400 nm (UV-A lamps). The UV irradiance from 295-385 nm is 28.9 $Watts/m^2$ (total energy) and the UV irradiance from 295-400 nm is 39 $Watts/m^2$ (energy total). The representative spectral power distribution of xenon arc lamps and UV-A lamps may be found in ASTM G154.

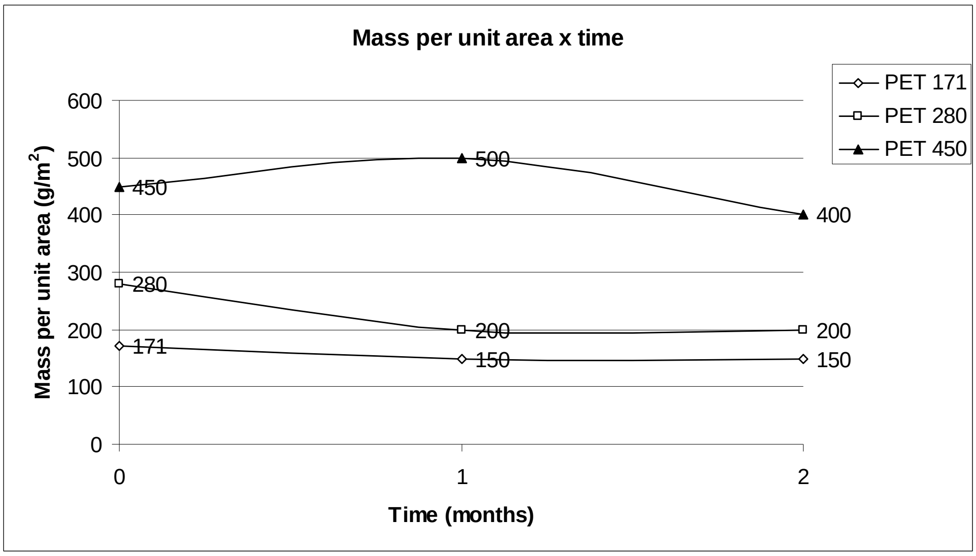
By use of the above, is possible to evaluate the time necessary to achieve the UV radiance in a UV weatherometer. For example, using an arc xenon lamp the energy total required is 28.9 W/m^2. The energy level reached in this research is equal to 52.10 MJ/m^2. The time in a UV weatherometer (xenon arc lamp) is:

Time (xenon arc) $= 52.10 \times 1x\ 10^6\ W.s/m^2 / 28.9\ W/m^2 = 500.77$ hours = 20.86 days.

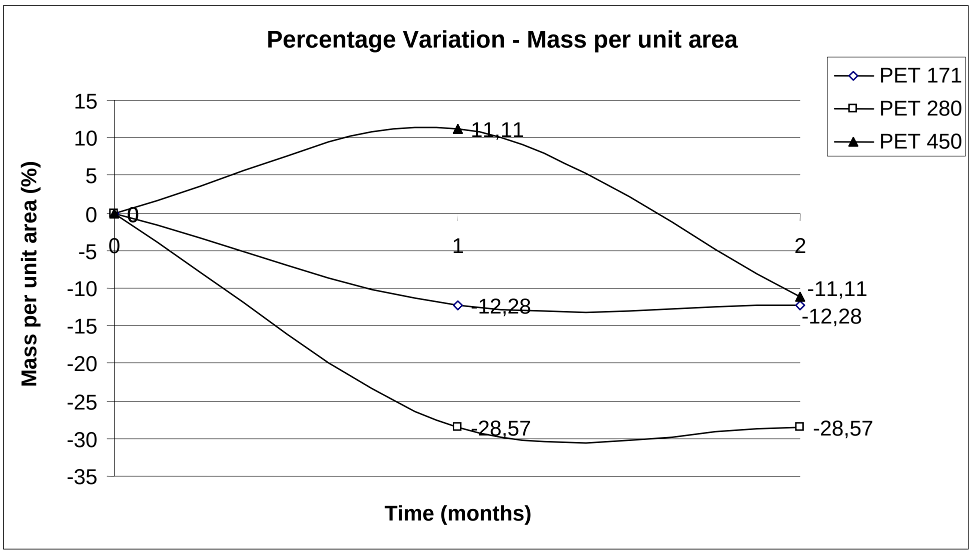
Using a UV test device programmed with an eight-hour UV cycle followed by a four-hour condensation cycle, the total energy generated is:

8 h (28800 s) x 28.9 $W/m^2 = 0.832\ MJ/m^2$. The number of cycles to obtain the energy is: 52.10 / 0.832 = 62 cycles.

The total experimental time is: 63 x 8 (UV) + 63 x 4 (condensation) = 756 hours. Thus, the test device needs 756 hours testing time to obtain 52.10 MJ/m^2. Similarly, using a UV-A lamp the time total using the test device is 564 hours. Remember that the UV radiation is generated only during the eight-hour cycle.



(a)



(b)

Figure 2. Variation of mass per unit area verses time (a) g/m^2 (b) percentage variation

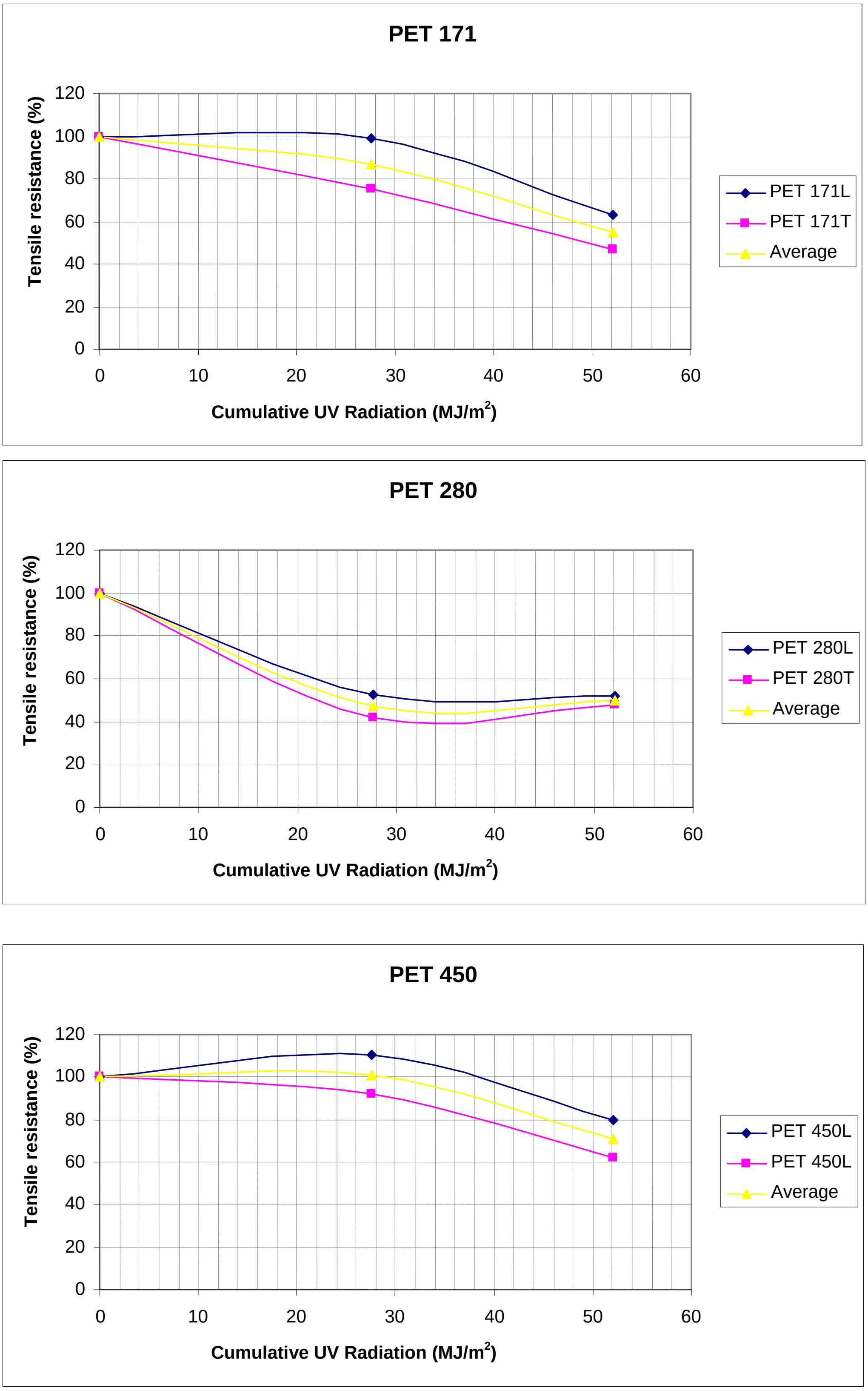


Figure 3. Variation of tensile resistance verses cumulative UV radiation

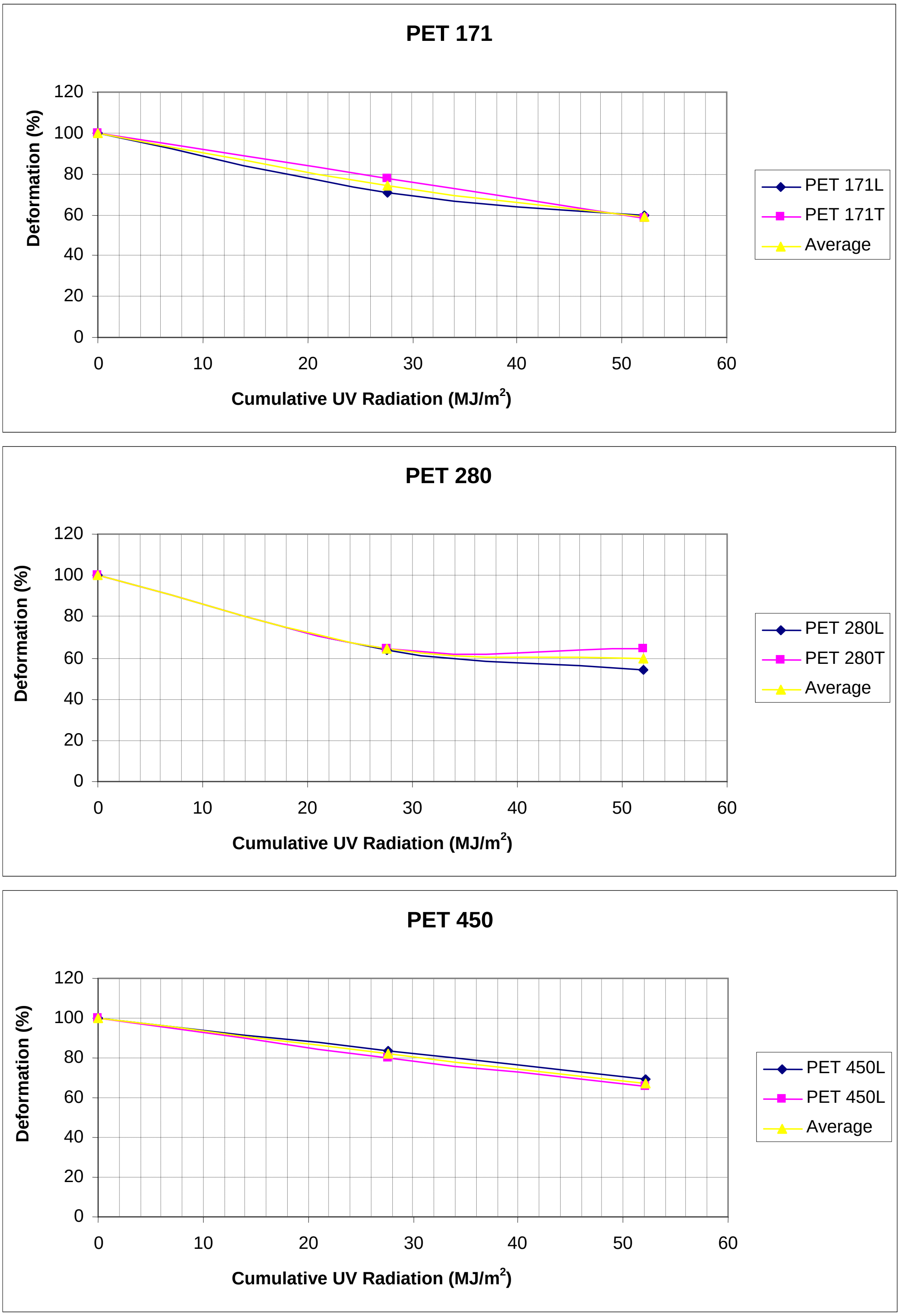


Figure 4. Variation of deformation verses cumulative UV radiation

CONCLUSIONS

Results of tensile properties and mass per unit area for non-woven PET geotextiles (171, 280 and 450 g/m^2) exposed to weathering for 1 and 2 months were presented. After the exposure periods, some changes occurred in mass per unit area and in tensile properties. The samples showed a general reduction in mass with exposure.

Tensile resistance presented a trend of reduction verses time. The same behaviour was observed concerning the deformation. The samples became stiffer than fresh samples.

The cumulative UV radiation may be useful when an accelerated method is desirable. Some examples were presented and the cumulative UV radiation equivalence obtained by calculating the time necessary to achieve the UV radiance in a UV weatherometer using arc xenon and UV-A lamps.

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