The effect of marine environment on the mechanical performance of Dacron sailcloth

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ABSTRACT – REZUMAT

The effect of marine environment on the mechanical performance of Dacron sailcloth

The usage of sails is increasing parallel to the sustainability initiatives in marine transportation not only for recreational craft but also for large vessels carrying commercial goods and passengers. In this study, the marine environmental degradation of the sailcloth which significantly shortens the lifetime of these materials was investigated experimentally. Dacrons, which are relatively cheap, easy to form, and resistant to breakdown, but problematic to keeping their original shape while subjected to wind loads, were selected as the sailcloth. The combined effect of seawater exposure, temperature, UV, wet-dry cycle, water repellent treatment on the Dacron's mechanical performance was measured by tensile tests performed for the Dacron specimens with nine different areal weights and in two different fibre directions (warp and weft) and by dynamical mechanical analysis for a representative Dacron sailcloth. The comparative results show that the marine environment has significant degradation effects on the mechanical performance of sailcloths.

Keywords: *Marine environmental degradation, Dacron sailcloth, marine textiles*

Efectul mediului marin asupra performanței mecanice a pânzei de vele Dacron

Utilizarea pânzelor se dezvoltă în paralel cu inițiativele de sustenabilitate în transportul maritim nu numai pentru ambarcațiunile de agrement, ci și pentru navele mari care transportă mărfuri comerciale și pasageri. În acest studiu, degradarea pânzei de vele din cauza mediului marin, care scurtează semnificativ durata de viață a acestor materiale, a fost investigată experimental. Pânza Dacron, care este relativ ieftină, ușor de manipulat, rezistentă la rupere, dar problematică în a-şi păstra forma originală în timp ce este supusă la sarcina datorată vântului, a fost selectată ca pânză de vele. Efectul combinat al expunerii la apa de mare, temperatură, UV și ciclul umed-uscat, tratamentul hidrofug asupra performanței mecanice a pânzei Dacron a fost măsurat prin teste de rezistenţă la rupere efectuate pentru mostrele de Dacron cu nouă mase diferite și în două direcții diferite (urzeală și bătătură) și prin analiză mecanică dinamică pentru o pânză de vele Dacron reprezentativă. Rezultatele comparative au arătat că mediul marin are efecte de degradare semnificative asupra performanței mecanice a pânzei de vele.

Cuvinte-cheie: *degradarea din cauza mediului marin, pânză de vele Dacron, textile marine*

INTRODUCTION

To improve the sustainability of maritime transportation by propelling ships using renewable energy sources, considerable efforts are being put forward on a global scale. Also, strict regulations on minimising GHG emissions have prompted technical experts to explore energy-saving and emission-reduction technologies in ships, including novel hull and superstructure design, new propulsion systems, advanced energy management and operational optimization. Additionally, new energy sources such as the utilization of wind energy and solar energy to replace fossil fuels in ships could be a promising way to help conventional shipping become green [1]. Using sails as a part of wind energy systems is one of the focused alternatives in these efforts. For instance, the ship whose today's biggest triangular sail is the passenger ship "Wind Star" was built in 1986 (figure 1). The ship has a rigging system consisting of 50 m masts, brackets and six polymer lateen sails covering an area of 2000 m^2. By this rigging, the energy efficiency of the ship has been increased by approximately 25% [2].

Fig. 1. Wind Star, a triangular sail-assisted ship (Windstar Cruises 2022)

A plate found in Kuwait that has been dated back to seven thousand years ago depicts a man in a boat using sail [3]. Until the recent two centuries, sails have been the dominant mode of marine propulsion of ships. The materials used to make sail have evolved from natural materials such as animal leathers, papyrus, cotton and flax to today's composite ones with woven synthetic fibres such as Nylon, Polyester (PET), Pen (Pentex), Kevlar, Technora, Twaron, Spectra, Dyneema, Centran, Zylon (PBO), Vectran, Carbon fibre and coated with polymeric coatings. Synthetic fabrics command sixty per cent of the global fibre market [4].

The most commonly used synthetic fabric due to its cost-effectiveness is aliphatic wowen PET which is known by its commercial name. Dacron is relatively cheap, easy to form, and resistant to breakdown. However, it has the problem of keeping its original shape when subjected to load [5]. It has been produced by several producers since the 1950s. Dacron sailcloth is generally used in the crosscut configuration (figure 2) and has different mechanical performances in warp and weft directions showing a relevant weakness in the bias direction.

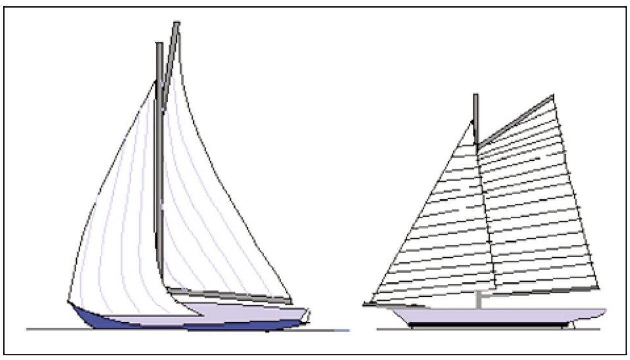

Fig. 2. Sail designs: *a* – vertical seam construction; *b* – crosscut construction

Sails are improving continuously in terms of their material, weight, fibre orientations and geometry mainly under the competition in sailing races like America's Cup. It is well known that the sail performance is directly related to the materials from which the sails are made and their behaviours under the harsh marine environment. There are mainly two forms of sailcloth: woven, which consists of a weft/warp direction, and laminated. Woven sailcloth is generally made of Dacron with a resin which blocks the yarns and improves the stability of weaving [6].

There is a lack of data on the mechanical performance throughout the material's lifecycle from the sailcloth manufacturers' side. However, a sailing boat designer needs such kind of data while studying the performance of the sail on the mast of a rigging arrangement. The sailcloth is generally assumed to have a smooth surface with almost zero porosity and be seawater resistant, not to mention the effect of ultraviolet (UV) radiation on the behaviour of the fabric [5, 7]. There is almost no experimental research data regarding the sailcloth's environmental behaviour in the literature. Since Dacron is a typical type of sail due to both its popularity in usage and the surface treatment it undergoes during the manufacturing process [8], this study is focused solely on Dacron sailcloth.

Apart from the sailcloth itself, the other elements of sailing boats have also been investigated by a few numbers of researchers. For instance, the failure modes of sailing boats' masts were studied by Boote et al. [9] using the real scale measurements of accelerations induced on the masts of two sailing boats during their trip from South Africa to Italy to predict possible failure of the masts in time. The study of Blicblau et al. [10] that has investigated the effects of the forces acting on the laser boat's sailcloth experimentally may also be worth mentioning in the same sense.

Environmental ageing is an essential element in understanding the long-term performance of a material. For this purpose, accelerated ageing procedures have been applied and then the degradation has been measured in the related properties compared with the initial values measured on unaged reference specimens [11]. In the last two decades, a certain amount of degradation of mechanical properties when polymer-based composite materials are exposed to thermal and moist environments has been reported. It is also concluded that those kinds of materials have exhibited the behaviour that absorbed moisture reduces the desired properties such as its glass transition temperature and also causes plasticization of it, resulting in the reduction of the strength [12]. In the case of UV radiation exposure, the breaking of polymer chains produces free radicals and reduces the molecular weight causing severe degradation of mechanical properties [13, 14].

To improve the performance of sailcloth, manufacturing industries have defined several cloth treatments called 'finishes'. Finishing treatments can be considered as the prevention of environmental degradation related to water vapour. Water-repellent treatment is one of the important finishing processes [15]. The most important chemicals for oil and water repellence for polymer-based textiles are fluorocarbon [FC] compounds which are organic compounds which are perfluorinated carbon chains. The efficiency of FC compounds is due to the structure of the bond between the F and C atoms. Since the length of a C-F bond (1.35 Ä) is shorter than that of a C-C bond (1.54 Ä), the F atom strongly bonds with the C atom and the movement of fluorinated alkyl groups is restricted. This causes fluorocarbon compounds to have low boundary surface tension and liquids can never penetrate the related fabric after water and oil-repellent treatments [16]. According to the study of Namlıgöz et al. [17], water-repellent results obtained from the new chemicals such as polymeric dendrimers containing FC were significantly better than conventional ones. As for the conventional FC compound, a higher concentration of FC was suggested.

To understand the degradation level of mechanical performance, in addition to the tensile test, dynamic mechanical analysis (DMA) at a certain frequency over a range of temperatures has been considered a useful analytical technique for the characterization of sailcloth as a polymeric material. By DMA, the temperature dependencies of the dynamic moduli, stress relaxation, mechanical loss, and damping phenomena, as well as locating the glass transition of the materials can be concluded [18].

In this study, the combined effect of seawater exposure, temperature, UV, wet-dry cycle and finishing (water-repellent treatment) on the Dacron's mechanical performance which influences the end use of this sailcloth in the marine environment have been investigated experimentally. Tensile tests were performed for the Dacron specimens with nine different areal weights and in two different directions (warp and weft) and dynamical mechanical analysis for a representative Dacron sailcloth is made. The comparative results were given with the conclusions.

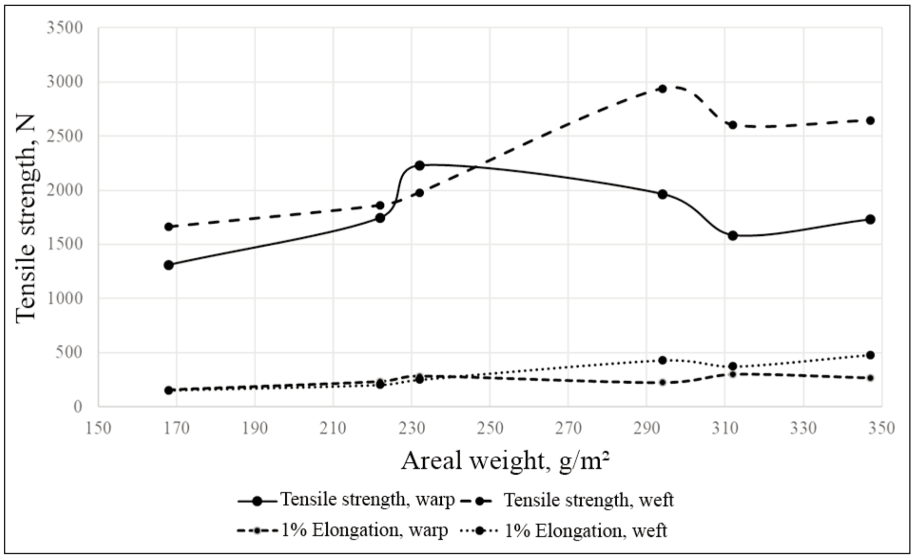

Fig. 3. The tensile strength and 1% elongation force of Dacron sailcloth with different areal weights in two fibre directions (warp and weft)

EXPERIMENTS

Materials

Dacron sailcloth is used in this study due to its common use in sailing practice.

From a face-to-face interview among the sailors of a local sailing club in Izmir (Turkey), their experiences and perceptions on the usage of Dacron sailcloth have been recorded, as can be listed below:

(1) The effective lifetime of this sailcloth in practice can be taken as 5 years-approximately. After this lifespan, the sailcloth loses its mechanical performance significantly by showing large deformations under wind loads when under sailing conditions above 25 knots of wind speed in particular.

(2) UV exposure can severely degrade this sailcloth. In other words, its resistance to UV exposure is relatively poor.

(3) To extend the lifetime of the Dacron sailcloth, it is advisable to take the following considerations into account:

– In the design stage:
  - The local sailing conditions such as significant wind directions and speeds, Proper geometry and joining method of sailcloth units

– In storage:
  - Maintenance and storage of sailcloth after the sailing season should be properly done, i.e. washing sailcloth with fresh water and storing it in a place at room temperature.

– In usage:
  - A small proportion of UV-resistant fabrics as possible should be exposed to direct sunlight (while the rest of the sailcloth is kept in folded condition).
  - Extreme loads on the rigging should be avoided.

From a Dacron sailcloth manufacturer's data of tensile tests performed using sailcloth with areal weights from 168 to 347 g/m^2 and thicknesses from 0.215 to 0.4 mm respectively, the relation between the sailcloth's areal weight and their tensile strength is depicted in the figure 3 [19].

The areal weight of Dacron sailcloth samples used in the study and their fibre alignments are given in table 1.

Table 1

DACRON SAILCLOTH USED IN THE STUDY	
Type of sailcloth samples	**Areal weight (g/m^2) / the direction of fibre alignment**
1	177 / Warp
2	177 / Weft
3	225 / Warp
4	225 / Weft
5	186 / Warp
6	186 / Weft
7	187 / Warp
8	187 / Weft
9	262 / Warp
10	262 / Weft
11	280 / Warp
12	280 / Weft
13	310 / Warp
14	310 / Weft
15	350 / Warp
16	350 / Weft
17	415 / Warp
18	415 / Weft

Tests

Ageing

Different ageing processes were applied to test samples by exposing them to natural sunshine for 15 days in August in Izmir (38°24’45’’N – 27°8’18’’E) by placing them behind glass with the solar angle of 60° from the vertical plane; by applying a wetting-drying process with synthetic seawater (a 5% solution of NaCl) and by exposing them to UV on Prowhite UV Test Box under 35 watt/m^2 light intensity for 72 hours according to ASTM G 154-02 standard. A total of six ageing processes given in table 2 were studied.

Table 2

AGING PROCESSES	
Ageing status	**Ageing applied**
No-ageing	-
Aging-1	– 15 days exposed to natural sunshine
Aging-2	– 15 days exposed to natural sunshine – Wetted 3 times in daytime with 2 hours intervals daily
Aging-3	– UV for 72 hours
Aging-4	– Aging-2 + Aging-3
Aging-5	– Water repellent treatment + Aging-3
Aging-6	– Water repellent treatment + Aging-2 + Aging-3

Water-repellent treatment

For the fluorocarbon finishing of sailcloth, 50 g/l Periguard UFC was added to the padding liquid and the pH of the liquid was adjusted to 5.5 by the addition of acetic acid. After immersing of fabric into the padding liquid, the fabric is squeezed throughout rollers under 1 kg/m^2 pressure. The fabric dried at 170°C in an oven after treatment. Curing was achieved at 170°C for 1 min in the oven.

Tensile tests

Test specimens were cut from a sailcloth. The tensile properties of the samples were determined by the EN ISO 13934-1 strip method at a crosshead speed of 250 mm/min using the Zwick/Roell model Z010. The tensile strength and the modulus were determined from the stress–strain curves. Three samples were tested in each set and the average value was reported with ±1 standard deviation. Tensile properties were determined by the direction of the fibre alignment.

Dynamic Mechanical Analysis (DMA)

DMA was performed on the DMA Analyzer Q8000 at the labs of the University of Ljubljana Faculty of Natural Sciences and Engineering in Slovenia. Temperature-dependent viscoelastic properties of fabrics were measured between 0 and 200°C. During the tests, the frequency was 1 Hz while the amplitude was 10 μ. From the stress and strain amplitude and their phase angle, storage modulus (E’), loss modulus (E’’) and mechanical damping parameter (Tan δ = E’’/E’) were calculated.

RESULTS

Tensile test

The results of the tensile test are given in figure 3 and the degradations on the tensile strength are also summarized in table 3.

From figure 4 and table 3, it was observed that the tensile strength of the sample increased while the square areal weight increased.

Each of the environmental ageing processes had significant degradation effects on the original tensile strength of the sailcloth. These degradations increase while the number of ageing effects/agents increase, i.e. the largest degradations were seen in the combined ageing conditions, in Aging-4 (15 days exposed to natural sunshine + at the same 15 days-period wetted three times in daytime with two-hour intervals + UV for 72 hours), in particular.

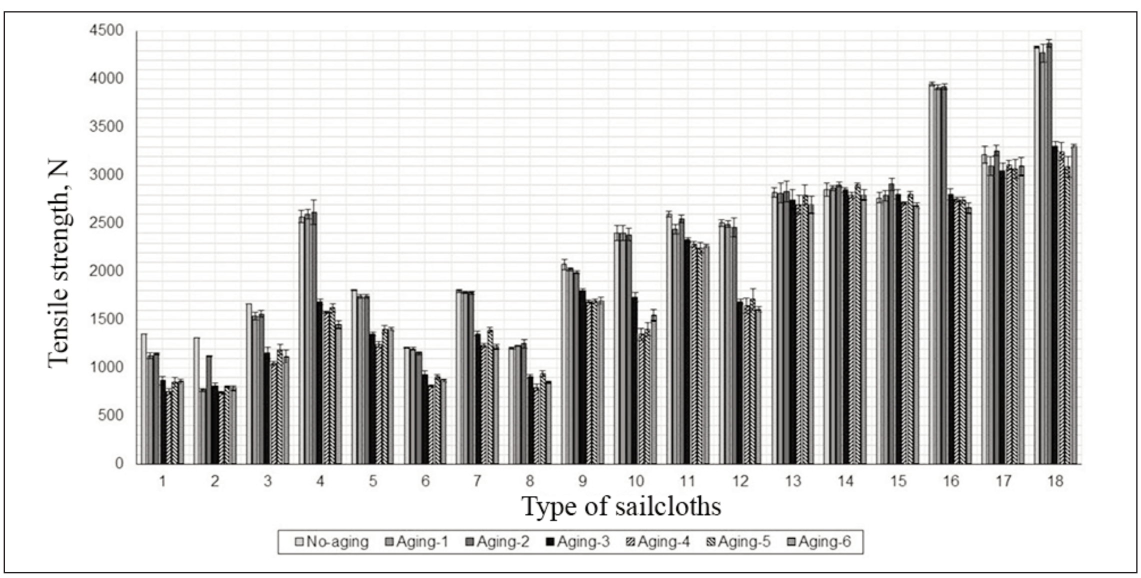

Fig. 4. Results of tensile tests

Table 3

TENSILE STRENGTHS OF THE SAMPLES AND THEIR DEGRADATION							
Type of sailcloth samples	**Tensile strength (±1 standard deviation), N and *Degradation, %***						
	No-ageing	**Aging-1**	**Aging-2**	**Aging-3**	**Aging-4**	**Aging-5**	**Aging-6**
1	1667 (2.16) ***0***	1542 (40.03) ***8***	1563 (37.38) ***7***	1153 (59.56) ***31***	1046 (18.06) ***39***	1189 (53.15) ***29***	1118 (68.49) ***33***
2	2572 (62.89) ***0***	2599 (48.13) ***–1***	2620 (126.70) ***–1***	1688 (28.33) ***35***	1579 (6.60) ***39***	1625 (43.64) ***37***	1451 (36.04) ***44***
3	1352 (2.94) ***0***	1127 (32.89) ***17***	1152 (9.98) ***15***	870 (45.11) ***36***	755 (2499) ***45***	854 (51.56) ***37***	858 (27.76) ***37***
4	1311 (1.70) ***0***	772 (13.14) ***42***	1124 (7.35) ***15***	816 (24.34) ***38***	743 (10.61) ***44***	804 (13.14) ***39***	793 (23.85) ***40***
5	1810 (4.08) ***0***	1749 (20.27) ***4***	1747 (22.23) ***4***	1354 (21.65) ***26***	1246 (29.22) ***32***	1406 (39.90) ***23***	1402 (20.46) ***23***
6	1215 (4.08) ***0***	1200 (11.22) ***2***	1154 (14.38) ***6***	934 (37.85) ***24***	817 (10.20) ***33***	908 (22.45) ***26***	870 (12.96) ***29***
7	1804 (14.31) ***0***	1787 (8.73) ***1***	1782 (11.90) ***2***	1355 (23.62) ***25***	1236 (21.42) ***32***	1396 (25.92) ***23***	1222 (24.39) ***33***
8	1203 (10.20) ***0***	1229 (4.19) ***–2***	1252 (41.60) ***–4***	910 (20.46) ***25***	798 (32.78) ***34***	944 (31.03) ***22***	851 (10.23) ***30***
9	2077 (55.20) ***0***	2028 (13.57) ***3***	1992 (15.52) ***5***	1807 (18.24) ***13***	1690 (17.20) ***19***	1695 (18.02) ***19***	1699 (37.97) ***18***
10	2402 (76.54) ***0***	2401 (79.63) ***0***	2387 (63.30) ***1***	1735 (49.89) ***28***	1350 (60.49) ***44***	1401 (70.32) ***42***	1549 (60.40) ***36***
11	2595 (29.33) ***0***	2444 (48.32) ***6***	2546 (39.10) ***2***	2332 (25.66) ***10***	2284 (30.23) ***12***	2250 (52.26) ***13***	2266 (21.40) ***13***
12	2507 (31.05) ***0***	2495 (36.81) ***1***	2462 (94.81) ***2***	1691 (23.54) ***33***	1646 (75.53) ***35***	1713 (110.33) ***32***	1607 (28,25) ***36***
13	2825 (52.17) ***0***	2820 (99.68) ***1***	2833 (109.60) ***1***	2373 (105.73) ***29***	(96.33) ***39***	(100.76) ***36***	(87.50) ***33***
14	2856 (66.25) ***0***	2872 (23.10) ***1***	2907 (24.56) ***2***	2000 (25.76) ***30***	1656 (34.75) ***42***	1770 (26.56) ***38***	1890 (55.46) 36
15	3217 (88.43) ***0***	3101 (94.38) ***1***	3261 (57.78) ***1***	2300 (76.89) ***28***	2025 (53.11) ***37***	2190 (99.00) ***32***	2280 (93.56) ***29***
16	4337 (12.92) ***0***	4273 (89.07) ***1***	4375 (39.94) ***1***	3079 (50.26) ***29***	2820 (93.12) ***35***	3035 (105.19) ***30***	2950 (23.79) ***32***
17	2771 (51.49) ***0***	2791 (50.86) ***4***	2910 (61.68) ***1***	2807 (49.83) ***31***	2714 (17.66) ***34***	2803 (27.90) ***30***	2688 (25.47) ***28***
18	3954 (19.07) ***0***	3916 (25.84) ***1***	3922 (30.43) ***1***	2808 (59.76) ***24***	2752 (28.33) ***25***	2743 (34.87) ***29***	2664 (52.43) ***24***

In the samples with water-repellent coating finishes, a 1–2 % difference was found between the values of warp and weft alignments. However, after the subjected to Aging-2, there was a remarkable difference (5–10%) between the values of the samples with water-repellent coating and the values of non-coated samples.

Degradations of fibres in the weft direction in the form of monofilament which are thicker than the fibres in the warp direction were found to be much more serious. Surface finishing (water-repellent treatment) also caused a significant decrease in the initial strength of the samples.

Dynamic Mechanical Analysis (DMA)

Dynamical mechanical properties including glass transition temperature (Tg) were characterized due to the supermolecular structure of the fabric, segment mobility and the energy of intermolecular activity.

From the figure 4, the results can be summarised as below:

- Storage modulus of all the samples was slightly observed to decrease starting from 100°C while for the control sample with no-aging, the decrease was noted to be much more significant (figure 4, *a*).
- For all the samples above 100°C, the decrease was more significant. In the degraded samples, at 150°C, the storage modulus of the material is higher than those of non-aged ones.
- Glass transition temperature decreases from 130°C to 124°C for all the aged samples.
- The loss modulus of the samples that were affected significantly by the environmental agents has a

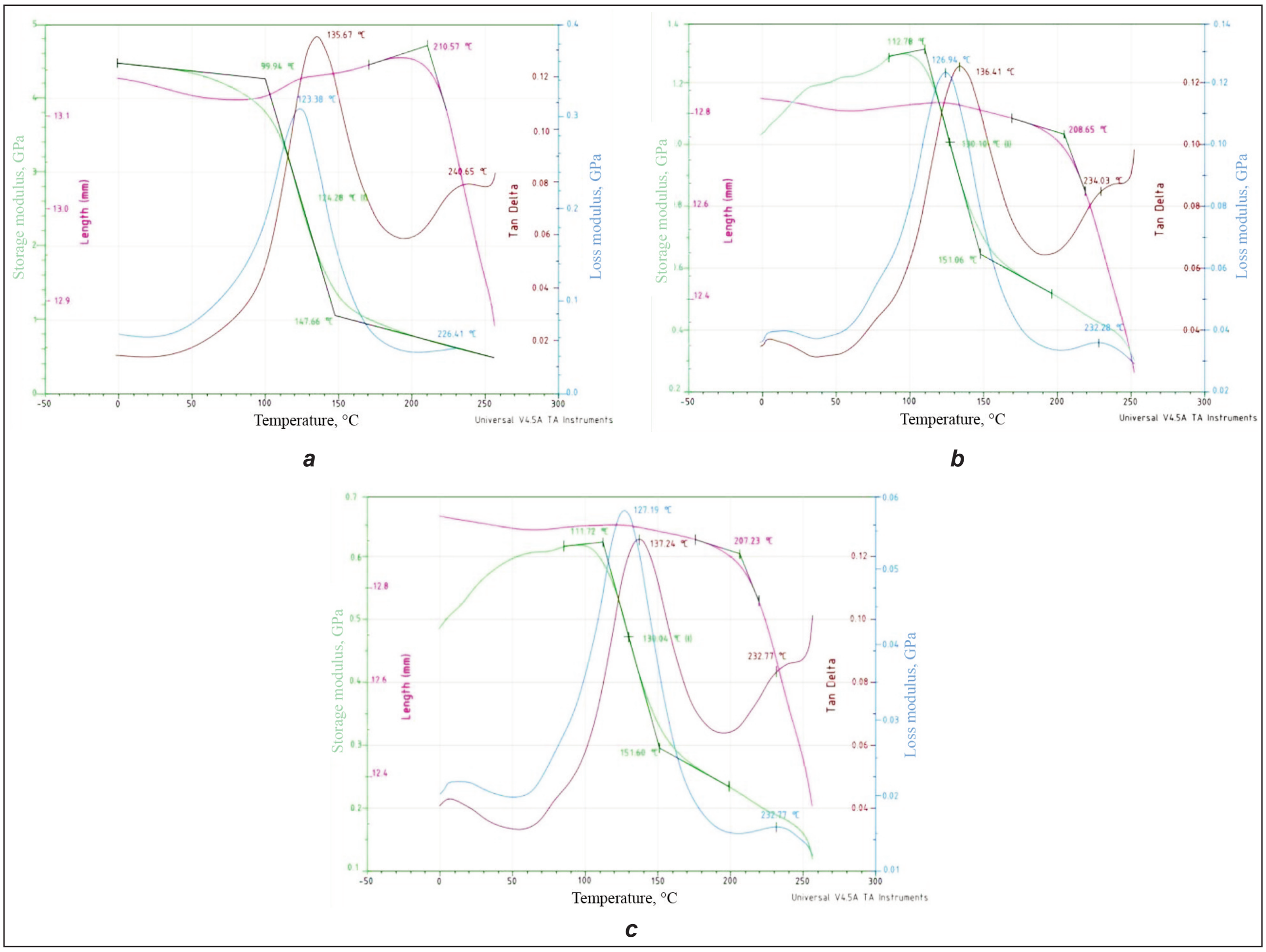

Fig. 5. DMA analysis of sailcloth-16 (350 g/m^2) in weft direction: *a* – no-aging; *b* – Aging-3; *c* – Aging-4

maximum of 127°C as a consequence of a drastic decrease of storage modulus above 100°C.

- Maximum Tan δ of the sailcloth, can be seen at 135, 136 and 137°C. These values can be a consequence of the intense segmental motion of the sailcloth.

CONCLUSIONS

Effects of marine environmental degradations on commonly used sailcloth were shown using experimental data in this study. Choosing the right sailcloth with a proper fibre alignment is crucial not only in the design stage but also in the lifecycle of a sailing boat. The assessment of such degradation effects through the lifetime of these fabrics needs further extensive research.

From this study, which considers the combined effects of seawater and UV exposures, wetting-drying cycles and finishing, it is seen that the marine environment has a significant effect on the mechanical performance of sailcloth and water-repellent treatment is a solution to prevent sailcloth from severe adverse effects of environment. With sail design optimized with this kind of experimental data, end users will not have to turn to economically and environmentally unsustainable options.

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REFERENCES

[1] Pan, P., Sun, Y., Yuan, C., Yan, X., Tan, X., *Research progress on ship power systems integrated with new energy sources: A review*, In: Renewable and Sustainable Energy Reviews, 2021, 144, 111048

[2] *Windstar Cruises*, 2022, Available at: https://en.wikipedia.org/wiki/Windstar_Cruises [Accessed on September 17, 2022].

[3] Carter, R., *Boat remains and maritime trade in the Persian Gulf during the sixth and fifth millennia BC*, In: Antiquity, 2006, 80, 307, 52–63

[4] Smelik, A., *Review Essay: The material culture of textiles: Toward sustainability*, In: Matter: Journal of New Materialist Research, 2022, 3, 2, 176–183

[5] Tesei, L., Tesei, G., Mancini, L., Tromba, G., Zanini, F., *Applications of phase-sensitive X-ray imaging to the structural analysis of composite laminate high-performance sail fabrics*, In: Advance Engineering Materials, 2005, 7, 11, 1054–1056

[6] Spalatelu-Lazar, M., Léné, F., Turné, N., *Modelling and optimization of sails*, In: Computers and Structures, 2008, 86, 1486–1493

[7] Ambroziak, A., Klosowski, P., *Polyester sail technical woven fabric behaviour under uniaxial and biaxial tensile test*, In: Journal of Theoretical and Applied Mechanics, 2018, 56, 1, 227–238

[8] Benfratello, S., Cirello, A., Palizzolo, L., *Effect of surface finish on the mechanical behavior of Dacron© 360 woven*, In: Ocean Engineering, 2011, 2, 1, 17–27

[9] Boote, D., Vergassola, G., Delfino, P., Faloci, F., *Real scale measurements of yacht's mast accelerations*, In: Ships and Offshore Structures, 2021, 16, 10, 1125–1142

[10] Blicblau, A., Singh, M., Pokman, V., *A study on the resultant speed of a laser sailboat under various wind conditions*, In: Mathematics in Engineering, Science and Aerospace (MESA), 2012, 3, 2, 143–162

[11] Davies, P., Environmental degradation of composites for marine structures: new materials and new applications, In: Philosophical Transactions of the Royal Society A-Mathematical Physical and Engineering Sciences, 2016, 324, 20150272

[12] Ray, B.K., Rathore, D., Environmental damage and degradation of FRP composites: A review report, In: Polymer Composites, 2015, 36, 412–423

[13] Yousif, E., Haddad, R., *Photodegradation and photostabilization of polymers, especially polystyrene: review*, 2013, SpringerPlus 2, 398

[14] Pal, S.K., Thakare, V.B., Singh, G., Verma, M.K., *Effect of outdoor exposure and accelerated ageing on textile materials using in aerostat and aircraft arrester barrier nets*, In: Indian Journal of Fibre and Textile Research, 36, 145–151

[15] Dalbaşı, E.S., Çoban, S., Kayseri, G.Ö., *Thermo-physiological comfort properties of various shirt fabrics treated with conventional and nano sized water-oil repellent and wrinkle resistant agents*, In: The Journal of Textile Institute, 2021, 113, 6, 1104–1113

[16] Çoban, S., *General textile finishing (in Turkish),* Izmir: Ege University Textile and Apparel Research Application Center Publication, 1999

[17] Namlıgöz, E.S., Bahtiyari, M.İ., Hoşaf, E., Çoban, S., *Performance comparison of new (dendrimer, nanoproduct) and conventional water, oil and stain repellents*, In: Fibres and Textiles in Eastern Europe, 2009, 5, 76, 76–81

[18] Ghosh, P., Bose, N.R., Mitra, B.C., Das, S., *Dynamic mechanical analysis of FRP composites based on different fiber reinforcements and epoxy resin as the matrix material*, In: Journal of Applied Polymer Science, 1997, 64, 12, 2467–2472.

[19] *IYU Sailcloth*, 2022, Available at: https://iyusailcloth.com/Yachting.htm/ [Accessed on September 17, 2022]

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