Functional Test

Customer:

TommiDive, Von Daehnin katu 25 D 8, 00790 Helsinki

Research Contract:

e-mail_TommiKosonen_270614.txt

Target:

Fabric samples of blue and yellow fabric for diving/snorkeling shirt, white, green and red cotton fabric and 4 sunscreens with different sun protection factor.

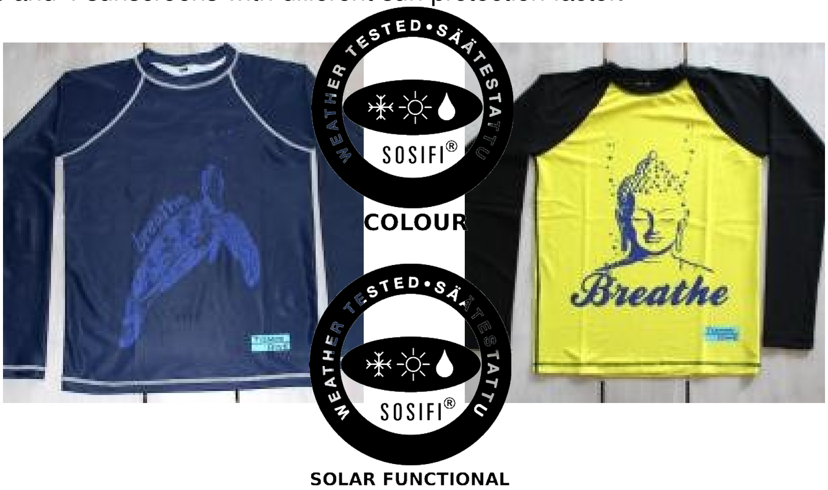

Fig. 1. *TommidDive shirts for diving/snorkeling.*

Testing Time:

The start of the test: July 4, 2014
The end of the test: July 11, 2014

Purpose of the Test:

This test is performed for testing how well the TommiDive diving shirt fabric protect against sunshine and particularly against UV radiation. In addition we get the information on how much the colours of the shirts fade under sunlight.

Test Method:

The test method is to measure fading of red colour of a certain sail fabric when protected by TommiDive yellow or blue shirt fabric and exposed with simulated sunlight. In addition similar test was done under UV-A radiation exposure. Earlier tests have shown that the red colour of the used sail fabric easily fades when exposed to simulated sunlight or UV-light. For comparison 3 other fabrics and four sunscreens were used to protect the red sail fabric against sunlight.

Validation of the Test Method:

Simulated sunlight has essentially similar spectrum as natural sunlight and so the effect on the sail fabric should be the same as under natural sun. UV-part of sunlight is known to cause most of the colour change in fabrics like the used red sail fabric. UV-light of the sun mostly consist of UV-A. The red sail fabric can behave somewhat differently under sunlight than human skin, but the changes in the sail fabric still show how well the red red sail fabric is protected against sunlight and UV-A light when covered with the fabrics or sunscreens.

Performed Actions:

The samples were exposed under simulated sunlight and under UV-A light.

The light from the solar simulator (simulated sunlight) has effectively similar spectrum as the natural sun. The properties of the simulated solar radiation used in this test, and those of natural sunlight, are described in Fig. 2 and Table 1. Figure 2 shows the solar spectrum and the spectrum of the simulated radiation in the wavelength range of 200 - 1000 nm. Table 1 shows the spectral distribution and, for reference, the allowed tolerances based on a widely used solar test standard MIL-STD 810G in the ranges of ultraviolet (UV), visible, and thermal radiation (IR).

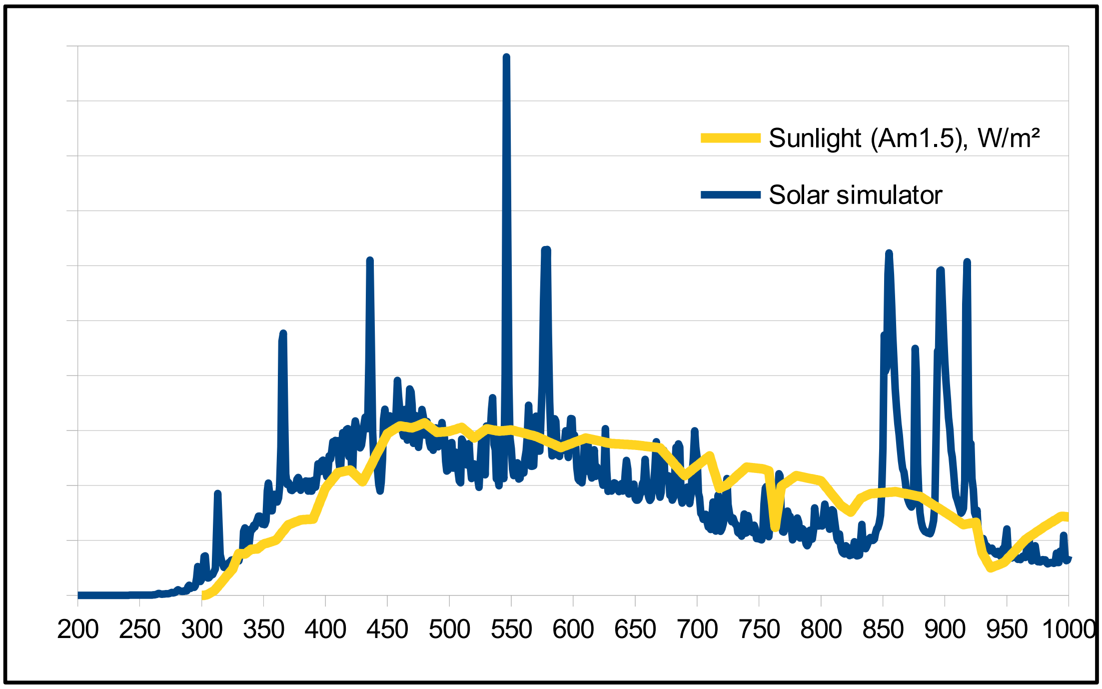

Fig. 2. *Solar spectrum (blue curve) and spectrum of the simulated radiation (red curve) in the wavelength range of 200 – 2400 nm covering UV-, visible, and IR-radiation.*

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Table 1. Spectral distribution of real solar radiation (Sun), radiation from the solar simulator and the allowed tolerances in the ranges of ultraviolet (UV), visible, and thermal radiation (IR).

Spectral region	Sun (Natural radiation)	Solar simulator	Tolerance MIL-STD-810G
	[% of total]	[% of total]	[% of total]
UV	6.1	7.47	4.5 – 8.1
Visible	51.8	44.36	43.8 – 57.0
IR	42.1	48.2	33.7 – 50.5

The spectrum of the UVA-340 lamps used in this test and the UV-spectrum of the sun are presented in Fig. 3.

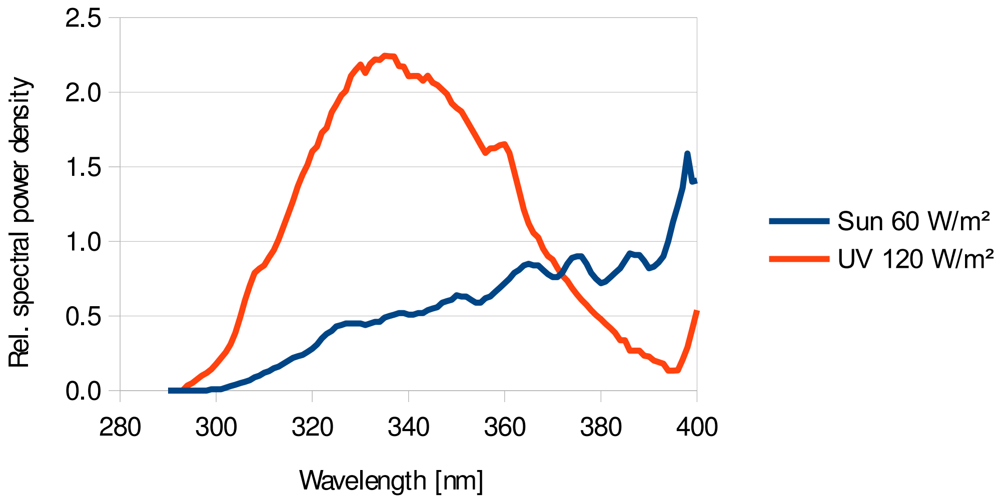

Fig. 3. *Spectra of solar UV radiation (blue curve) and UV radiation of the lamps used in the test (red curve). Relative spectral power density as a function of wavelength.*

The intensity and uniformity of the UV radiation field was measured with a precision pyranometer from a 5 × 3 matrix. The intensity was 121 ± 2 W/m^2.

The ambient air temperature in the UV-chamber was 34 ± 3°C during the test. The UV-intensity, ambient air temperature and relative humidity during a 24-hour test period are shown in Fig. 4.

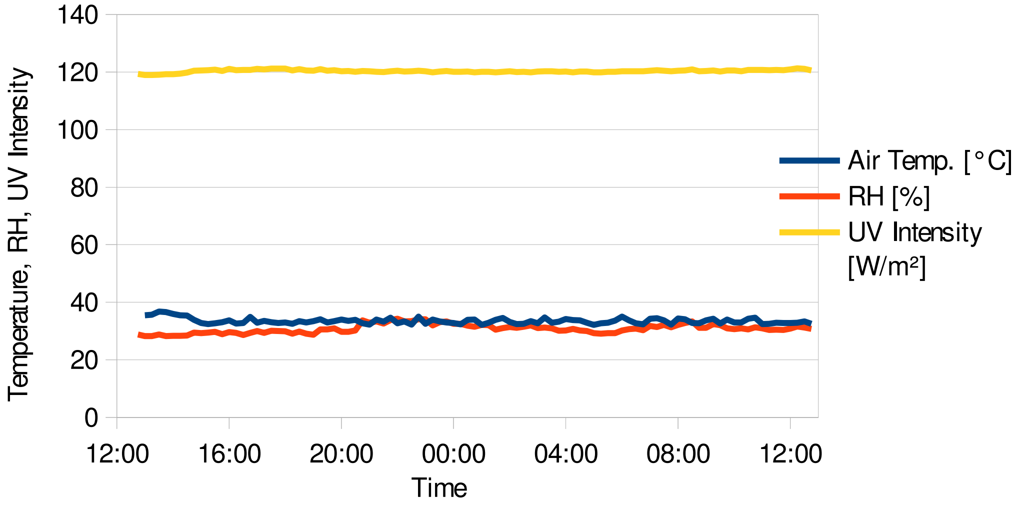

Fig. 4. *Conditions during a 24-hour test period. Ambient air temperature, relative humidity RH and intensity of UV radiation as a function of time are shown.*

Before the light exposure four samples partly covered with pieces of fabric and sunscreen were made. Two for simulated sunlight and two for UV-light.

UV-samples: A piece of TommiDive blue and yellow shirt fabric, a piece of white, green and red cotton fabric and four pieces of fabrics for baby clothes were attached on the sail fabric for light protection. In addition four areas of the sail fabric was protected with four different sunscreens. The fabrics under test were partly covered with aluminium foil for easier oervation of the colour fading.

Simulated sunlight-samples: A piece of TommiDive blue and yellow shirt fabric were attached on the sail fabric for light protection. In addition four areas of the sail fabric were protected with four different sunscreens. The fabrics under test were partly covered with aluminium foil for easier oervation of the colour fading.

The sunscreens used were with sunlight protection factor (SPF) of 50+, 30, 20 and 10. One with SPF of 30 was visually transparent, but the other sunscreens were visually opaque.

One of each sample types were put in tap water bath for two hours to simulate swimming.

The samples were then put under simulated sunlight and UV-light and exposure continuously. The exposure was stopped after clear visual indication of colour-fading of the sail fabric was noted. The simulated sunlight exposure was stopped after 90 hours and the UV-exposure after 162 hours. The exposed (upper) and unexposed (lower) parts of the samples can be seen in figures 5 – 7 below.

Fig. 5. *Fading of the TommiDive blue shirt fabric caused by the UV-A (left) and solar (right) exposure. Upper part of the fabric was exposed.*

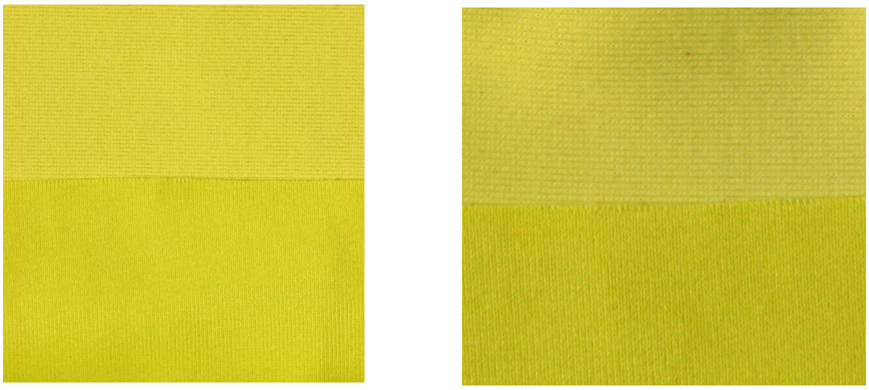

Fig. 6. *Fading of the TommiDive yellow shirt fabric caused by the UV-A (left) and solar(right) exposure. Upper part of the fabric was exposed.*

Fig. 7. *Fading of the white, green and red Cotton fabric caused by the UV-A exposure. Upper part of the fabric was exposed.*

Protection ability against sunlight was tested by comparing the colour change under each protection cover material (fabric or sunscreen). The figures 8 – 9 show the fading of the colour under each protection cover material. Comparison to the sunscreens is not very reliable since all the sunscreens did at least partly evaporate away from the surface of the fabric during the exposure and the three left clear residue on the surface of the fabric. Only the area under the sunscreen with SPF of 30 was clean-looking after the exposure.

Fig. 8. *Colour fading of the light sensitive red sail fabric under different protection (fabric or sunscreen). UV-A exposure.*

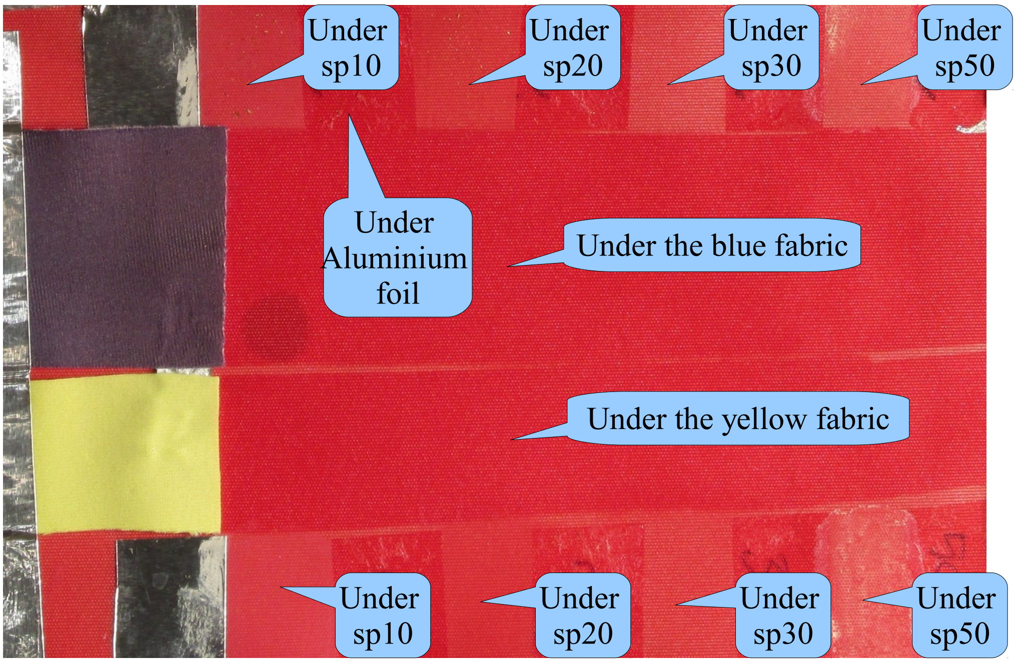

Fig. 9. *Colour fading of the light sensitive red sail fabric under different protection (fabric or*

sunscreen or aluminium foil) after exposure with simulated sunlight. Note the whitish residue left from some of the sunscreensn(specially the one with SPF of 50).

After the exposure the colour was measured as $L^*a^*b^*$ colour coordinate values. The measurement was done on the exposed surface of each fabric and on the surface of the red sail fabric under each protecting fabric and sunscreen.

Optical Analysis

The $L^*a^*b^*$ colour coordinate values of the samples were measured. The reflected specular component from the samples is included in the $L^*a^*b^*$ values. Colour difference ΔE represents the Euclidean distance between two colours.

L^*-coordinate indicates the lightness of the sample. The bigger the value the lighter the sample.
$+a^*$-coordinate indicates the red direction and $-a^*$ indicates the green direction.
$+b^*$-coordinate indicates the yellow direction and $-b^*$ indicates the blue direction.
The colour coordinates are shown schematically in Fig. 10.

Under ideal viewing conditions a ΔE value of 1 represents a just perceptible colour difference to the human eye. However, the human eye sees differently colour differences in different colours. The differences in darker colours are more perceptible to the eye.

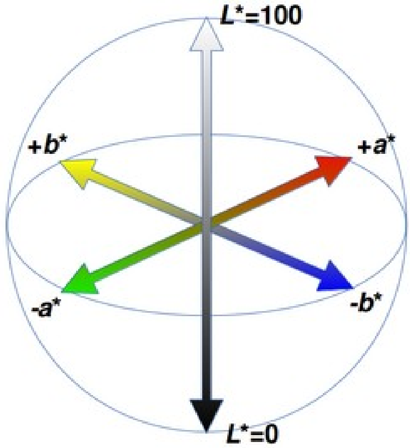

Fig. 10. *CIE L*a*b* colour coordinate system.*

Colour difference ΔE (SCI, specular component included) as a function of the UV energy is shown in Figs. 11 and 12.

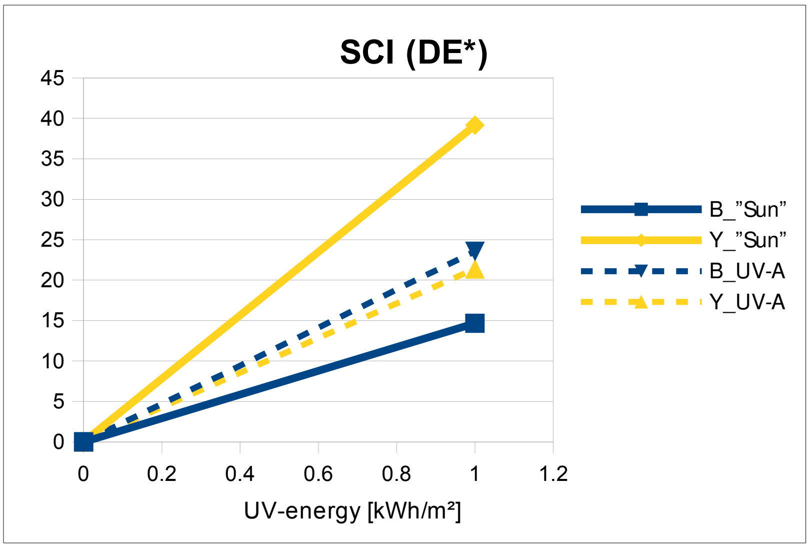

Fig. 11. *Colour difference ΔE of the TommiDive blue (B) and Yellow (Y) shirt fabric caused by the UV-A and solar exposure. Under ideal viewing conditions a ΔE value of 1 represents a just perceptible colour difference to the human eye.*

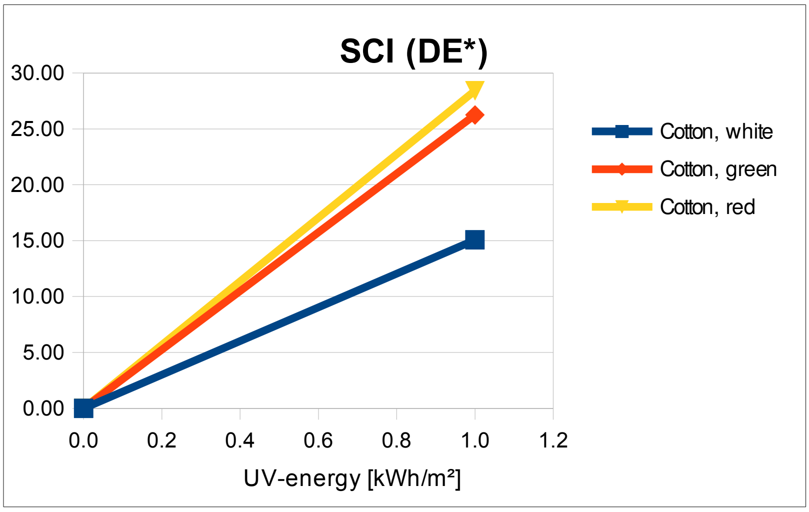

Fig. 12. *Colour difference ΔE of the white, green and red shirt fabric caused by the UV-A. Under ideal viewing conditions a ΔE value of 1 represents a just perceptible colour difference to the human eye.*

The ability to protect against sunshine can be evaluated by measuring the fading of the red sail fabric under each protective layer (fabric or sunscreen). The figs 13-15 show the results of these measurements. All the sunscreens did at least partly evaporate away from the surface of the fabric during the exposure and three of them left clear residue on the surface of the fabric. Only the area protected with the sunscreen with SPF30 (transparent oil) was found to be clear from residue after the exposure and only the measurement result of it is presented.

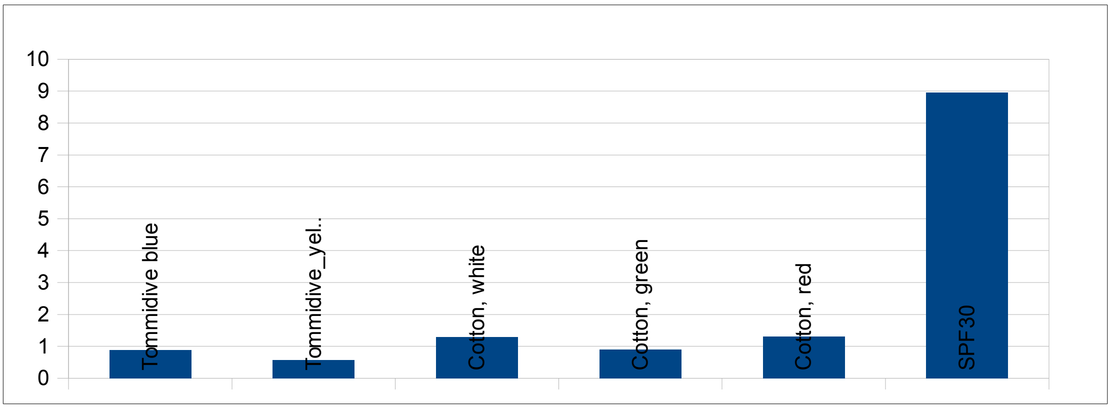

Fig. 13. *Colour fading of the light sensitive red sail fabric under different protection layer (fabric or sunscreen) after UVA-exposure. Lower value means better protection.*

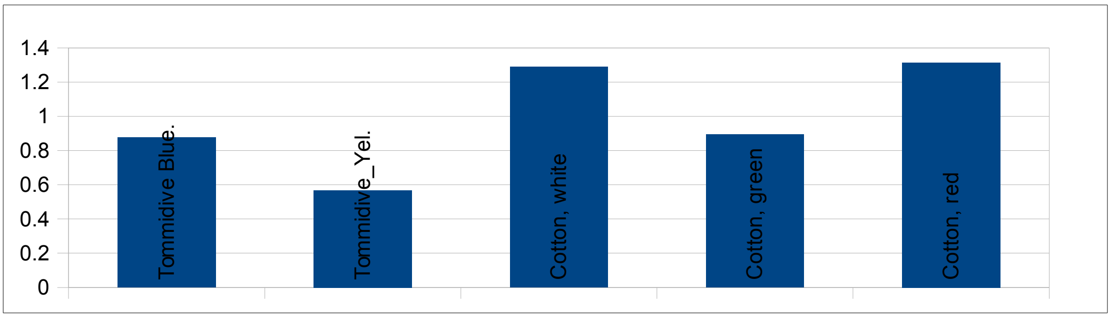

Fig. 14. *Colour fading of the light sensitive red sail fabric under different protection layers (fabric) after UVA-exposure. Lower value means better protection.*

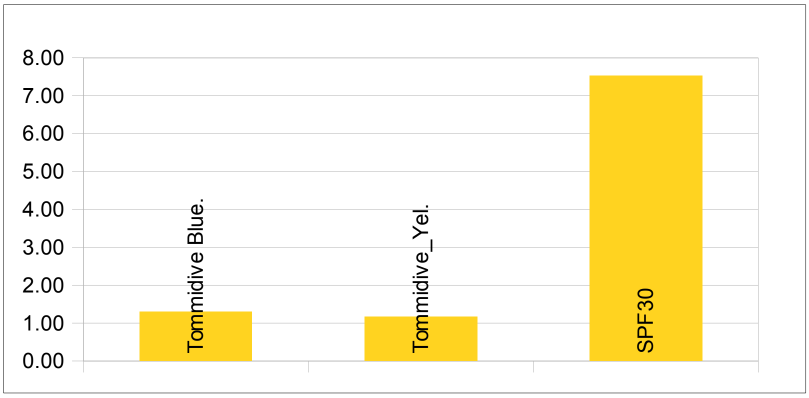

Fig. 15. *Colour fading of the light sensitive red sail fabric under different protection layer(fabric) after exposure with simulated sunlight. Lower value means better protection.*

Used Equipment:
Solar simulator, No.n 39
UV Tester, No. 17
UV intensity: Pyranometer No 11, calibrated 9th September, 2013, calibration is valid
Multimeter No 24, calibrated 2nd May, 2014, calibration is valid
No. 17 / Photodiode, calibrated 11th July, 2014, calibration is valid
Temperature: No. 64 / Temp, calibrated 12th June, 2014, calibration is valid
Relative humidity: No. 64 / RH_aux, calibrated 11th April, 2014, calibration is valid
Colour: No. 8, calibration is made before every measurement session, calibration is valid

Analysis:

Radiation Correspondence:
The mean UV radiation energy in Southern Finland during one year is 54 kWh/m² onto a horizontal surface and 47 kW/m² onto a south facing vertical surface. Thus at this test the total UV-energy of 19 kWh/m² to 25 kWh/m² corresponds to the UV-energy onto a horizontal surface during 4 to 6 months in Southern Finland.

This estimate is based only on the total energy dose and does not take into account the differences in the spectra of the simulated and natural sunlight.

Recommendations:
Comparison between the protecting ability of the fabrics and the sunscreens is not very reliable since all the sunscreens did at least partly evaporate away from the surface of the fabric during the exposure and some of the sunscreens also left clear residue, which affects the measured colour coordinate values. Shorter similar test with even more light sensitive material as substrate or UV-measurement could give more reliable comparison.

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Conclusions:

This test was performed for comparing the TommiDive suit fabric to other fabrics and sunscreens in their ability to protect from Sunlight exposure and particularly UV-light exposure.

The test results show that TommiDive diving shirt fabric protects well from sunlight exposure. It prevents transmission of sunlight better than the white, green or red cotton fabric (T-shirt). Based on the test results all the fabrics seem to obstruct sunlight better than the tested SPF30-sunscreen.

Remarks:

The sunscreens did at least partly evaporate away from the surface of the fabric during the exposure and some of the sunscreens also left clear residue, which affects the measured colour coordinate values. This makes it harder to compare the fading of the colours under the protective layers (fabrics, sunscreens).

Actions, operations and reporting are in accordance with IEC/ISO 17025 'General requirements for the competence of testing laboratories'.

Signatures:

Ari Kuusisto
Littoinen, August 25, 2014
Solar Simulator Finland

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