APPLICATION NOTE

Smart Industry

Identifying Counterfeit Textiles

Overview

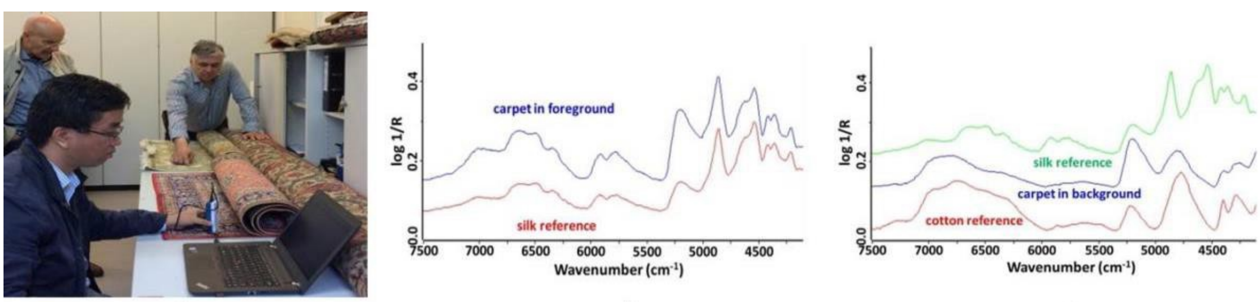
Textiles are important materials that are used in everyday life, with a broad range of applications. Based on the origin of the raw material, textiles can be either natural (e.g. cotton, silk, wool, cashmere, etc.) or synthetic (e.g. acrylics, polyamides, polyesters, etc.). Customers are now more conscious than ever on the correlation between price and quality of the textiles they are buying. However, with increasing prices and the variations of types and quality, counterfeit textile products are becoming more and more common. Whether it is clothes or carpets, people are cheated by being offered material made from synthetics or wool as genuine silk at exaggerated prices.

A simple tool for the rapid test of the correct identity of the textile article of interest would be a significant progress in consumer protection. This tool has to be portable, affordable, and should allow users to analyze their target textiles without destroying their products. Miniaturization of near-infrared (NIR) spectrometers has advanced to the point where handheld instruments could provide reliable and affordable means to serve this purpose. In this application note, we demonstrate the possibility of using NeoSpectra spectral sensors for the analysis of different textiles types.

Authentication of Silk Carpets

Mercerization of wool lends the final product a gloss that, for the naked eye, may look very similar to silk. This similarity is exploited by untrustworthy carpet manufacturers to sell such carpets to a credulous customer as a silk product for an unrealistic prize.

Figure 1 shows that plotting the NIR spectra corresponding to each type of carpet can easily and quickly discriminate between silk and mercerized wool carpets. This demonstrates that NeoSpectra spectral sensors can be used to discriminate between authentic and counterfeit silk carpets, even by non-experts, with the simple visualization of their corresponding NIR spectra. In more complex situations, material-specific evaluation algorithms can be developed to qualify and/or classify different types of textiles.



a b c

Fig.1 Authentication of a genuine silk carpet and discrimination from a carpet made from mercerized wool:
(a): measurement of the diffuse reflection NIR spectrum of a carpet
(b): authentication of the silk carpet (foreground) by visual comparison to a silk reference spectrum
(c): identification of the mercerized wool carpet (background) by visual comparison to a (non-mercerized)

Classifying the Raw Materials

In order to demonstrate the ability of NeoSpectra spectral sensors to identify and/or classify the different kinds of textiles commonly found in consumer textile-based products, we show how it is used to perform discrimination of nine different classes of natural and synthetic textile materials (cotton, wool/cashmere, silk, Kevlar, Nomex, polyacrylonitrile/acrylics, elasthanes, polyamide 6 (PA6)/polyamide 66 (PA66) and polyethylene terephthalate (PET)) based on their diffuse-reflection NIR spectra.

Sample sets:

- Total 72 samples:
  - 48 calibration samples
  - 24 test samples
- Samples and spectra were recorded in triplicate

Measurement conditions:

- Wavelength range: 1298 - 2606 nm
- Background: 99% Spectralon™ (a reflection standard with almost flat spectral response in NIR)
- All measurements were performed at room temperature

Some standard and simple data treatment processes were performed on the measured spectra:

- For each sample, the triplicate spectra sample were averaged
- The wavelength scale was converted into wavenumbers and the 7504 – 4001 cm^{-1}
- Spectra were pretreated by a 2nd derivative with a Savitzky Golay smoothing procedure of 5 data points and a 2nd order polynomial
- Standard normal variate (SNV) procedure was applied to correct for scattering effects

In Fig. 2 the NIR spectra of exemplary representatives of the nine textile classes are shown before (a) and after (b) spectral pretreatment.

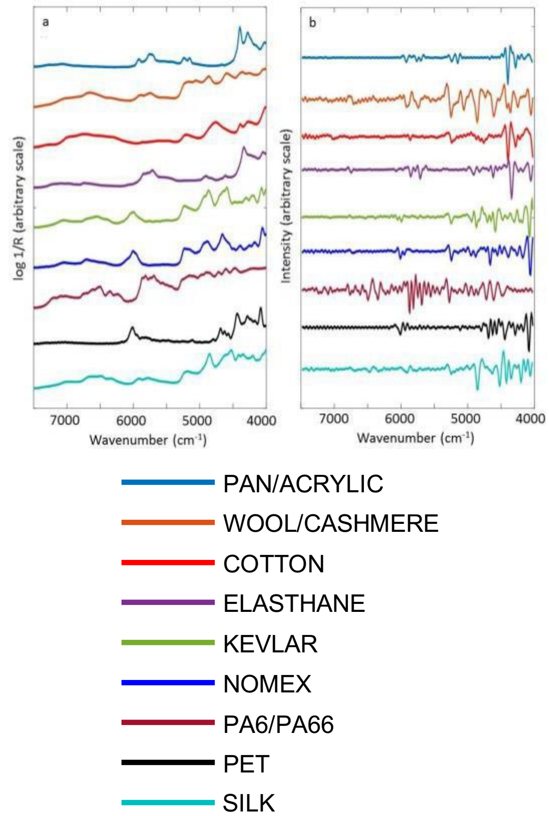


Fig. 2. Comparison of the original NIR spectra of selected representatives of the nine textile classes (a) and the corresponding spectra after pretreatment by 2nd derivative and SNV (b).

Data Evaluation

PCA 5 (principal component analysis) models were developed with the spectra of the calibration samples of all nine textile classes and their identification performance was verified with the spectra of the test set samples. After application of the PCA, the number of PCs is lower than the original variables and this reduction of PCs allows patterns in the data to be easily visualized and analyzed. In Fig. 3a the PCA score plot based on the first three PCs is shown for the calibration samples of the nine textile classes. Figure 3b represents the same score plot including the test samples. Thus, the nine textile classes can be clearly discriminated in their score plot and test samples are correctly assigned to the respective clusters.

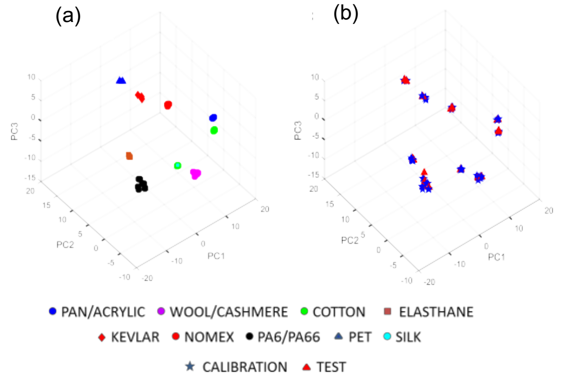


Fig 3. The PCA score plots of the first three PCs based on the calibration spectra of the nine textile classes (a) and the correspondingscore plots with the inclusion of the test samples (b).

SIMCA 5 (soft independent modeling of class analogies) analysis was used to test the identification capability for the spectra of the test set samples. SIMCA is a classification method analyzing similarities by using the PCA models developed for the spectra of different classes to assess to which class an unknown sample belongs to. The classification results are represented in so-called Coomans plots 5 and in the present case textile species identity is achieved if the spectra of the test samples are assigned to the relevant quadrant defined by the SIMCA model. Exemplarily for all possible textile class pairs the Coomans plot (5% significance) representing the discrimination of wool/cashmere and silk is shown in Fig. 4. While the blue and black symbols represent wool/cashmere and silk calibration spectra respectively, the red diamonds belong to the test spectra of the nine textile classes. Of these test samples the classes. In analogy, the SIMCA analysis of the other textile pairs correctly assigned the test samples to their respective classes.

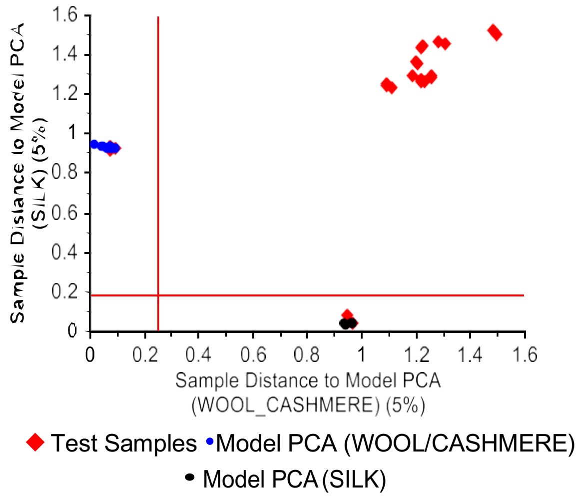


Fig. 4. The Coomans plot for the wool/cashmere and silk textile classes. The red diamond symbols represent the prediction results for test samples of various identity.

Conclusions

The investigations clearly demonstrate that the spectra of the most common textile materials measured with the NeoSpectra spectral sensor provide suitable and rapidly available analytical data for the correct identification of unknown textile test samples. In a first step the PCA applied to the calibration spectra of nine different textile classes yielded a clear separation into clusters and the spectra of test samples were correctly identified. Furthermore, the SIMCA analyses based on the PCAs of all possible textile-class pairs provided a perfect identification of test sample.

www.neospectra.com
www.si-ware.com
info@si-ware.com

Si-Ware Systems
3, Khaled Ibn Al-Waleed Street
Sheraton,Heliopolis,
Cairo 11361, Egypt
Tel: + 20 222 68 47 04

Si-Ware Systems, Inc.
1150 Foothill Blvd., Suite M
La Canada, CA 91011 USA
Tel:+ 1 818 790 1151