COLOR CHANGE TEXTILE MATERIALS: A FEASIBILITY STUDY ON THE USE OF PH-INDICATOR DYES IN TEXTILE PH-SENSORS

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ABSTRACT

This paper verifies the possibility of using standard water-soluble pH-indicator dyes in color change textile materials made out of conventional textiles and produced by a dyeing process. After a screening process in which the color depth, levelness and the color change properties of the dyed samples were examined, some dyes were selected to study in more detail. It was found that the behavior of the indicator dyes is different when the dyes are incorporated in textile materials instead of being dissolved in an aqueous solution. Our results show that it is possible to develop a textile pH-sensor using pH-indicators and conventional textiles.

Key Words: halochromism, sensor, cotton, nylon, pH-indicators

1. INTRODUCTION

In the past, textile materials that change their color due to a change of an external stimulus were assigned as undesired. Yet, these materials can be used in textile sensors with a first signal or warning function.

Several stimuli can cause a color change. Thermochromism (color change due to a temperature change) and photochromism (color change due to a change in light) have been the subject of quite some studies but halochromism (color change due to a change in pH) is a relatively new research field [1]. pH is however an important value in daily life and a pH-sensitive textile sensor could be used in a broad range of applications [2].

Research about halochromism is mainly focused on the synthesis of new halochromic dyes [3]. Studies on dyeing textile fabrics with these dyes are limited. Therefore we studied the dyeing of cotton and nylon with pH-indicators.

2. MATERIALS AND METHODS

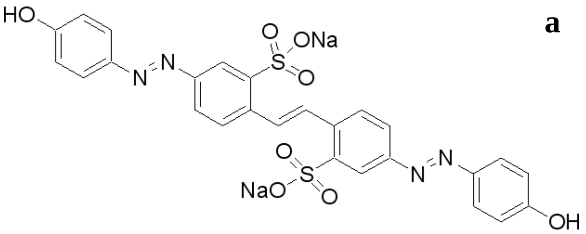
Cotton fabric was supplied by Utexbel (Ronse, Belgium) and Sanicalor Medical (Brussels, Belgium), nylon was supplied by Concordia Textiles (Waregem, Belgium). The pH-indicators were obtained from Sigma-Aldrich.

Dyeings were performed in a Mathis Labomat BFA-8 dyeing machine using a direct dyeing process. pH was measured using a combined reference and glass electrode from Eutech Instruments. The UV-Vis spectra were recorded with a Perkin-Elmer spectrophotometer.

3. RESULTS AND DISCUSSION

Cotton and nylon fabrics were dyed with a set of pH-indicator dyes. On the basis of 2 criteria a selection of promising halochromic systems was made. First the ability of the indicators to dye the different textile materials was investigated by evaluating the color depth and levelness of the fabrics. Next, the color change with a pH-variation is examined. This process leaded to the selection of the pH-indicators Brilliant Yellow and Alizarin.

Brilliant Yellow is an anionic diazo dye (Fig.1a) and used as a pH-indicator in solution in the pH-region from 6.5 to 8.0. The pH-indicator Alizarin (Fig.1b) is an anthraquinone dye that is normally used as a pH-indicator in solution in the pH-regions from 5.8 to 7.2 and from 11.0 to 13.0.



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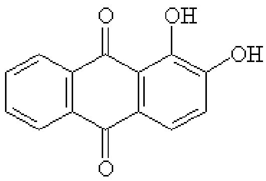

b

Fig. 1: Molecular structure (a) Brilliant Yellow and (b) Alizarin

Cotton dyed with Brilliant Yellow showed a clear color change. Therefore cotton with Brilliant Yellow was investigated in more detail. The optimum dyeing conditions were determined by testing different salt (5 % owf, 10 % owf and 30 % owf) and dye concentrations (0.1, 0.2, 0.3, 0.5, 0.7 and 1 % owf). The exhaustion was measured using UV-Vis spectroscopy. The results of the experiments are shown in Fig. 2 and 3. The exhaustion measurements together with color depth measurements leaded to the optimum dyeing conditions being 30 % owf salt and 0.3 % owf dye. Also the color change was studied more deeply. It was found that cotton with Brilliant Yellow has a yellow color at low pH, turning to orange at pH 5 and 6 and to red at higher pH-values. The behavior of the dye on cotton was thus different when compared to the behavior of the dye in solution. The color changes were investigated using a UV-Vis spectrophotometer.

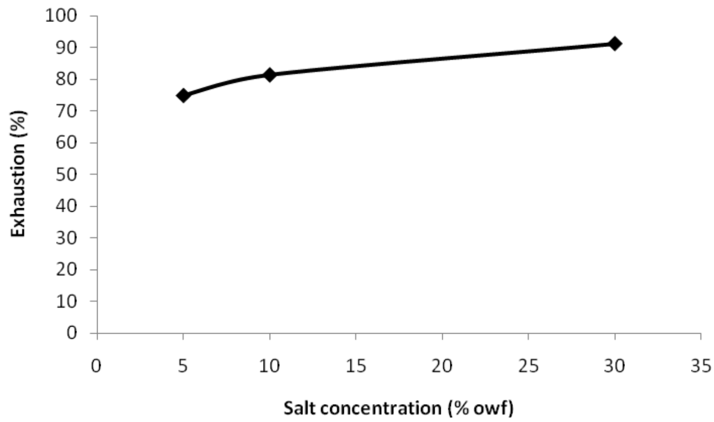

Fig. 2: Exhaustion as a function of salt concentration (0.5 % owf dye)

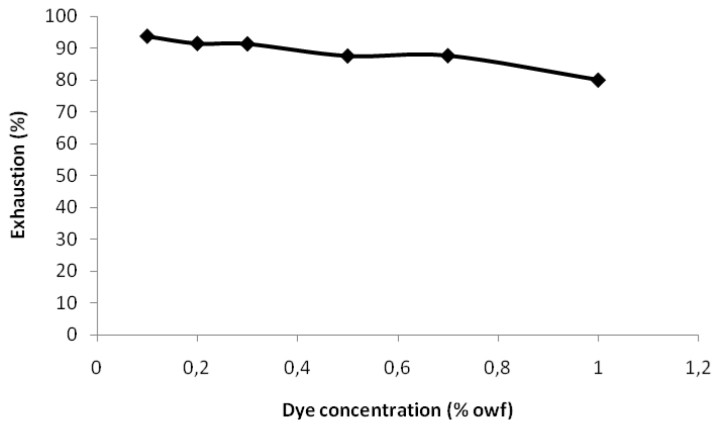

Fig. 3: Exhaustion as a function of dye concentration (30 % owf salt)

When Alizarin was applied on cotton and nylon, the color change of the dye was still persistent. Analog to the study of Brilliant Yellow, the dyeing conditions were optimized and the reaction with a change in pH was studied in more detail. It was found that it was not possible to obtain a high exhaustion when cotton was dyed with Alizarin. However, when nylon was dyed, high exhaustions were acquired.

4. CONCLUSIONS

We can conclude that it is possible to develop a textile pH-sensor out of conventional textiles and pH-indicator dyes. In the case of Brilliant Yellow on cotton and Alizarin on nylon, the dyeing conditions can be optimized to obtain high exhaustions. This was not the case with Alizarin on cotton. By incorporating the dyes in textile fabrics, changes in the behavior of the dyes were noticed.

5. REFERENCES

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