APP-SUPPORTED OPTIMIZATION OF RINSING PROCESSES

In the dyeing of cotton using reactive dyes, the rinsing process consumes by far the most water, energy and process time in order to achieve a good fastness level. Optimization of the rinsing process is therefore most effective if focused on resource consumption and process time. The "BEZAKTIV Soaping Advisor" calculation program provides a predictive calculation of the fastness rating, which allows the optimum rinsing process to be determined and subsequently used.

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Climatic conditions in many countries around the world result in prevalent water shortages. Especially in these countries, the increasing consumption of freshwater by industry in general presents a problem, and the textile industry is responsible for a major proportion of this water use. In particular, dyeing cotton with reactive dyes consumes large quantities of water.

Dyeing cotton with reactive dyes is one of the main reasons for high water consumption in the textile industry. This is due to the rinsing out of unreactive dye hydrolyzate, which is necessary to achieve the fastness levels demanded by consumers. This rinsing process is always a compromise between achieving the best possible wet fastness level and the lowest possible number of rinsing baths. In short, the following applies to rinsing: as much as necessary, as little as possible. Unfortunately, the optimum rinsing process differs for each recipe, therefore the normal standard recommendations for rinsing processes are not much help. Rinsing frequently lasts so long in production that the liquor becomes almost colorless. In practical terms, this results in far more rinsing than is necessary. Alternative scenarios, for example, how a different rinsing temperature or another liquor ratio, cannot be explored to see how they might affect fastness. Only by predictive calculation of the fastness ratings for various rinsing scenarios can the optimum rinsing process be determined.

A predictive calculation of the fastness rating is based in principle on three pieces of information:

- 1. Hydrolyzate concentration on the fabric after dyeing
- 2. Hydrolyzate equilibrium between the cotton and the liquor
- 3. Correlation between residual hydrolyzate concentration and fastness level

These few essential pieces of information are, however, dependent on a number of factors and consequently require much measurement in the laboratory in order to create the mathematical models and thus arrive at an accurate a prediction as possible for the dyeing and rinsing conditions.

Hydrolyzate concentration on the fabric after dyeing

Dyeing is decisive for the later rinsing. Dyeing determines how much dye hydrolyzate is created and remains on the fibers. For a low hydrolyzate concentration on the cotton after dyeing, the absolute degree of fixation is less important than achieving as small a difference as possible between the degrees of exhaustion and fixation. Fig. 1 shows an example of a dye for which a very low hydrolyzate concentration remains on the fibers, even in the case of a dark dye.

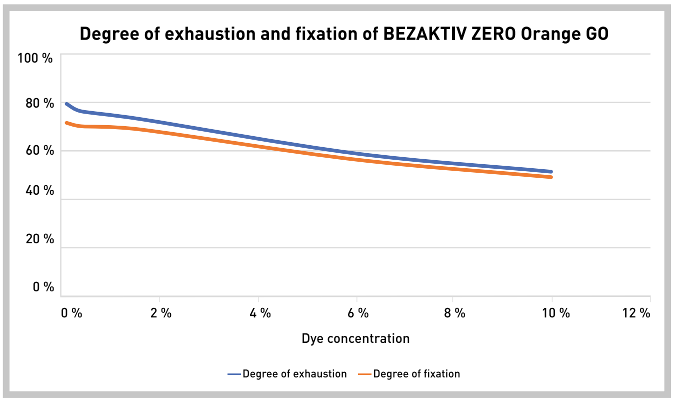

Fig. 1: It is advantageous for the wahing off when there is only a small difference in the degree of exhaustion and the degree of fixation.

Hydrolyzate equilibrium between the cotton and the rinse liquor

To determine this parameter after dyeing would be a complex task in the laboratory. However, it is irrelevant to the equilibrium point whether it arises from the removal of the hydrolyzate from the fibers or the uptake of the hydrolyzate on the fibers. Therefore, the equilibrium constant is much simpler to determine by first hydrolizing the dye and then quantifying the uptake of the hydrolyzate on the undyed cotton by photometric measurements, immediately after equilibrium has been reached.

The hydrolyzate concentration, liquor temperature and salt content of the liquor are very important for the equilibrium point. Fig. 2 and 3 show two examples of dyes that have very different equilibrium constants. At a hydrolyzate concentration of 0.05 % in relation to the cotton, approximately 85 % of the hydrolyzate is found in the liquor in the case of BEZAKTIV ZERO Orange GO, which has very good wash-out properties, at a salt concentration of 4 g/l and a rinse temperature of 40 °C. Only 15 % remains on the cotton. On the other hand, with the highly substantive hydrolyzate of BEZAKTIV Orange S-RL 150 under the same conditions, only 20 % hydrolyzate is washed out and 80 % continues to adhere to the cotton.

In the second example (Fig. 3), it is impressive to see how the washing out of a highly substantive hydrolyzate – such as that of BEZAKTIV Orange S-RL 150 – greatly depends on the salt concentration and the rinse temperature. In contrast, in the case of BEZAKTIV ZERO Orange GO, the washability overall is at such a high level that the salt content and the rinse temperature play only a subordinate role (Fig. 2).

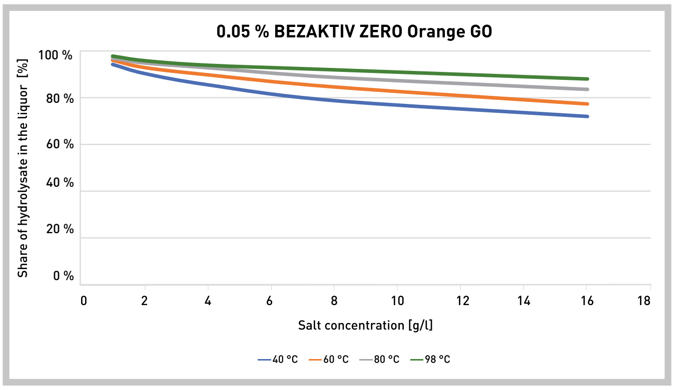

Fig. 2: Efficiency of rinsing for a dye hydrolysate with low substantivity.

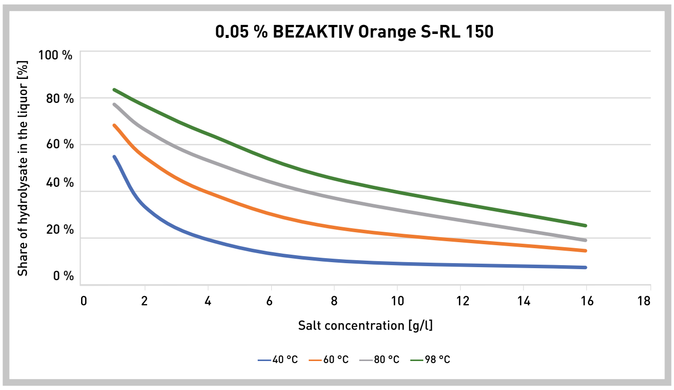

Fig. 3: Efficiency of rinsing for a dye hydrolysate with high substantivity.

Correlation between residual hydrolyzate concentration and fastness level

The hydrolyzates from two different dyes in the same concentrations do not always result in the same ratings in terms of fastness to water in accordance with DIN EN ISO 105- E01. To determine the correlation, hydrolyzate can be applied onto cotton by pad in various concentrations and the resulting fastness rating assessed. Fig. 4 shows how the remaining residual concentrations of hydrolyzate of BEZAKTIV ZERO Orange GO and BEZAKTIV Orange S-RL 150 correlate with fastness ratings. The fastness rating for any residual hydrolyzate concentration on the fibers can be calculated mathematically from this correlation.

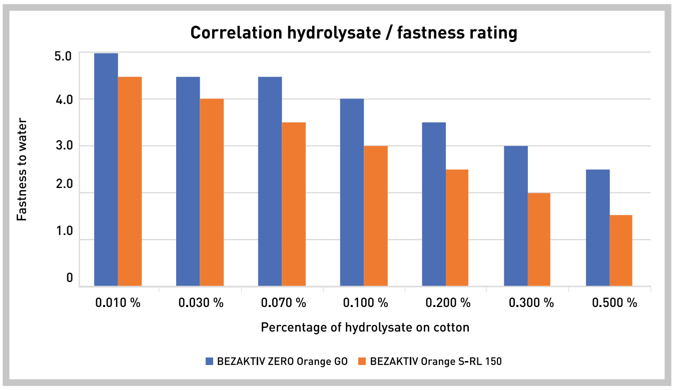

Fig. 4: Correlation between the concentration of residual hydrolysate and fastness rating.

Carry-over

The data shown above were determined for the complete BEZAKTIV range and form the basis for the BEZAKTIV Soaping Advisor. In addition, however, there is another important parameter that users must determine for themselves, and that is the carry-over. This depends on the presented textile form of the cotton and therefore must be determined at least approximately using preliminary laboratory tests on each of the articles to be dyed. The carry-over directly affects the dilution of hydrolyzate and salt and therefore has a considerable influence on the washing off of the hydrolyzate, particularly in the case of a low liquor ratio. Tab. 1 shows how much the carry-over affects dilution based on the salt concentrations for a liquor ratio of 1:6.

The lower salt dilution with a higher carry-over also has an indirect negative effect on the washing off of the hydrolyzate by increasing the substantivity of the hydrolyzate and reducing the effectiveness of the washing off. This is particularly noticeable in the case of a hydrolyzate with a high substantivity as shown in Fig. 3.

	Carry-over	150 %	200 %	300 %
Salt concentration	Dyeing	60 g/l	60 g/l	60 g/l
	1. Rinsing bath	15 g/l	20 g/l	30 g/l
	2. Rinsing bath	3.8 g/l	6.7 g/l	15 g/l
	3. Rinsing bath	0.9 g/l	2.2 g/l	7.5 g/l
	4. Rinsing bath	0.2 g/l	0.7 g/l	3.8 g/l
	5. Rinsing bath	0.06 g/l	0.25 g/l	1.88 g/l

Tab. 1: Liquor dilution for various values of carry-over.

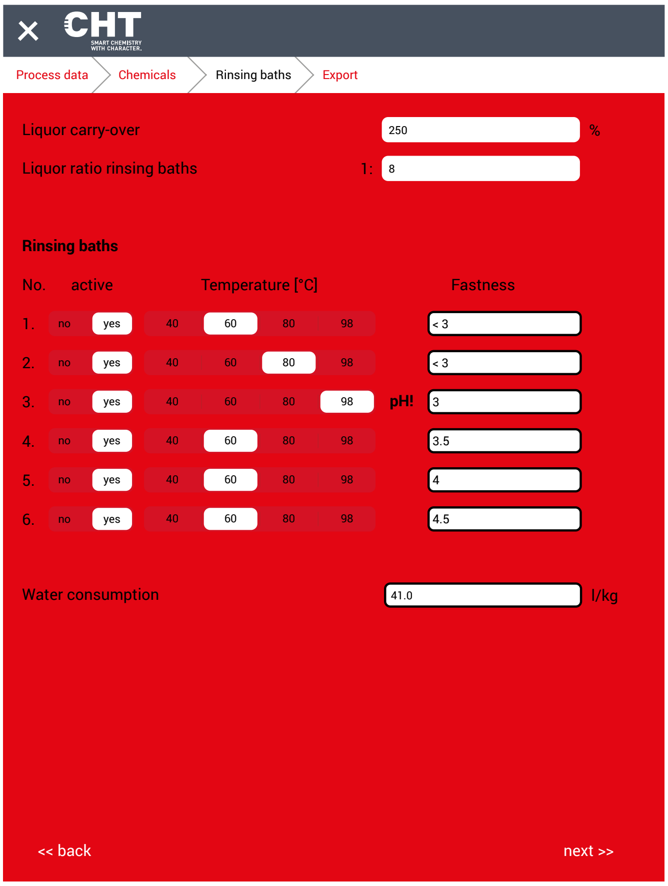

Fig. 5: Calculation example with a liquor ratio of 1:8.

BEZAKTIV Soaping Advisor

The program is presented on four pages. Page 1 is for dye selection and input of the main data for the dyeing process. Page 2 shows the recommended quantities of dye and chemicals. Page 3 is where the carry-over and the liquor ratio for the rinsing baths must then be input. Finally, up to six rinsing baths can be activated and the temperature selected for each one. The anticipated fastness rating in accordance with DIN EN ISO 105-E01 is displayed adjacent to each activated rinsing bath. The input data and calculations can be exported on page 4 as a PDF file.

Optimization of the rinsing process

With the help of the program, it is now very easy to simulate and compare different rinsing variants. The rinsing process can be optimized by changing the parameters for liquor ratio, temperature and number of rinsing baths such that users obtain the greatest benefits in relation to water consumption, energy demand and process duration, depending on the available capacity and cost structure of their production facilities. The possibilities of the optimization process can be seen in the following practical example. For a 2.5 % dyeing using BEZAKTIV Orange S-RL 150 with a carry-over of 250 % and a liquor ratio of 1:8 in the rinsing baths, six rinsing baths are required to achieve a fastness rating of 4–5. See Fig. 5.

On the other hand, if the liquor ratio in the rinsing baths is increased to 1:10 as shown in Fig. 6, the number of rinsing baths can be reduced by two, which brings down the water consumption of the whole dyeing process from 41 l/kg to 38 l/kg of cotton. In spite of the somewhat higher liquor ratio, the water consumption is reduced and the process shortened by approximately 45 minutes.

This illustrates how quick and easy it is to determine whether a rinsing bath can be “saved” by a temperature increase or whether the temperature in a rinsing bath can be reduced without visibly affecting the fastness level. The big advantage of the BEZAKTIV Soaping Advisor is that alternatives for the standard production rinsing process can be evaluated for individual dyeing recipes in seconds. The program can therefore offer every factory an extremely easy way of designing its production processes to be more cost efficient and resource conserving.

The savings in water, energy and time are potentially enormous – and can be achieved without the need for additional investment. In terms of sustainability, there is hardly any other forward-looking solution that can beat having a process perfectly designed for each individual batch. The BEZAKTIV Soaping Advisor brings this aspiration a great step nearer and contributes to making textile production “greener” overall. With this tool, the CHT Group underlines its focus on innovative solutions for greater sustainability.

The CHT Textile Dyes App is available free-of-charge in the App Store and in the Google Play Store.

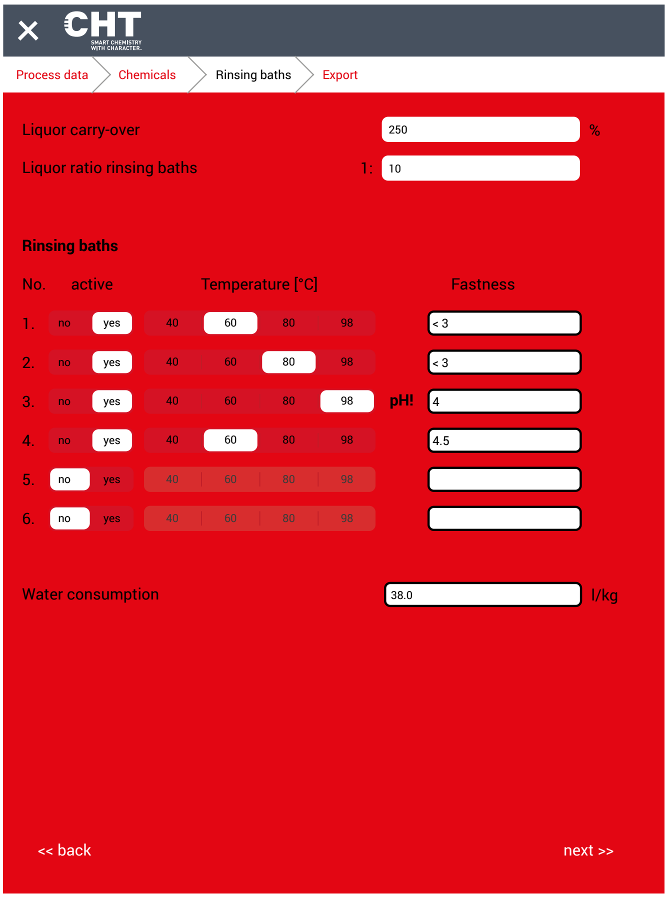

Fig. 6: Potential savings by increasing the liquor 1:10.