

## Sustainable processing and coloration of textiles

by Dystar Ecology Solutions.

### Background

As was indicated in the first publication in this series of articles on sustainability, with the increasing global consumption of manufacturing goods, product manufacturing systems have come under intense scrutiny with regard to their impact on the environment. It is therefore imperative that the textile industry address such issues as it is one of the most polluting manufacturing industries in the world. At every stage of textile production, large amounts of energy, clean water and chemicals are used to process the textiles and apparel which we consumers demand.

In turn these processes generate air, water and soil pollution through often-untreated effluent disposal and waste generation which place a heavy burden on the environment.

DyStar has always been committed to the highest standards of product safety and ecology and to the development of products and processes offering Best Available Technology with reduced environmental impact to textile processors. Through its econfidence® program described in outline in the first paper in this series DyStar is making expertise in dye chemistry, ecology, and process know-how available to all parts of the textile supply chain.

In order to achieve reduced load on environment, we need to optimize and standardize the entire supply chain and resources. DyStar, as a responsible player in the field of textile coloration, has been working in this direction for a long time.

The details were given in an earlier article in this series. In this article we focus on the coloration processes using Best Available Technology from DyStar to maximize output with minimum impact on the environment. Specifically we look at the two major fibers processed today and show how the application of BAT and advanced process optimization can minimize resource use and pollution load.

1. Exhaust dyeing of cellulosic fibers with reactive dyes.
2. Exhaust dyeing of polyester with disperse dyes.

### 1. Exhaust dyeing of cellulosic fibers with reactive dyes

The main effluent control parameters of textile dye house wastewater include volume, total dissolved solids, chemical oxygen demand (COD), biological oxygen demand (BOD), colour and pH. Each is quantifiable and in many industrialised countries concentration or total load limits are established which may not be exceeded in effluent discharge to either independently operated waste water treatment plants (WWTP) or to surface waters. The permitted limits for discharge to a WWTP are typically higher than those allowed for surface waters such as rivers and lakes.

However perhaps the single most important focus for coloration of cellulosic fibres is the elimination of nonconformance by using reactive dye technology engineered to support Right-First-Time production incorporating laboratory to bulk transferability and production lot repeatability.

For medium to deep shades the impact on the environment can be significantly reduced by exploiting the unique properties of the Remazol® Ultra RGB reactive dyes.

The key targets of the Remazol Ultra RGB development programme were:

- ❖ High tinctorial strength of the individual dyes
- ❖ High degree of fixation on the cellulosic fibre
- ❖ Minimised dye-dye interaction which causes 'blocking'.

Blocking is typical in many commodity reactive dye combinations based on a golden yellow, red and navy/black reactive dye ternary leading to poor reproducibility and overloading of dye in an attempt to reach the desired depth of shade. Dye overload results in poor Right-First-Time performance, very low fixation efficiency and consequently a high pollution load in the dye house effluent due to unfixed dye hydrolysis.

The high build-up of the Remazol Ultra RGB dyes may be observed in the Diagram 1 and Diagram 2:

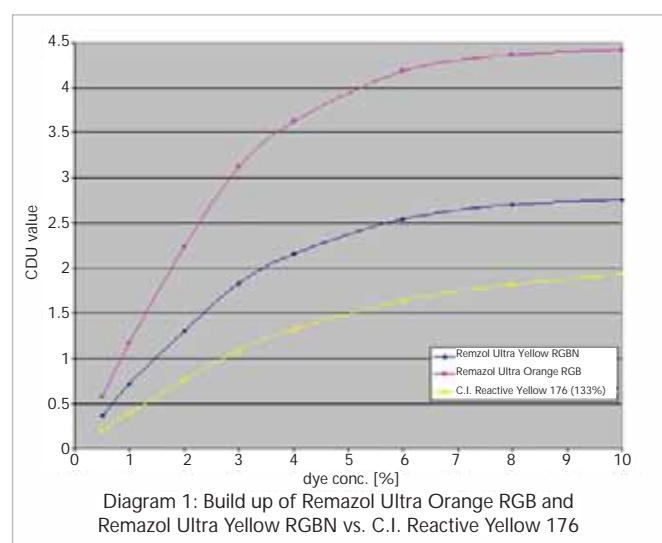


Diagram 1: Build up of Remazol Ultra Orange RGB and Remazol Ultra Yellow RGBN vs. C.I. Reactive Yellow 176

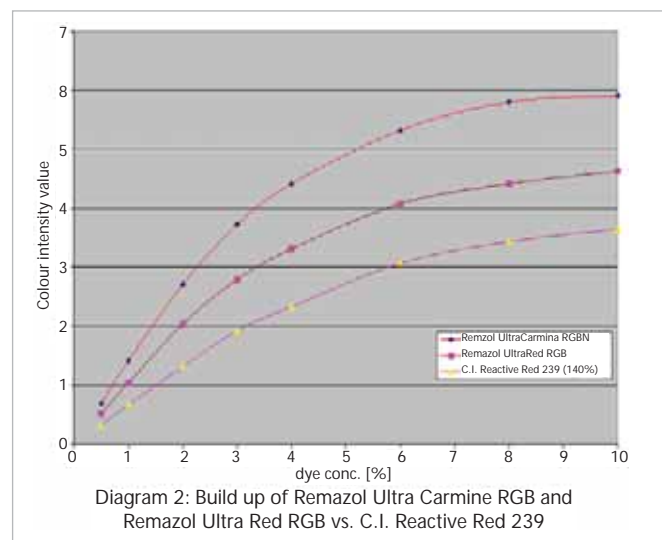


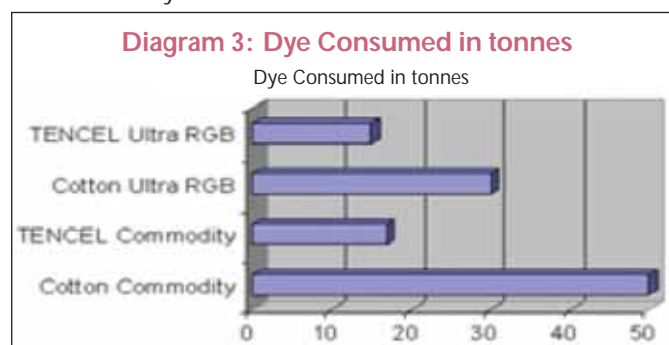
Diagram 2: Build up of Remazol Ultra Carmine RGB and Remazol Ultra Red RGB vs. C.I. Reactive Red 239

The key to avoiding dye overload is to form the covalent bonds with the cellulose fibre at a percentage of dye application where the graph is steep, because the rate of fixation levels off with saturation of the available sites in the fibre.

Dye recipes formulated to the same visual deep shade has indicated a reduction in quantity of dye required by the Remazol Ultra RGB combination compared with commodity dyes approaching ~ 50% Remazol Ultra RGB dyes demonstrate outstanding buildup and tinctorial value by exhaust, cold pad batch and continuous application methods to achieve deep shades from a lower concentration of dyes and chemicals than is currently available from competitive systems.

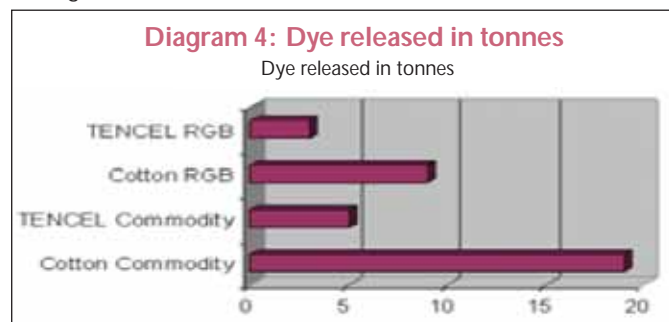
In exhaust application the electrolyte required is dependent on the percentage of reactive dye applied in order to neutralise the negative ions when alkali is added to effect the dye-fibre fixation stage. The electrolyte concentration used for the application of Remazol Ultra RGB dyes may be reduced by up to 40% compared with similar visual depth shades dyed with lower efficiency commodity dyes. By forming the dye-fibre covalent bonds at the steep part of the fixation curve, the amount of dye hydrolysate formed in competition with water is reduced. This contributes to a saving in water usage during washing off and a significant reduction in total colour loading of the effluent.

The Diagram 3 illustrates the reduction in quantity of dye required by the Remazol Ultra RGB combination compared with commodity dyes approaching ~ 50%. The figures are derived from a model small/medium sized dye house operating 50 weeks per year and indicate the dye applied and hydrolysed dye discharged on an annual basis calculated for both unmercerised cotton and Tencel® A100 lyocell fibre in knitted fabric constructions.



### Colour in effluent

The unfixed colour removal in the model was calculated from controlled dyeings, and the optical density of total colour to be removed and discharged in effluent was measured with the following calculated results:

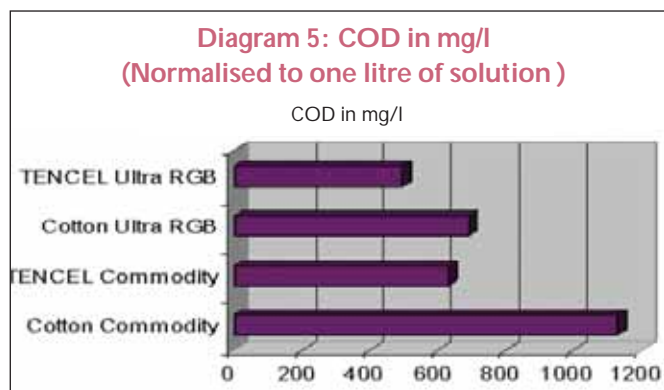


### Impact on effluent loading

As an illustration of the impact on the dye house effluent load we have taken the above dye house model processing byexhaust application on knitted cotton interlock and Tencel A100 using an overflow jet at 10 : 1 Liquor Ratio and a carryover of liquor 300% between drain and fill baths. A typical procedure uses three baths for preparation/rinsing of cotton, two baths for preparation/rinsing of Tencel, one bath for dyeing each fibre, and five baths for the rinsing/ soaping stages of cotton and four rinsing/soaping stages for Tencel A100 giving a total water consumption of ~ 66 litres per kilo of cotton fabric and ~ 52 litres per kilo of Tencel respectively.

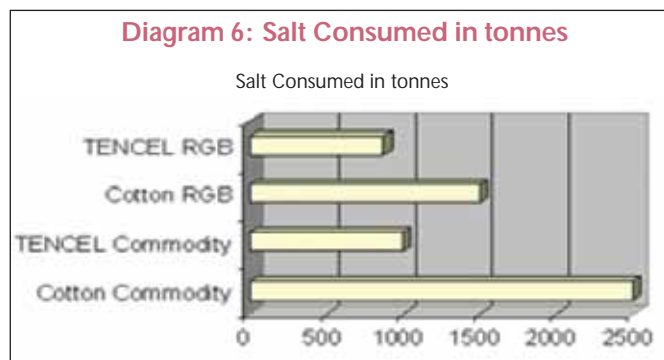
### Chemical oxygen demand

Diagram 5 illustrates COD values normalised to one litre of solution of the different fibres and dyes. If the fixation yield is not optimal (illustrated by commodity ternary) the remaining colour in the exhaust dye bath produces a high COD.



### Reduction in total dissolved solids

Electrolyte consumption largely contributes to the TDS loading which is significantly reduced by use of the speciality Remazol Ultra RGB technology compared to use of commodity dyes particularly in deep shades, and can be further reduced by the use of Tencel A100 compared with unmercerised cotton.



### 3. Exhaust dyeing of polyester fibre with disperse dyes

Due to limited availability of clean water and the ever increasing cost of oil-derived raw materials, polyester fiber production which is growing at a rapid pace has a considerable environmental footprint. Hence, we need to minimize the resources used for the coloration of polyester fibers irrespective of whether the fiber is virgin or recycled. In a brochure published in 2008 DyStar identified ways of reducing resource use in exhaust dyeing of polyester fiber using Dianix disperse dyes and Sera processing auxiliaries by the intelligent application of process optimization software (Optidye P). Looking at the two primary concerns in dyeing processes, namely energy and water use the following minimization options were identified:

#### Energy saving options can best be achieved through:

- ❖ Frequency-regulated motors for reels and pumps
- ❖ Optimized dyeing processes and temperature / time optimization
- ❖ Compatible, level-dyeing dyes for reliable dyeing
- ❖ High Right-First-Time performance (RFT)
- ❖ Heat recovery from hot discharge liquors
- ❖ Low liquor ratio

#### Water saving can best be achieved through:

- ❖ Optimized machinery loading.
- ❖ Lowest possible liquor ratio.
- ❖ Combined washing and dyeing processes.
- ❖ Optimized rinsing processes.
- ❖ Reuse of rinsing baths.
- ❖ Compatible, level-dyeing dyes for reliable dyeing.

By using DyStar Dianix "green" dye selection and tailored Sera process auxiliaries in combination with DyStar's Optidye PES program the following benefits can be achieved: also see Diagram 7 on the next page:

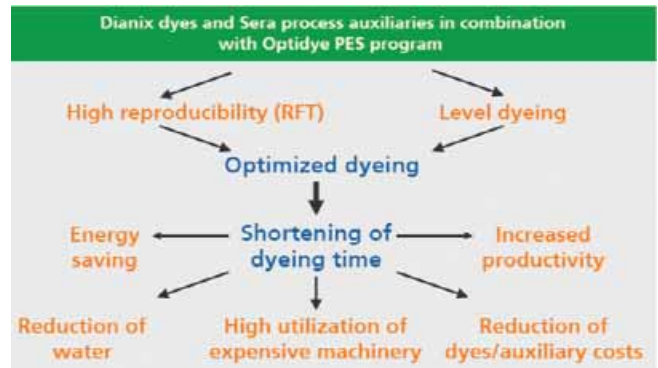
- ❖ High reproducibility (RFT)
- ❖ Level dyeing
- ❖ Energy saving
- ❖ Reduction of water
- ❖ Reduction of dyes/auxiliaries cost
- ❖ Increased productivity
- ❖ High utilization of capital intensive machinery
- ❖ Reduced load on effluent

DyStar continues to develop new, innovative products which have reduced impact on the environment. One such example introduced in 2009 is Dianix Yellow Brown S-4R 150%, which is designed to comply with II RSL's and ecological requirements of major brands, retailers and independent ecolabels as an alternative to the old commodity dye C.I. Disperse Orange 30.

The benefits of this integrated approach to dye and auxiliary selection in combination with sophisticated process control can be seen from the Diagram 8 & 9.

The optimized process using DyStar products and process technology leads to the following benefits (calculated using ABACUS® - a unique process evaluation program from DyStar Textile Services):

- ❖ 43% Electricity
- ❖ 46% Steam
- ❖ 50% Water
- ❖ 39% Process time
- ❖ 38% cost in total
- ❖ 58% increase in production.



## Conclusion

Best Available Technology for the coloration process through the use of higher strength and build-up Remazol® Ultra RGB reactive dyes particularly for deep shades and Levafix® CA dyes for pale to medium shades, will contribute to reduced color in effluent, Chemical Oxygen Demand (COD) and Total Dissolved Solids (TDS) compared with commodity reactive dyes and represents the preferred technology in markets where environmental restrictions are required to be met. Similarly, by using DyStar Dianix "green" dye selection and tailored Sera process auxiliaries in combination with DyStar's Optidyne PES program great savings on resources can be achieved and environmental restrictions can be met. If you wish to know more about DyStar efforts in sustainable textile processing, Please visit us at [www.dystar.com](http://www.dystar.com). ♦

