

# Pollution control in the textile industry – the chemical auxiliary manufacturer's role

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*Following their paper in the previous issue on atmospheric and effluent control, the authors discuss the need to establish effective waste water management systems and how this may be achieved as economically as possible.*

## **INTRODUCTION**

With new legislation and the establishment of the National Rivers Authority (NRA), pressure is being applied to all effluent dischargers to reduce water-borne pollution emission. This even applies to the water service companies themselves. The result has been a general tightening up of consent limits and increased charges to cover the full treatment costs incurred by the water companies.

The challenge facing manufacturing industry is to find effective and inexpensive ways of treating its effluent prior

to discharge in order to meet new consents and reduce the overall cost for disposal. However, some form of pretreatment such as screening, equalisation or pH adjustment is usually necessary, whether the discharge is to the municipal treatment works or direct to a water course (Figure 1). After pretreatment the effluent, still containing the full polluting load, may be discharged to the local sewage works or may undergo on-site treatment, either to obtain partial load reduction for discharge to the sewer or to achieve more complete reduction for discharge to a water course.

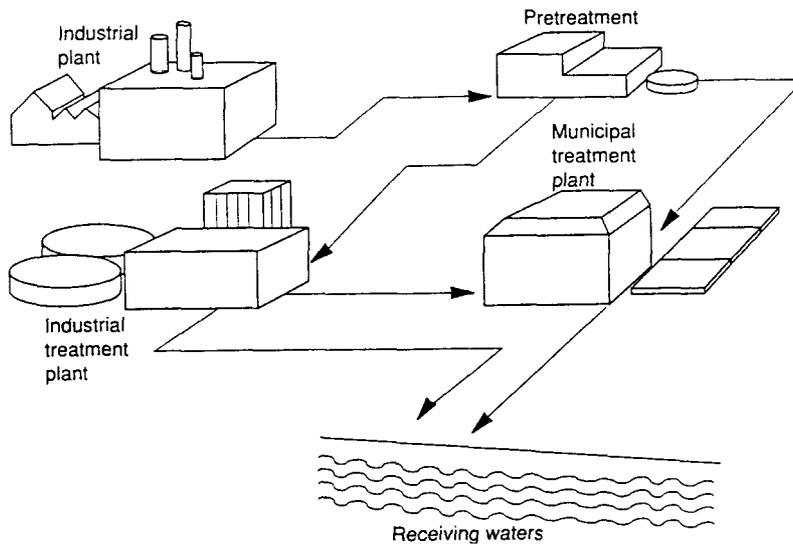


Figure 1 - Wastewater management alternatives

The advantage for industry of relying completely on the local sewage works for effluent treatment is that capital investment and operational responsibilities are kept to a minimum. Disadvantages are that problems may be encountered in staying within consent limits and charges incurred may be very high in order to meet the costs of higher standards imposed on the water company by the NRA.

### TREATMENT METHODS

Typically, textile waste waters have high biological oxygen demand/chemical oxygen demand (BOD/COD), a substantial proportion of which is represented by substances present in a highly emulsified and/or soluble form. The organic polluting load can be many times greater than that in ordinary domestic sewage and can also be highly coloured.

A number of pretreatment processes such as equalising/balancing, gravity adsorption or neutralisation are available, and actual treatment can be achieved by chemical oxidation, ultrafiltration, adsorption, and biological or physico-chemical techniques. Selection of the appropriate method of treatment is influenced by a large number of factors related to each effluent characteristic, such as relative costs, levels of treatment required or site restrictions, etc. For example, biological and physico-chemical treatments are often used in tandem to obtain maximum removal of organics in textile waste water. The dual use of methods combats certain organics that are not biodegradable, as well as other organic constituents that may not be amendable to chemical precipitation.

### PHYSICO-CHEMICAL TREATMENT

#### Precipitation/coagulation

Effluent will contain impurities in dissolved, colloidal and suspended forms. The first stage of treatment involves the precipitation and coagulation of these impurities to produce microflocs, either by pH adjustment (such as acid cracking), or by inorganic coagulants (multivalent metals) or by organic coagulants.

Organic coagulants are low molecular mass, highly charged polyelectrolytes that are usually cationic, and can be used either as an alternative to, or in conjunction with, inorganic

coagulants. Their mechanism can be explained in terms of the charge patch model (Figure 2).

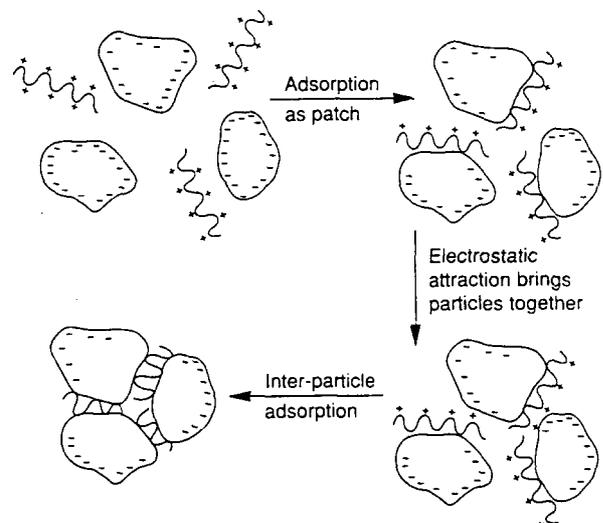


Figure 2 - The 'charge patch' coagulation model

#### Flocculation

When the impurities in the waste water are in the form of microflocs and other suspended solids, the second stage of flocculation aggregates them into larger agglomerates. This is usually achieved by adding lowly to moderately charged polyelectrolytes with a very high molecular mass; the charge may be anionic or cationic. Flocculation involves adsorption of the polyelectrolyte onto particle surfaces. These form loops and tails which act as physical bridges across particles, thus binding them together into a polymer-particle matrix or floc, i.e. a bridging mechanism (Figure 3).

#### Solid/liquid separation

This is achieved by various means, including gravity sedimentation, filtration and centrifugation. Another method gaining in popularity is dissolved air flotation, where solids are induced to float by introduction of microscopic air bubbles which attach to the flocs and accelerate their rise to the surface. The flocs form a float which is skimmed by mechanical scrapers in the form of sludge.

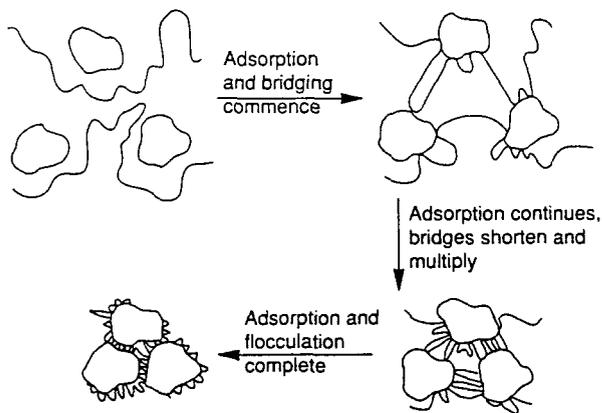


Figure 3 - The 'bridging' flocculation model

### EXAMPLES OF PHYSICO-CHEMICAL TREATMENT OF TEXTILE WASTE WATERS

Within the textile industry commercially successful processes have been developed and used for treating wool scouring effluent, permethrin removal and colour removal.

#### Wool scour effluent

Liquor produced from scouring wool fleeces is rich in wool grease, organic and inorganic excretions (suint), dirt, vegetable matter and detergents. It is highly polluting, with a BOD ranging from 20 000 to 40 000 mg/l and a COD as high as 100 000 mg/l. Gravity settlement alone is effective only in removing the 'heavy solids' but does little for the reduction of BOD/COD. However, a substantial proportion of the colloidal dirt (stabilised by detergent) can be removed by flocculation with polyelectrolyte. The choice of polyelectrolyte tends to be a high molecular mass bridging flocculant, with slight anionic or cationic charge depending on the particular characteristics of the liquor to be treated.

In the flocculation process (Figure 4) colloidal particles and dense solids are bound together to form large, rapidly settling flocs. Typical reductions in suspended solids (and the accompanying reduction in COD) are given in Table 1.

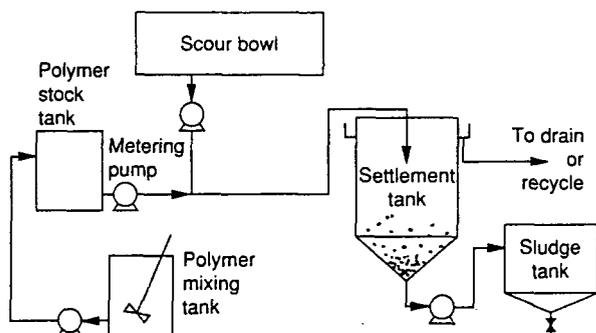


Figure 4 - Flow diagram of a typical wool-scour treatment plant

This simple process provides partial treatment, sufficient for meeting consent limits and for reduction of costs for discharge. Recycling of the liquor to the scouring bowls is also possible, thus enabling further economies to be made.

TABLE 1

#### Typical data from treatment of wool scour effluent

Treatment	COD		SS	
	(mg/l)	Reduction (%)	(mg/l)	Reduction (%)
Untreated	100 490		30 950	
Centrifugation	91 500	9	26 200	15
60 mg/l Zetag 92				
Centrifugation	60 460	40	19 370	37
100 mg/l Zetag 92				
Centrifugation	50 650	50	13 400	57

#### Permethrin removal

Permethrin is one of the most widely used mothproofing agents in the textile industry. Currently the use of mothproofing agents is under threat as a result of Department of Environment legislation, due to come into effect in 1993, which will severely limit their discharge into the environment. This follows EEC directives that have included mothproofing agents on the 'dangerous substances' list.

Allied Colloids was asked to devise a treatment process for removal of permethrin from spent tape scour liquor. The liquor was from the end bowl of a continuous scouring process, and contained permethrin, formic acid, detergents, salts and extracted impurities. The high formic acid content presented certain difficulties in establishing an effective chemical pretreatment.

Despite this, an effective system was developed (Figures 5 and 6) involving adsorption of permethrin onto an inorganic absorbent material (Organosorb), flocculation with non-ionic polyelectrolyte (Magnafloc 351) and gravity settlement. Typically, the final permethrin content was 0.04 mg/l from an initial value of 50 mg/l, a reduction of 99.92%.

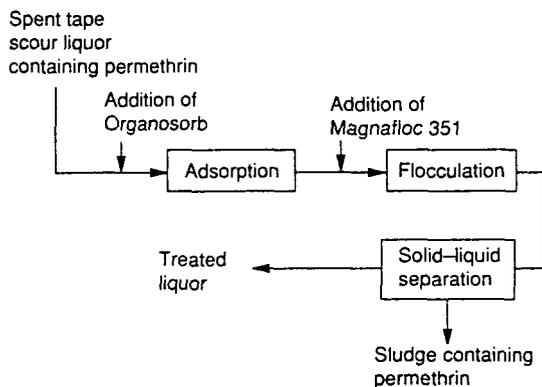


Figure 5 - Permethrin removal treatment process

#### Dye removal

Another problem for the textile industry is the disposal of spent dyebath liquors or the combined effluent containing them. Associated with the spent dyes may be residues from other processing aids employed in the textile finishing process. These effluents show a high degree of polluting strength as evidenced by their intense colour and high BOD/COD.

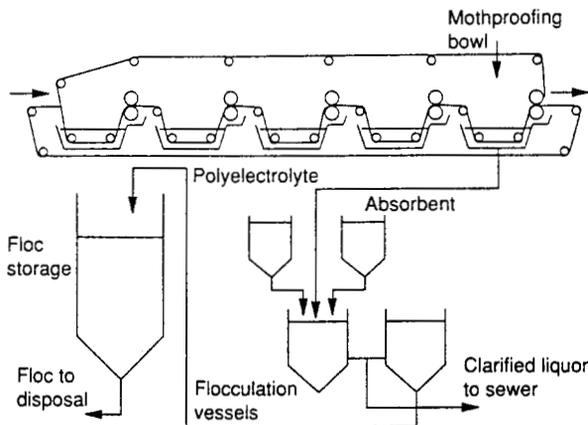


Figure 6 - Scheme for treatment of tape-scour effluent (by kind permission of Dr T Shaw (IWS))

Physico-chemical treatment is applied either to the crude effluent or following initial biological treatment, e.g. activated sludge. Essentially, the process involves the use of a

coagulating agent followed by the addition of a bridging flocculant, and finally dissolved-air flotation. Almost complete colour removal can be achieved with greater than 50% reduction in COD.

## CONCLUSION

Textile companies are facing problems, in some instances of crisis proportions, in dealing with the effluent that they generate. The solution to the problem will vary from company to company depending on many variables such as the volume and nature of the effluent, location, site geography and finance available. Unfortunately for some companies, the inevitable conclusion will be that there is no viable solution.

There will be in-house debates but there should also be frank discussions with all those concerned and those who can help. This will include the NRA, water service companies, suppliers of plant and equipment for effluent treatment and also chemical suppliers.

# LETTERS

## Dyeability of alkali-treated polyester fibre

From Dr K V Datye

In their recently published paper on the dyeing of alkali-treated polyester fibre, Needles Holmes and Park found that the treated fibre became dyed to increasing depths and with increasing loss in weight as the duration of the alkali treatment was increased [1]. The smaller the dye molecules, the greater was the increase in dye uptake. The authors suggest that the interior portion of the fibre is more readily dyed than is the fibre as a whole, and that the morphology differs from the skin (surface) to the core of the fibre. At the fibre core the molecular structure is either amorphous or semi-crystalline, making it capable of accepting more dye than is possible at the skin regions. Dyeings were carried out at 100°C without carrier.

The results could be better explained if the role of surface area of the polyester fibre during dyeing is considered [2]. In a non-steady-state dyeing, the overall apparent diffusion coefficient in the early stage of dyeing is given by Eqn 1:

$$C_t / C_\infty = \left( \frac{Dt}{\pi r^2} \right)^{1/2} \quad (1)$$

where  $C_t$  and  $C_\infty$  are the concentrations at time  $t$  and at equilibrium respectively,  $D$  is the diffusion coefficient and  $r$  is the radius of the fibre. The cross-sectional area ( $\pi r^2$ ) increases linearly with the loss in mass of the fibre [3]. The data presented in Table 1 in the original paper [1] is plotted in Figure 1, which shows this linear relationship. It is therefore expected from Eqn 1 that  $C_t$  will exhibit an inverse relationship with fibre diameter (radius). Typical data from the paper are plotted in Figure 2. It appears from Figures 1 and 2 that the higher dye uptake of the fibre after mass has been lost,

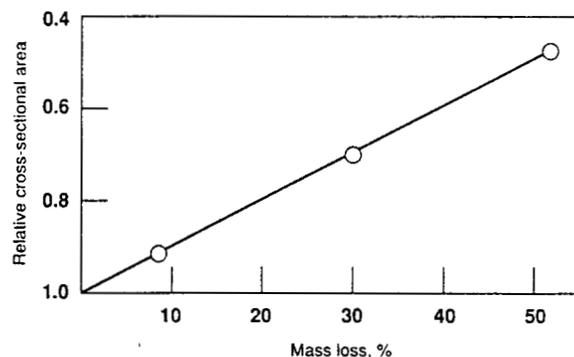


Figure 1 - Relationship between cross-sectional area of fibre and loss of mass on alkali treatment

at a given dyeing time, is directly related to the increased surface area.

As the fibre becomes thinner because mass has been lost, the surface area per unit mass of the fibre increases, which in turn increases the rate of dyeing. The observed effect of molecular size of the dye is in agreement with that reported in the literature [2]. In extensive studies on the treatment of polyester with alkali [3] the fibre density was found to remain constant over the entire range of loss in fibre mass, indicating the absence of structure variations from the surface to the core of the fibre. It has been reported that skin structure develops only when the take-up speed during manufacture of the fibre exceeds 400 m/min. Generally available commercial fibres do not have any significant skin-core structure variations. The staple fibres used in the study are usually produced at a too low a take-up speed to allow