Yellowing of White Fabrics and Garments

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Throughout the ages, white has been considered as a symbol of purity, cleanliness or being 'next to God'. Therefore, even today, about 20% of textiles are finished as full white. To produce a good long-lasting white, which retains its appeal even after repeated home laundering, requires careful consideration of various factors in processing. These factors are listed below.

Preparation of good basic white before optical brightening

As every dyer is aware, with a good basic white, it is easy to produce a dazzling white after a suitable optical brightening.

The factors that can affect basic whiteness are:

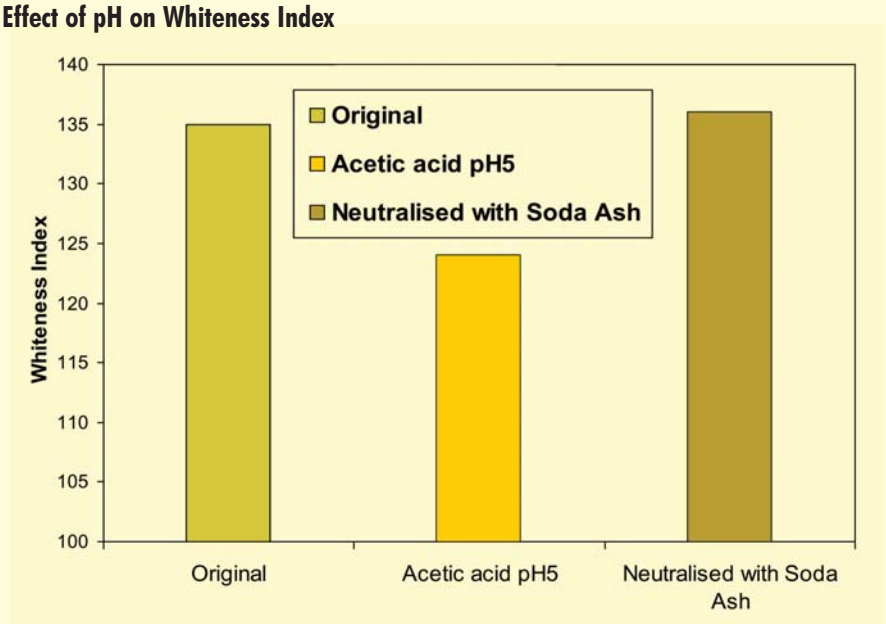
- Quality of water
- Concentration of hydrogen peroxide used
- Type and concentration of peroxide stabilizer
- Type and concentration of demineralising agent used
- Process parameters such as time & temperature

Here we are only considering hydrogen peroxide bleaching. Some dyers also use sodium hypochloride bleach followed by peroxide bleach, or sodium chlorite bleach followed by hydrogen peroxide bleach, or hydrogen peroxide bleach followed by reductive bleach with sodium hydrosulphite.

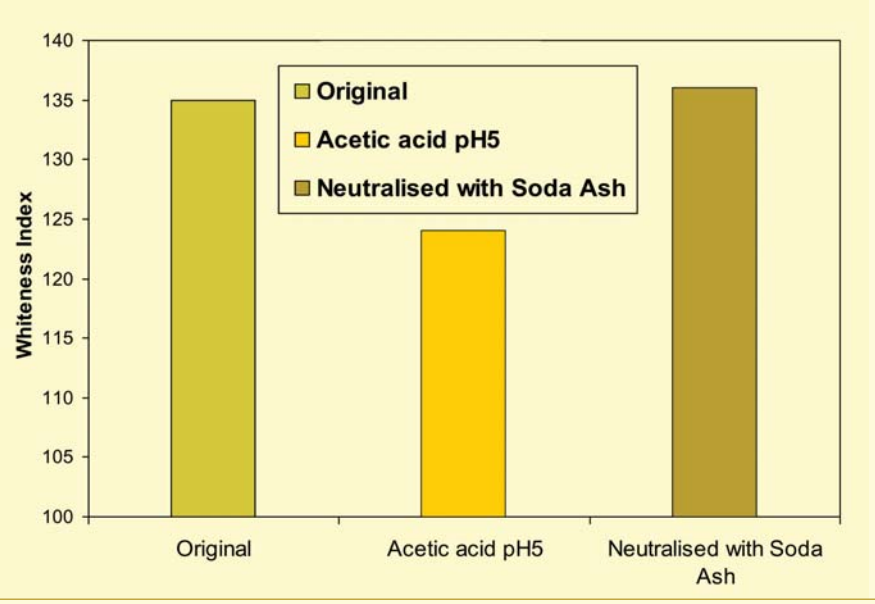
Quality of water – Preferably soft/softened water should be used for peroxide bleaching. In the absence of a water-softening facility, surface water is better than ground water. The presence of Ca^{+2}, Fe^{+3} or Cu^{+2} rapidly decomposes peroxide, leading to poor whiteness. Also Fe^{+3} or Cu^{+2} can lead to catalytic damage of cotton during peroxide bleaching. Fc^{+3} contamination also leads to dulling of basic white.

Concentration of hydrogen peroxide – Depending upon the quality of cotton, concentration of 6-8% hydrogen peroxide of 50% strength is sufficient to produce good basic white. If peroxide bleaching is carried out after sodium hypochloride bleaching or sodium chlorite bleaching, then concentration of hydrogen peroxide

Effect of pH on Whiteness Index



Effect of OBA Conc on Whiteness Index

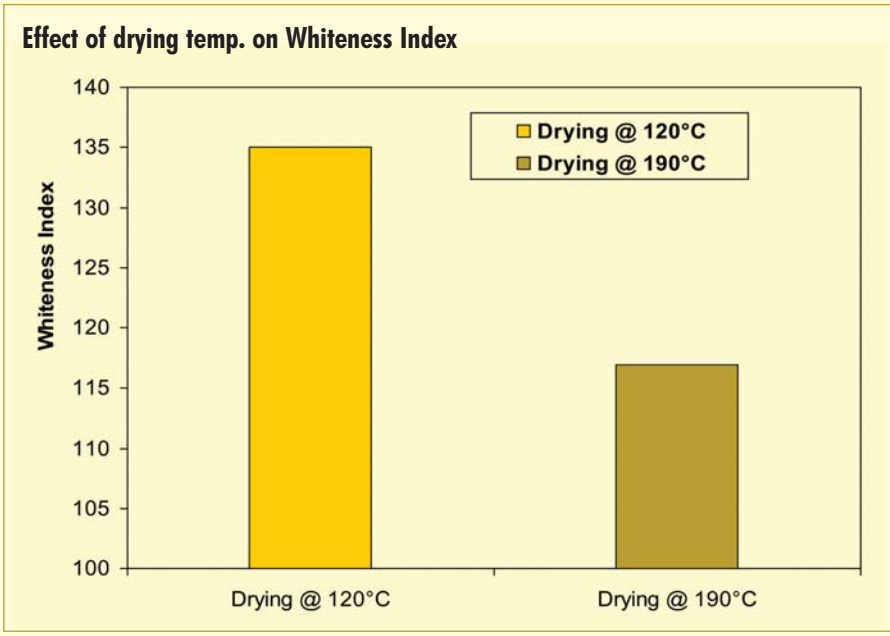


can be reduced. Pretrials in the lab are necessary to optimize concentration of hydrogen peroxide.

Type and concentration of peroxide stabilizer – Usually organic stabilizers, with or without Magnesium salts, are used for batch as well as continuous operation. Organic stabilizers are usually based on sequestering agents to prevent decomposition of peroxide due to metal ions. In the exhaust process, about 20-30% residual peroxide at end of bleaching with good whiteness indicates proper bleaching without damage to cotton. In continuous bleaching, maintaining the concentration of peroxide over a prolonged period in the liquor is important. Also, uniformity of bleaching over the width of fabric is required. The stabilizer should also be capable of chelating iron ions to avoid pinhole damage. Sarastabil MRS is a magnesium-free, silicate-free organic peroxide stabilizer for the exhaust process, and the recommended concentration is 15% of hydrogen peroxide of 50% concentration. Sarastabil M Conc is recommended for continuous process due to its stability to high concentration of caustic soda and peroxide. Sarastabil M Conc is also silicate- free and Magnesium-free.

Type and concentration of demineralising agent - Based on various trials conducted, it is our practical experience that addition of demineralising agent in bleaching with peroxide for full white increases basic whiteness. Depending upon the mineral content of cotton, Saraquest W can be added 0.3 - 0.5% in exhaust process or 0.5 g/kg to 1 g/kg Sarasol NEA in continuous process.

Process Parameters – Classical peroxide bleaching is carried out at pH 11 – 11.5, at 85°C. However most of the processes in industry are combined scouring and bleaching, in which a higher concentration of caustic soda is used for scouring purposes. Thus the pH of the bath is around 14. Treatment temperatures are either 95-98°C or 110°C, with treatment times of 90 mins and 45 mins respectively. A higher concentration of alkali or a longer bleaching time can improve whiteness, provided an additional quantity of peroxide stabilizer is added to stabilize peroxide under these strong conditions.



Optical Brightening

a) Once the required basic white is obtained at the end of bleaching, optical brightening is carried out. In industry, combined optical brightening with scouring/bleaching is usually carried out, to shorten the process. However in our experience, better whiteness is obtained if optical brightening is carried out in separate bath or along with reductive bleaching. The following parameters are important to obtain required whiteness:

- Type and concentration of optical brightener
- Type of toning component
- pH of neutralization

Type and concentration of optical brightener – For optical brightening of cotton, three different types of OBA are available, based on their affinity to cotton.

These are:

- High-affinity OBAs, used only for exhaust application, like Sarawhite Conc.
- Medium-affinity OBAs, which can be used for exhaust application along with Glauber's salt for exhaust or for continuous application along with bleaching or in finishing with or without resin like Texwhite U.
- Low-affinity OBAs, predominantly used along with resin finishing by pad application. In this case, application with resin improves wash fastness of these low-affinity OBAs.

Possible causes of yellowing during OBA treatment

1) pH shifting beyond prescribed pH. This usually happens with high-affinity OBAs for cellulosics, which are not stable below pH 5.0. Thus in subsequent neutralization after OBA treatment, or during finishing, if pH is highly acidic, the whiteness index is reduced. However, it can be partially restored by treating with soda ash (Fig.1).

2) Sometimes excess OBA is used, due to oversight or wrong calculation. Increasing the concentration of OBA beyond a saturation limit leads to dulling and yellowing. Such faults can be corrected by appropriate stripping (Fig 2).

3) Incorrect fixation temperature for polyester OBA in exhaust or pad-thermasol application leads to yellowing due to unfixed OBA. Subsequent corrective treatment at required temperature can correct this fault.

4) Presence of metal ions, particularly zinc, can lead to the dulling of OBA for cotton. Zinc contamination could be due to unreacted zinc in zinc formaldehyde sulphoxylate in reductive bleach, or zinc salt catalyst in resin finishing. Avoiding such chemicals can avoid yellowing.

5) Excess drying temperature can also lead to yellowing. While cotton is dried and finished at 120-140°C, and polyester and polyester blends at 170-190°C, excess temperature and extra contact time at elevated temperature can reduce whiteness (Fig.3). Thus, for material treated with OBA and then subjected to high temperature in a

subsequent operation, pretrials are necessary to assess the suitability and stability of the given OBA.
6) Dyestuff contamination during application, such as dyestuff residues from dyeing machinery or preparation tanks, can lead to dulling. Ensure proper cleaning before you use OBA on any given equipment.

Possible causes of yellowing during finishing

Some of the causes discussed above, such as highly acidic pH, excess thermal exposure, dyestuff contamination and zinc contamination, are also valid for yellowing during finishing. Apart from these causes, the following are some more examples pertaining to finishing:
1) Certain organic softeners and silicone softeners have a tendency to lead to yellowing of whites after finishing. Special softeners for white that are non-yellowing, such as Gamasoft–KA, Sarasoft-SNY, Sarasoft-1367, Sarasoft-GA, Sarasoft-UK or Supercone-2100, are recommended especially for finishing whites. For unknown suppliers' samples, lab trials are advised, to avoid unpleasant surprises after finishing.
2) Leaching of low-affinity or medium-affinity OBA in the finishing bath can reduce the whiteness index and may lead to yellowing or dulling. There is also a possibility of interaction between leached-out OBA and organic cationic softeners and conventional silicone softeners, leading to precipitation in the finishing bath or spots on the substrate.
3) OBAs whose light fastness is poor, when they remain exposed to a strong light source, either natural or artificial, show yellowing of the exposed portion.
4) Exposure to SOx, formed during burning of sulphurous fuel for drying and dry finishing, can also lead to yellowing.
5) Possible causes of yellowing during storage

Precautionary measures to avoid yellowing during processing do not end at the finishing stage. A dyer also has to ensure that the white material produced by him, with so many precautions, remains white until it reaches its end user or final consumer.
1) Phenolic yellowing due to antioxidants used in plastic packaging material and Nox in air cause yellowing of textiles during storage. Apart from antioxidants from packaging, material can be contaminated with phenols from sewing-machine lubricating oil, rubber, elastic material, foam padding, etc. So screening of all these material before approval for use is necessary. Also, proper ventilation of the storage area, to prevent build-up of NOx in air (NOx is heavier than air), is recommended.
2) Ageing of softeners and yellowing of polyurethane fibres can also lead to yellowing. Check the suitability of each product for prolonged storage.
3) Yellowing of indigo by ozone. Ozone can break down indigo into colourless phenyl-glycine and yellow-coloured isatin. The degradation can take place by ozone alone or due to combined actions of ozone, UV radiation and NOx. To avoid ozone fading, special finishes are available, such as Sarafinish OZE, which is recommended for denim.

Thus it is better to have precautionary actions at every stage to avoid not only value loss but also costly reprocessing. ❍