TEXTILE CHEMICAL ANALYSIS AND TEXTILE WET / CHEMICAL PROCESSING

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PREFACE

Textile wet / chemical processing is the important sequence of treatments in textile materials that makes them suitable and eligible for the conversion and construction of various end use products. This processing comprises the involvement of different aspects of chemicals based on the suitability of subsequent requirements, needs the analysis. Textile chemical processing is varied between one type of textile to that of the other. For instance, the strong alkali treatment called mercerizing is highly suitable on cotton textiles however which is not being followed on any other textiles due to the impact of its strong effect leading to damage.

Textile wet processing requires the knowledge of scientific aspects of textile polymers, chemicals, auxiliaries, dyes/pigments and water; and their inter relationship during application for specific performances such as mercerizing, dyeing, printing, finishing. The application of suitable chemicals on the respective textiles gives the desired effect demanded by the end users. Hence, the selection of chemicals and other items for treatment on textiles is an important task of the textile chemical processors.

Textile chemical processing comprises the involvement of water, chemicals, auxiliaries, dyes and pigments. The role of each and every component fixed for the application of textiles is in appreciable manner. For instance, the quality of water is reflected in all the stages of processing. If the water is good / soft the textiles would be processed in a proper way if not the emergence of problems is inevitable.

In this manual, the chemical processing suitable for the basic textiles used extensively is elaborated. This manual would be suitable for the textile wet/chemical processing industries (desizing, scouring, bleaching, dyeing) as well as for the textile students in different level of degrees and also to the respective faculty members handling the subjects, to solve the purpose of coinciding the theoretical knowledge with that of the practical experimentations. Any feed back regarding this manual would be frankly appreciated.

✍ *Dr. J. Jeyakodi Moses*

ABOUT THE BOOK

Textile chemical processing comprises the involvement of:

(a) Textile fibre substrates (fibres / yarn / fabric),
(b) Water
(c) Chemicals
(d) Dyes
(e) Auxiliaries

Textile fibre substrates: Textile fibre substrate is the main component in the chemical processing on textiles. The textile fibre substrates may be loose fibre or yarn or fabric, either woven or knitted or non-woven fabric.

Example of fibre fibre substrate: Natural [Cellulose – cotton, jute, linen, sisal, pineapple; Protein – wool, silk, rabbit hair], modified natural [lyocell, viscose, cupprammonium, polynosic] and synthetic [polyester, nylon, acrylic, lycra, polypropylene]

Water: Water is also the important component being used in the textile chemical processing. Without water the transfer of chemicals, dyes and auxiliaries is not possible. Water is the important medium to conduct each and every component from one part to another part. Water is also useful for converting insoluble ingredient into soluble solution so that the wet processing on textile materials is smoothly carried out. The water used for the textile wet processing should be soft. If it contains hardness, many problems will be raised due to the unwanted reactions between the chemicals used in processing and the hardness salts present in hard water.

If water contains hardness that should be estimated and calculated. The hardness is crudely checked by adding

soap [R-COONa] that gives precipitate [$(RCOO)_2M$][M = Ca or Mg] due to hardness instead of giving good lather with soft water. The hardness in water is due to the presence of salts namely; calcium bicarbonate [$Ca(HCO_3)_2$], magnesium bicarbonate [$Mg(HCO_3)_2$], calcium chloride [$CaCl_2$], magnesium chloride [$MgCl_2$], calcium sulphate [$CaSO_4$] and magnesium sulphate [$MgSO_4$]. The hardness in water is categorized as temporary (or Carbonate) hardness [$Ca(HCO_3)_2$ and $Mg(HCO_3)_2$] and permanent (or non carbonate) hardness [$CaCl_2$, $MgCl_2$, $CaSO_4$ and $MgSO_4$]. Hence, total hardness = temporary hardness + permanent hardness. Hardness of water is expressed in terms of either ppm (milligram per liter) or mg/L. The hardness is expressed in terms of calcium carbonate ($CaCO_3$) equivalents. The reasons are; i) calcium carbonate is highly insoluble in water and also ii) its molecular weight is exactly 100. Therefore, hardness can be calculated using the formula:

$$\text{Hardness} = \frac{\text{Weight of the hardness causing substance in g/L}}{\text{Equivalent weight of the same substance}} \times 50 \times 1000 \frac{mg}{L} or\ ppm$$

[50 is the Eq. wt of $CaCO_3$ and 1000 is included to convert to mg /L or ppm]

The hardness is estimated by volumetric (titration) method using EDTA solution.

To estimate the hardness in water, first the total harness is calculated, followed by permanent hardness and finally temporary hardness. From the stock water, 100 mL is taken in a conical flask, into which 5 to 10 mL of ammonium chloride-ammonium hydroxide [NH_4Cl-NH_4OH] buffer is added to maintain the pH 9, followed by the addition of pinch of EBT (Eriochrome Black - T)

indicator. The solution gives the colour of wine red colour (due to the formation of temporary complex between EBT indicator and water hardness salts). The whole content of the solution is titrated against 0.01M EDTA solution. While adding EDTA solution, the temporary complex is now converted to permanent complex (between EDTA and water hardness salts). When all the temporary complex of EBT indicator and water hardness salts is fully converted to permanent complex of EDTA and water hardness salts, the indicator EBT is set free and the colour in the solution is converted from wine red to steel blue (The colour of EDTA and water hardness salt complex is colourless), which is the colour of free EBT indicator. From the titer value the total hardness can be calculated.

1 mL of 0.01 M EDTA ≡ 1 mg of $CaCO_3$

Therefore, V_1 mL of 0.01 M EDTA ≡ V_1 x 1 mg of $CaCO_3$

Hence,

$$\text{Total hardness} = \frac{(V_1 \times 1)}{100} \times 1000 = 10V_1 \frac{\text{mg}}{\text{L}} \text{or ppm}$$

The permanent hardness is estimated by taking 500 mL of stock water, boil them to dissociate the temporary hardness [$Ca(HCO_3)_2$ and $Mg(HCO_3)_2$], into the corresponding precipitates [as $CaCO_3$ and $Mg(OH)_2$]. The precipitate is allowed to settle, filtered and removed. The contents are made upto 500 mL using distilled water. From the made up water 100 mL is taken for permanent hardness estimation using EDTA solution as followed in the earlier (Total hardness estimation) case and calculated similarly.

1 mL of 0.01 M EDTA ≡ 1 mg of $CaCO_3$

Therefore, V_2 mL of 0.01 M EDTA ≡ V_2 x 1 mg of $CaCO_3$

Hence,

$$\text{Permanent hardness} = \frac{(V_2 \times 1)}{100} \times 1000 = 10V_2 \frac{\text{mg}}{\text{L}} \text{or ppm}$$

Therefore, Temporary hardness = Total hardness – Permanent hardness

= 10 V_1 mg / L or ppm -10 V_2 mg / L or ppm

= 10 ($V_1 – V_2$) mg / L or ppm

Chemicals: Chemicals play a vital role in chemical processing on Textiles. Chemicals are utilized for treatments of textiles in order to make them ready for next suitable application. The treatments can be given for purifying textiles by removing all the unwanted impurities; modifying the arrangement of polymers; making the textiles white; giving attractive colour to the textiles; and to create required design / fashion to the textiles. While applying chemicals on textiles the suitability of chemicals towards the textiles is to be identified, so that the performance of textiles will be in the quality way.

The selection of chemicals would be based on the suitability of pH values on the textiles. For instance, Cellulose (cotton) chemical processing is suitable in alkaline pH (9 – 11.5); Protein (wool, silk, hair) chemical processing is suitable in acidic pH (3 – 6.5); and the synthetic and modified and blended textile's chemical processing is suitable in near neutral pH (6-8). The main chemicals used are based on acids, alkalies, acid liberating agents and alkali releasing agents. Some examples of chemicals are; Hydrochloric acid, sulphuric

acid, formic acid, acetic acid, oxalic acid, citric acid, lactic acid, sodium hydroxide, sodium carbonate, sodium bicarbonate, ammonium chloride, ammonium hydroxide, sodium hydrosulphite, sodium sulphide, sodium bisulphate, sodium / zinc sulphoxylate formaldehyde, calcium hypochlorite, sodium hypochlorite, hydrogen peroxide, peracetic acid, ozone, etc.

Dyes: Dyes are used on textiles to promote various colours in different shades to give many varieties of products. Dyes are classified into water soluble and water insoluble dyes. Water soluble dyes: Direct dye, acid dye, basic dye (cationic dye), mordant dye, metal complex dye, reactive dye, etc. Water insoluble dyes: Vat dye, sulphur dye, pigment dye, ingrain dye, disperse dye. Dyes for natural fibres: 1) Cellulosic - Direct, reactive, vat, sulphur, ingrain, basic, pigment dyes, etc. 2) Protein – Acid, basic, reactive, metal complex, mordant, direct dye, etc, 3) Synthetic – for nylon – acid, basic, reactive, metal complex, disperse, etc; for acrylic – Cationic (basic), disperse, reactive, etc; for polyester – disperse dyes

Auxiliaries: Auxiliaries are involved in the chemical reactions in addition to the main chemicals. Auxiliaries increase the performance of the processes. Without auxiliaries, it is very difficult to achieve quality wet processing treatments. Auxiliaries give different activities in chemical processing. They reduce the surface tension between the grey textile materials and the processing solutions. Auxiliaries are in different types: Anionic surfactants (soap, turkey red oil), cationic surfactants (quaternary ammonium compounds), non ionic surfactants, exhausting agents, retarding agents, leveling agents, etc.

Hence the wet processing treatments on textiles can be divided into i) Pretreatments ii) Main treatments iii)

Dyeing iv) Printing, and v) Finishing

Pre treatments: Pre treatments are performed on textile fibre substrates in order to remove the natural and added impurities so as to the make them absorbent and free from the hindrances and suitable for the next processes leading to quality products including garments / apparels. Example for pre treatments - on cotton are; Desizing (woven fabric), wetting / scouring, etc; on silk – degumming; on wool – mild scouring / degreasing, felting / non felting, decatizing, potting, etc; on synthetics – desizing, antistatic, etc

Main treatments: Main treatments are performed on textile fibre substrates to impart the main character / properties suitable for respective textile products. Examples of main treatments - on cotton are; bleaching, mercerising, etc.

Dyeing: Dyeing is the process of imparting colour to the textile fibre substrates to give different colouration in different shades and hues using various dyes suitable for the quality textile products. Dyeing is performed successfully on selective textiles using soft water, suitable dyes with appropriate chemicals and auxiliaries and also with respective machinery.

Printing: Printing is the process of imparting colour to the textile fabric in a localized area so that required design is created. By printing it is possible to bring out the taste and ideas on the fabric in a fashioned way. Printing avoids the unwanted application of colours on the fabric and leads to give savings in many ways to the processors. Preparation of good printing paste suitable for the respective textile fabric gives quality print / design.

Finishing: Finishing is the process of giving attraction to

the textile products. Finishing facilitates to give final touch up on the products suitable to the needs and requirements of the market and customers. Finishing enhances the properties of the basic textiles and gives value to them. Finishing corrects the faults and covers the defects so the products will not loose their value and hence wastage is avoided or reduced.

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CONTENTS