5.1 Introduction

The concept of ease of care includes soil removal, wrinkle recovery and minimum ironing and these factors are considered for assessing performance characteristics of uniform fabrics.

The soiling of textile materials is one of the difficult problems associated with their use. Soiling is defined as the unwanted accumulation of oily or particulate materials on the surface or interiors of fibrous structures, often resulting in discolouration, change in appearance and loss of fabric lustre [1]. Soiling and cleaning of cotton garments were considered a major problem before the advent of wash wear and durable press fabrics. The problem of removing soils from a fabric came into the picture when cotton fabrics began to be treated with nitrogenous cross linking agents to produce durable press fabrics.

With the increasing standard of living, there has been a demand from homemakers for reducing the labour involved in home laundering. The high cost of commercial laundering, along with the ease of care fabrics, has
resulted in the production of fabrics that could be laundered easily. The emphasis on easy care has led to considerable attention to the finishes given to polyester-cotton blends particularly that of soil and stain resistance.

5.2 Review of literature

Scientific investigation of soil deposition, redeposition and release have greatly increased in recent years, mainly due to the increased use of man-made fibres and blends. Literature pertaining to several parameters affecting soiling mechanism, its release and finishes imparted to render soil release characteristics to fabrics are presented.

5.2.1 Types of soil and mechanism of soiling

The composition of soil varies with the uses to which textiles are put and the environmental conditions during their use. Analytical studies on nature and composition of the soil deposited on apparel during normal use consist mainly of two components, a) fluid component usually an oil or a grease, and b) solid component made up of small particles of soil [2,3].

Soiling tendency is closely associated with the properties of fibre surfaces [4]. Fabric is soiled either
by direct contact with another soiled surface or by contact with air-borne or liquid-borne substances. Liquids with which the fabric comes into contact may evaporate leaving behind dissolved or suspended particles. In the case of hydrophobic fibres, a large surface density is built on the fibre surface by friction during use or laundering. Thereby soil particles are attracted from the atmosphere [5-12]. Another important source of soil is the wash liquor itself and it takes place due to pick-up by the fabric of soil suspended in wash liquor [10-12]. Retention of oily soil on garments after wear and laundering varies with the fibre content of the fabric [10]. The mechanism of retention of particulate soil has been studied by several workers [5,10]. Soils may be retained in a number of ways - macro-occlusion, micro-occlusion, sorption, oil-bonding and bonding by finishes. Soiling of fabrics may be due to interfacial attraction, electrostatic attraction, mechanical forces and also hydrophobicity and oleophilicity of the substrate [9,13-19]. By and large, soiling is an overall effect of fibre properties, soil characteristics and soil-fibre interaction [19].

Several theories have been put forward to explain the mechanism of soiling and soil release [18, 20-23] and the effect of physical and chemical characteristics of the fabric surface on soil and soil release [19-30].
5.2.2 Composition of synthetic soil

The solid particulate widely used included metal oxide [7], iron oxide [17,30], oleic acid [31], carbon black [32] and vacuum cleaner dirt [26,33]. The use of dispersions of carbon black was seen in several studies as a synthetic soil because a small amount can produce extensive greying a textiles similar to that noted in natural soiling [1]. Some research workers have applied both solid and oily components in synthetic mixtures to duplicate natural soiling [32,34,35].

5.2.3 Soil application

Methods of soil application vary with the type of testing conditions. There are different ways of applying soil in the laboratory. They are by contact soiling [36] tumbling with particulate soils [7,30,33,37-39], the use of soiled felt tubes [38], tumbling with dry soil [7,40], applying dry soil in an accelerator abrasion tester [35,36], immersion technique [41], padding and spraying [42], rubbing the test piece with soil [43], application of soil with abrasion machine [43], soiling in a launder-o-meter with steel balls [44], application of soil from a blower [9,19,45], synthetic soil in aqueous dispersion and organic solvent [13,42,46], etc.
5.2.4 Methods of soil evaluation

The amount of soil deposited during soiling can be estimated by chemical methods and reflectance measurements made on the soiled samples. The most popular method for estimating the amount of soil deposited on a fabric and also the amount of soil released during laundering is by the reflectance method. The other methods are (a) microscopic technique [21,53,56], (b) gravimetric [36], (c) chemical [57], (d) use of gray scale for staining [58], etc.

The degree of soiling or soil removal is calculated using the Kubelka Munk equation [59]. It is assumed that light reflection decreases linearly with increased amounts of soil present.

5.2.5 Soiling and fibre characteristics

Fibre morphology and fabric construction have been shown to affect soil removal [59]. The soiling phenomenon is dependent on the relationship between size of the particulate particle and the size of the surface crevices [15,60]. Compton and Hart [15,16] concluded that geometric bonding was the principal mechanism affecting particulate soiling in the absence of oils and greases. While Tsuzuki and Yabyuchi [61] reported that fibre cross
sections affect the removal of oily soil as well as particulate soils. Tight twisting of yarns can keep soils away from interior surfaces [60]. Fibres of irregular cross sectional contour not only provide channels which can entrap soil, but also provide greater surface area for a given weight of the fibre [31, 62]. A study of oily soil on polyester fabrics by Brown et al [63] showed that, fabrics from staple fibres accumulated about five times more oily soil than those from continuous filament yarns under the same conditions.

5.2.6 Detergents

An important variable affecting the detergent action by all surfactants is their concentration in washing solutions [1]. In order to get good soil removal, complete wetting of the fabric is very essential for the effective interaction with the wash liquor. The function of a detergent in the cleaning process is accelerating the wetting of the fabric and the soil in water [47]. It has been suggested [64] that practical problems with soil removal from fabrics which are difficult to clean, arise from addition of too little detergent. Several studies have been carried out on cleaning efficiencies of different detergents under varying conditions of soiling and detergency [65, 66]. Laundering experiments at different
temperatures have shown [30] that, as the temperature of wash liquor increases, the rate of detergency of the absorbed soil also increases. The relationship between the concentration of the detergent and the soil release property of a fabric depends on the type of detergent, nature of soil and the temperature of wash liquor in laundering [27, 67].

5.2.7 Finishes for improving soil resistance and soil release

Many soil release finishes have been introduced in the market and they have been investigated [13, 68-72] for their chemical nature and mechanism by which they operate for soil removal and preventing soil deposition during aqueous laundering conditions. Mercerization of cotton eliminates most of the surface irregularities and lowers the surface area, thereby producing an improvement in resistance to soiling [7]. Most of the above mentioned works are related to white fabrics, but very few studies have been reported on coloured fabrics.

5.3 Experimental

5.3.1 Materials

Test fabrics as mentioned in Section 4.3.1 have been used for experimentation. 20 x 20 cm of fabrics from
each material was selected to study the soiling and soil release characteristics.

5.3.1.1 Selection of soil and soil composition

A modified procedure of Shimauchi et al [44] and AATCC test procedure [74] was adopted, in order to make the artificial soiling closely approximating to natural soiling. Soil ingredients, its proportion, material-liquor ratio and effective method of application were standardized to get reproducible result, by a series of trials in the laboratory:

- Carbon black - 20 parts
- Sodium chloride - 20 parts
- Urea - 20 parts
- Egg albumin - 10 parts
- Iron oxide - 2 parts
- Liquid paraffin - 2 parts
- Lissapol Nx - 1 part
- Water - 25 parts

Carbon black was included because a small amount could produce greying of textiles similar to that noticed in natural soiling [1]. Compton and Hart [15,16] also found a good correlation with natural soiling by using carbon black. The addition of protein to natural soil
combination produced a better correlation with that of natural soil [74]. Sodium chloride and urea were chosen to represent human perspiration [55,74].

5.3.1.2 Selection of detergent

The detergent and concentration as mentioned in Section 4.3.2.1 were used for laundering the soiled samples.

5.3.2 Methods

5.3.2.1 Preparation of soil solution

The soil ingredients as mentioned in Section 5.3.1.1 were blended in a mortar for about 30 minutes to give a slurry particulate soil. The mixture was diluted by adding 400 parts of water by volume and further diluted to 10 times of its volume. The soil was used immediately after mixing.

5.3.2.2 Soiling procedure

The edges of tests fabrics were folded and stitched to prevent fraying. Immersion technique [41] was used for soiling. The fabrics were first deresinated [75] and dried. 500 ml soil solution at 50°C was taken in a basin and each test piece was dipped 20 times in the solution. Each operation of soiling was limited to one minute. Preliminary trials showed that the optimum
time for soil deposition was 20 minutes and this procedure gave uniform soiling.

5.3.2.2.1 Single level soiling

To study the progress of soil release after soiling, the test swatches soiled once were subjected to five consecutive cycles of washing. The extent of soil release was measured by using reflectance meter after each wash and compared with the reflectance values of unsoiled washed swatches.

5.3.2.2 Multiple level soiling

The effect of soiling was studied by subjecting the sample for soiling after every five washes. The extent of soil release was determined reflectometrically for the 1st washing after soiling and after every 5th wash (before subsequent soiling).

5.3.2.3 Laundering procedure

The procedure mentioned in Section 4.3.2 was used for soil removal studies, with the difference in quantity of water for washing, rinsing and loading being kept constant by the addition of dummy wash load. After washing, each test piece was rinsed using the same fabric-liquor ratio and line dried.
5.3.2.4 Soil measurement

The extent of soil deposition and soil release were measured by using reflectance meter model C-6 with a probe and tristimulus green filter to give a spectral response similar to that of the human eye. All the reflectance readings of the soiled and washed swatches were taken on four layers of fabric. Measurements were taken in the centre of five cms square from four different positions on each side, making a total of eight readings. The reflectance readings for black and white were calibrated and standards were checked after each set of specimens were read and necessary adjustments were made to read 0 and 100 for black and white, respectively. Readings were avoided if any crease was seen, since crease lines appear brighter than the body of the swatches [76].

The extent of soil removed from 1st to 5th washes in single level soil was evaluated by 10 postgraduate students of Textile Technology Department by using gray scale following the standard recommended in AAICC evaluation procedure [75].

The Kubelka Munk relationship was used by Bacon and Smith [59] by using reflectance values in a form to get scattering light by fabric and soil.
$K/s = \frac{(1 - R)^2}{2R} \quad \ldots \quad (5.1)$

where $K$ = coefficient of reflectivity

$s$ = coefficient of light scattering

$R$ = observed reflectivity for monochromatic light

It is assumed that $K$ values increase proportionately with the amount of light absorbing material, while $s$ remains constant, so that $K/s$ is a linear function of the concentrations of light absorbing material in the fabric.

5.3.2.4.1 Soiling parameters

Soiling parameters were calculated by using Mares's method [29].

(a) **Percent soiling**

$$\text{Percent soiling} = 100 \frac{R_o - R_s}{R_o} \quad \ldots \quad (5.2)$$

(b) **Percent soil removal**

$$\text{Percent soil removal} = 100 \frac{R_L - R_s}{R_o - R_s} \quad \ldots \quad (5.3)$$

where $R_o$ = reflectance value before soiling

$R_s$ = reflectance value after soiling

$R_L$ = reflectance value after soiling and launderings.
5.4 Results and Discussions

The results are presented in two sections. They are soil deposition in multiple levels of soiling and washings and soil release in single level and multiple levels of washing. In the present study, fabrics made out of cotton, polyester, and blends made out of polyester cotton, polyester viscose were chosen (as mentioned in Section 4.3.1). These fabrics vary in their fabric construction as well as in colours.

5.4.1 Soil deposition in multiple levels of soiling

When soil deposition in multiple levels of soiling was studied, (Fig. 5.1) it was found that fabric A (all cotton, plain weave, Khaki colour) shows the least soiling followed by fabric C (100% cotton, 3/1 twill weave Khaki colour) and G (80/20, 3/1 twill, Khaki colour). Fabrics A, C, G, being closely woven, picked up less soil. This finding corroborated with that of Bowers and Chantry [24] that fabric construction can have an important influence on fabric soiling. Fabric B (cotton, white, plain weave) shows highest soil deposition at initial soiling and subsequent soiling followed by fabric J (carbonized polyester, white, plain weave). Reflectance values are presented in Appendices 5.1 and 5.2.
FIG. 5-1 MULTIPLE LEVELS OF SOILING—PERCENT SOIL DEPOSITION BETWEEN SOILINGS AND WASHINGS.
In general, all the fabrics show higher soil deposition for 1st and 2nd soiling. In respect of all cotton fabrics, soil deposition increases up to 4th soil-wash cycles, then shows a decreasing trend. The blended fabrics show higher soil pick up for the first two washes. Then the soil pick up decreases gradually. For most of the fabrics, soil deposition is considerably less for the 6th and 7th wash cycles, probably due to retained soil left unremoved in washes. Considering the deposition in 6th and 7th soil wash cycles, not much difference could be observed among the blends, all cotton or all polyester fabrics. The soil deposition decreases with repeated soil washing; this is probably due to the soil being completely removed in each laundering. The data reveal a general idea of soil accumulation in successive soilings.

It is known that the extent of soiling and soil release after washing depends on the fabric construction [15, 16, 60-63]. In the present work, as expected, it is seen that the level of soiling is more for white fabrics than for coloured fabrics. It is also noted that green and Khaki fabrics, in general, seem to have picked up higher amount of soil than maroon and blue fabrics.

For navy blue fabrics (F) reflectance values did not give the correct level of soiling and soil removal,
because this colour tends to be black after soiling. Hence, fabric F is not considered for discussion.

5.4.2 Percent soil removal in single level soiling at subsequent five launderings

The Figure 5.2 shows the soil release behaviour of cotton and blended fabrics at single level of soiling. It can be seen from the figure that the extent of soil release after 1st wash is 88% for white carbonized polyester (J) and 68% for white cotton poplin. The polyester fabric shows high degree of soil removal. The cellular weave Khaki material (D) shows soil release to the tune of 60%, while for rest of the fabrics soil removal ranges from 28% to 45%. On subsequent washes, the percentage soil removal increases. However, the extent of soil removal is not as high as in the first wash. This finding corroborates with that of Dave [42] who has concluded that the build up of soil on long usage is more and ultimately the accumulated soil will become part of the fabric structure.

In the case of carbonized polyester fabric, it is shown that the soil retention after 5th wash is only 6% while for cotton it is 22%. It can therefore be concluded that polyester fabrics possess a better soil release property compared to cotton in aqueous soil medium.
FIG. 5.2 MULTIPLE LEVELS OF SOILING—PERCENT SOIL REMOVAL IN SUCCESSIVE SOILINGS AND LAUNDERINGS.
Polyester, being hydrophobic, releases this soil more effectively than cotton, which is hydrophilic. This finding is in agreement with that of Mares [29] who has found that percentage efficiencies of aqueous soil is greater than percentage efficiencies of oily soil.

When an attempt has been made to study the effect of colour on soil release, it is noticed that all coloured materials studied have less tendency to release soil than white fabrics. On subsequent washes, all coloured fabrics show an increase in the soil removal. It also appears from this work that blends have a tendency to release more soil than cotton.

5.4.3 Percent soil removal in successive soilings and launderings

The ranking of fabrics based on the soil removal is in the order: J, B, D, I, C, G, E, H and A (Figure 5.3). Carbonized polyester (J) shows maximum release followed by all cotton white colour (B). Fabric D with open weave shows, in comparison, an increase in soil removal. This finding corroborated with that of Bowers and Chantry [24]. They have found that loosely woven fabrics is easier to clean than closely woven fabrics. All fabrics, irrespective of their variation in fibre content, colour, geometrical
FIG. 5.3 PERCENT SOIL REMOVAL IN SINGLE LEVEL SOILING AT SUBSEQUENT FIVE LAUNDERINGS.
<table>
<thead>
<tr>
<th>Fabric code</th>
<th>Fibre content</th>
<th>Laundering levels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$L_1$</td>
</tr>
<tr>
<td>A</td>
<td>Cotton</td>
<td>4</td>
</tr>
<tr>
<td>B</td>
<td>&quot;</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>&quot;</td>
<td>3-2</td>
</tr>
<tr>
<td>D</td>
<td>&quot;</td>
<td>3</td>
</tr>
<tr>
<td>E</td>
<td>67.0/33.0</td>
<td>3-2</td>
</tr>
<tr>
<td>G</td>
<td>80.0/20.0</td>
<td>3-2</td>
</tr>
<tr>
<td>H</td>
<td>50.0/50.0</td>
<td>4-3</td>
</tr>
<tr>
<td>I</td>
<td>50.0/50.0</td>
<td>3-2</td>
</tr>
<tr>
<td>J</td>
<td>Carbonized polyester</td>
<td>2</td>
</tr>
</tbody>
</table>
parameters, show a decrease in percent soil removal in successive soilings and wash cycles.

5.4.4 **Gray scale evaluation**

The soil release characteristics of the samples washed for five times at single level soiling were compared by ten judges, with unwashed samples using the Gray scale [77] and their mean values are given in Table 5.1. Rating 1 indicates maximum difference and high soil release and rating 5 indicates very little difference between soiled washed samples and little soil removed. The ratings assigned to different samples indicate a general agreement between the ratings of the judges and that of values obtained from reflectance readings.

5.5 **Conclusions**

In an overall comparison, the carbonized white polyester fabric performs well in terms of ease of care of fabrics, followed by blended fabrics with reference to aqueous soil removal at single level and multiple levels of soilings and wash cycles.
REFERENCES


51. ibid., 64, 1973, 273.


REFERENCES


30. ibid., 27, 1957, 8.
52. C. Bhattacharya, Colourage, 27, 1980, 3.


