Comparison of Practical and Laboratory Laundering of Some Modern Fabrics[1]

R. T. HUNTER, C. R. KURGAN and H. L. MARDER,[2] Colgate-Palmolive Company, Research and Development Center, Piscataway, New Jersey

Abstract

The detergency and redeposition characteristics of several modern fabrics were compared under laboratory and home-laundering conditions. Good correlation was found between data from laboratory-controlled practical washing and home laundry although washing in the home was uniformly poorer than in the laboratory. Polyester-containing fabrics tend to gray by redeposition more than the other fabrics investigated, and the new Permanent-Press fabrics seem more susceptible to redeposition than their untreated counterparts. A systematic screening of factors affecting the performance of these fabrics in the home laundry indicates that detergent underusage is the major factor for the failure of polyesters to perform as well as cotton in either laboratory or practical laundry screening.

Introduction

During the past 15–20 years built synthetic laundry detergents have developed into complex mixtures of antiredeposition agents, brighteners, bluing agents, builders, and an array of surface-active ingredients. The combination of these compositions and the rise of the automatic washer has introduced a uniquely modern method of laundering to the American housewife.

Simultaneously with the developments in the detergent and washing-machine industries, a succession of developments within the textile industry has made it necessary to take into account that fabrics other than plain cotton make up an ever-increasing proportion of those textiles which are maintained by laundering. The growth of synthetic fibers, such as polyamides, acrylics, and especially the polyesters and their blends, has been accompanied by a revolution in cotton textile technology. The result has been a multitude of fabrics and blends of fabrics which have been modified by chemical finishes to confer ease-of-care properties and other special attributes. The most recent example of the progress of this technology is the Permanent or Durable-Press development, which combines the wash-wear concept with the blending of fibers to obtain other desirable properties.

The laundry performance of these new fabrics must be evaluated against the increasingly stringent standards of performance established for cotton. There has been much comment in the literature and technical meetings which indicates that the performance of many of these new fabrics does not meet these standards as well as desired. Literature references to possible problems in removing soil and in preventing the build-up of grayness in the modern launderable synthetics are frequent.

The objective of this work was to develop laboratory techniques for the evaluation of detergency of and redeposition on the newer fabrics. Since there is no universally representative soil and since these fabrics were not available with one of the so-called "standard" soils on them, two laboratory methods developed at Colgate were examined.

Experimental

The most meaningful way to study the interrelated phenomena of detergency and redeposition is in the actual laundry. Detergency is the more difficult of the two to pinpoint and usually involves long, drawn-out bundle tests. Redeposition can be studied by allowing clean fabrics to become soiled by washing them with soiled laundry. To do this on a practical basis, small swatches of each of several fabrics were sewn together, and the composites were distributed to each of seven families to be included in their normal wash under the detergent and washing conditions of their choice. Concurrently, similar experiments were run in Colgate's Practical Laundry Laboratory by using soiled laundry which was regularly obtained from a large number of families on a weekly basis. These loads are washed, ironed, and returned to the "customer" for re-soiling. For this practical laboratory experiment the composite swatches were included in randomly selected wash-loads with commercial detergent products.[3]

After 10 cycles of washing the swatches from both sources, i.e., the family laundry and Practical Laundry Laboratory, were read on a Hunter D-25 Color Difference Meter. Unless otherwise noted, readings of R_d were taken with the UV filter in place. This screens out optical brightener effects. (Throughout this work the familiar three dimensional, color-space diagram is used to describe instrumental readings. R_d refers to the white-black axis which runs from 0 to 100.)

Two separate groups of fabrics have been studied. The first of these groups forms the basic framework. Table I shows the history and description of the eight fabrics which were tested rather extensively and called Group I.

TABLE I
Fabric Identification (Group I)

Code	Description	Count (W × F)	Weight (Oz/Yd)
C	Mercerized cotton broadcloth	136 × 68	3.5
FC	Above fabric treated with 0.5% fluorinated polymer durable water & oil repellent.	136 × 68	3.5
PA	Nylon taffeta (70 den. type 200)	95 × 88	1.9
PE-1	Spun dacron (type 54)	60(40/2) × 54(30/1)	3.8
PE-2	Fortrel taffeta	44(30/2) × 40(30/2)	4.1
PE-3	Type IV Kodel taffeta (permanent brightener)	44(30/2) × 40(30/2)	4.1
PE/C-S	Dacron 54/cotton-65/35 shirting	88 × 60	2.7
PE/C-P	Dacron 54/cotton-65/35 poplin	....	4.6

[3] The laboratory testing was done in 120F water at 150-ppm hardness level with 0.15% detergent concentration. Length of the wash period was 10 min.

[1] Presented at the AOCS Meeting, Philadelphia, October 1966.

[2] Present address: Boyle-Midway Division of American Home Products Company, Cranford, N.J.

TABLE II

Fabric Identification [a] (Group II)

Code	Description	Count (W × F)	Weight (Oz/Yd)
C-2	100% Cotton broadcloth mercerized	136 × 60	5.2
PE-C	65% Polyester, 35% cotton broadcloth	128 × 72	4.4
DP	Above PE-C with carbamate resin	128 × 72	4.4

[a] All fabrics obtained from the Monsanto Co.

All Group I fabrics were purchased from Testfabrics Inc. Mercerized cotton broadcloth was chosen since it would be expected to have a relatively high resistance to soiling and good washability. A portion of the broadcloth supply was treated with an experimental fluoropolymer which was free from auxiliaries and extenders. With the exception of PE-3, which contains a permanent brightener incorporated during manufacture, none of the fabrics contained optical brightener. PE-2 and PE-3 were nearly identical in fabric construction. The two polyester-cotton blended fabrics were made from the same source fibers and were included to show the effect of fabric construction.

Group II fabrics (Table II) were studied at a later date for the purpose of checking data obtained from Group I fabrics and to update the fabrics to reflect the Durable-Press trend. The comparison between cotton broadcloth shirting and a polyester-cotton shirting was desired in addition to a study of the effects of a Permanent-Press finish on the blended fabric. These fabrics were obtained from Monsanto.

Results and Discussion

Group I Fabrics

The bar graph (Figure 1) shows the decreases in reflectance which were obtained by including the clean fabrics with white and colorfast wash loads both in the home and in the laboratory. The soiling is best appraised by the "intrinsic whiteness" change as measured with the UV filter in place. A review of Figure 1 will lead to the following basic conclusions.

1. The laboratory results were uniformly superior, i.e., generally gave about half as much graying of the fabrics as observed in the home washed fabric. However, even under these ideal conditions, 1–4 R_d units loss was observed.
2. Based on the intrinsic graying obtained in the home and the laboratory, the fabrics may be grouped into two classes. The cotton, fluorocotton, nylon, and shirting blend fell into the better performance category, and the three polyesters and the poplin blend were in the poorer group. The reflectance decreases of the better group (about one to three units) were roughly half that of the poorer.
3. As expected, there was considerable family-to-family variation in the home experiment. Results ranged from better than laboratory performance to very bad. Among those families in the latter category the polyesters suffered disproportionately in comparison to the cotton (Table III).

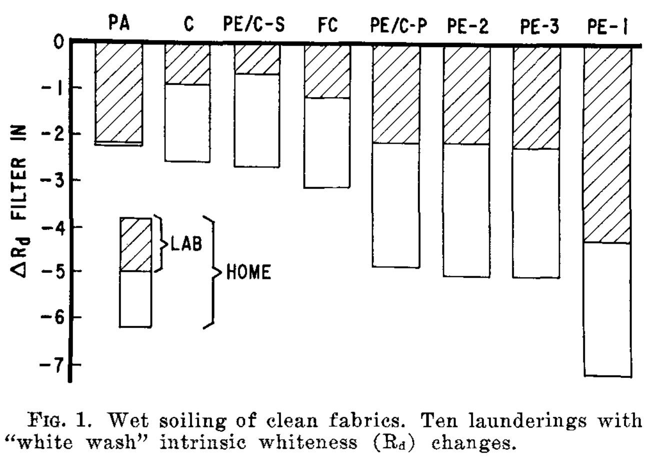

FIG. 1. Wet soiling of clean fabrics. Ten launderings with "white wash" intrinsic whiteness (R_d) changes.

TABLE III

Total Reflectance Loss by Families

Family No.	Intrinsic whiteness loss 10 "white washes"
1	26.8
2	46.6
3	84.5
4	15.5
5	41.6
6	28.5
7	8.4
Laundry laboratory	15.5

The considerable differences between the laboratory and home-washed fabrics can be attributed to what is loosely termed "poor laundry practice." The laboratory experiments for this study were carried out by trained professionals with sorted and weighed laundry, weighed amount of detergents, specially decolorized water, and a fixed temperature. Water hardness was added in known quantities.

Therefore many factors could contribute to the observed difference between home and lab results, such as water color, dye transfer due to poor sorting, water temperature, bleaching, and detergent underusage.

All of these factors are recognized as being traditionally important in the washing machine. To determine if any of them could be a major cause of the generally less satisfactory performance of the polyesters or might explain the disproportionately poor results obtained with them (in comparison with cotton) by certain families, work was continued on redeposition by using real laundry as the soil source and varying conditions of washing as needed.

Each of the first four factors was systematically eliminated as the primary contributor to the observed differences. The last of these, detergent under-usage, was found to be quite important in creating a problem in the wash.

Again with the technique of home wash, the composite swatches were soiled by washing with white loads at normal detergent concentration and at one-half the recommended usage levels.

All of the fabrics tended to soil more heavily at

TABLE IV

Wet Soiling: 10 "White Washes"
Effect of Detergent Concentration

	Δ R_d (Filter in)	
Fabric	Normal concentration	Half concentration
C	−1.2	−2.5
FC	−2.6	−6.9
PA	−1.8	−3.7
PE-1	−7.3	−19.4
PE-2	−3.2	−9.8
PE-3	−3.0	−9.2
PE/C-S	−1.4	−4.8
PE/C-P	−5.6	−12.6
Mean	−3.4	−8.5

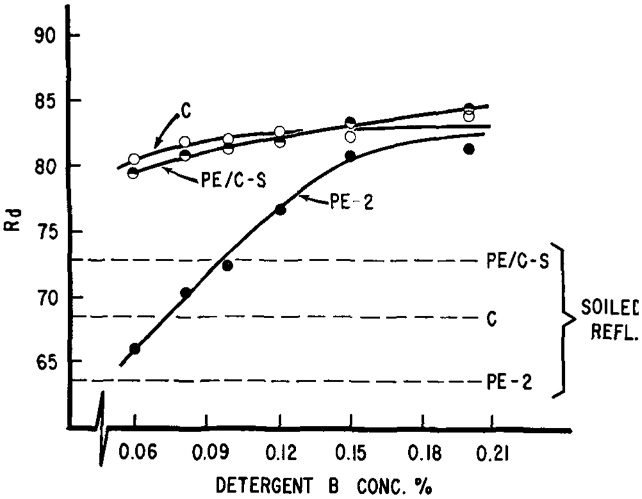

FIG. 2. Detergency of Spangler soil.

low detergent concentration (Table IV). With cotton the absolute magnitude of this effect was small, i.e., cotton proved to be fairly insensitive to detergent under-usage. However the "hydrophobic" fabrics suffered a greater loss of reflectance when washed at the lower concentration. The polyesters, in particular, exhibited relatively large increases in grayness.

Private market-research surveys have shown that housewives tend to under-use detergents in actual practice (particularly the high-foaming types). Therefore it is reasonable to conclude that prevalent washing practice in the home tends to accelerate the development of grayness on polyesters.

In order to study further the effect of under-usage the soiling and detergency method devised by Spangler (1) was modified slightly. This method was used to study the detergency of three of the Group I fabrics by Detergent B, an all anionic-active built detergent. A combination of synthetic sebum and air-borne particulate soil was padded on the fabric and dried. Swatches were then laundered in a Tergotometer at various detergent concentrations. Representative fabrics chosen for study were the cotton, the polyester-cotton shirting blend, and one polyester. Two soiled swatches and one clean swatch of each fabric were included in each wash load. Figure 2 shows the concentration dependence of detergency for these fabrics.

It is clear that the detergency of the polyester is

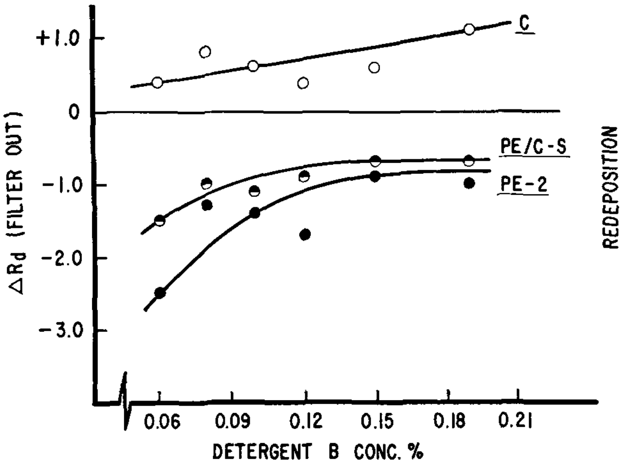

FIG. 3. Redeposition of Spangler soil in washing.

TABLE V

Redeposition at 120F Group II Fabrics (Δ Rd)

	0.15% Detergent P		0.15% Detergent PX	
	Practical laundry	Laboratory soil	Practical laundry	Laboratory soil
C-2	+1.4	+0.2	+3.5	+0.7
PE-C-2	−0.9	−0.1	+0.1	+0.2
DP	−1.2	−0.5	−0.9	+0.4

drastically affected by low detergent B concentration since the rate of increase in detergency with increasing concentration is quite steep. By contrast, the cotton and the blend are much less affected in the concentration range under study. Similar behavior was noted with the redeposition of soil on the clean swatches (Figure 3).

Redeposition on the polyester fabric increases rapidly as the detergent concentration decreases. Thus the under-use of detergent is particularly detrimental to the polyester and probably accounts for the extremely large amount of redeposition sometimes observed in home washing. Further it would appear that, at least with Detergent B, polyester detergency may not become maximized in the concentration range of 0.12 to 0.15%, which is usual for the 150-ppm water-hardness level in these tests, but rather in the range of 0.15 to 0.18%.

Group II Fabrics

Table V shows the redeposition ranking arrived at by each method when washing was carried out at 120F with two different detergents, at 0.15% concentration in each case. The over-all picture indicates that redeposition increases in going from cotton to polyester/cotton to polyester/cotton with Durable-Press finish.

The data also indicate a possible shortcoming of the laboratory method when used as a redeposition test. In detergent PX (which seems to be a better antiredeposition system than detergent P), for instance, there is some lack of discrimination when redeposition is prevented to a great extent. This would indicate that, for screening purposes, the soil load on the system should be increased.

Other data not included in the present work indicate that redeposition in good antiredeposition systems can be studied by using more soiled fabric and multiple washes. When this is done, the ranking of these three fabrics is identical with the practical method.

Several commercial laundry detergents were studied for their ability to remove Spangler soil from these three fabrics at two concentrations, 0.1% (slightly below normal use level) and 0.2% (slightly above normal use level). In this case the data (Table VI)

TABLE VI

Concentration Dependence of Soil Removal Spangler's Soil

	Δ Rd (0.2% conc.) minus		Δ Rd (0.1% conc.)
Detergent	Cotton broadcloth	PE/C shirting	Perm. press PE/C shirting
Anionic types			
1	2.8	7.4	6.0
2	2.5	12.3	6.1
3	0.8	7.5	4.3
Mean	2.0	9.1	5.5
Nonionic types			
1	2.2	2.6	2.7
2	2.9	7.9	5.7
Mean	2.6	5.2	4.2

are presented as the difference between the soil removed with the higher concentration of detergent and that removed with the lower concentration.

Again, the sensitivity of polyester-containing fabrics to detergent under-usage is indicated. Also, little or no difference was observed between built detergents with anionic and nonionic actives. Some investigators (2) have indicated a preference for nonionics in polyester cleaning but, under these conditions which closely approximate practical usage and appear to correlate well, anionics seem to do as good a detergency job as nonionics if sufficient detergent is used.

It is interesting to note that the experimental detergent PX, shown previously to be more effective at preventing redeposition than the all-anionic detergent P, contained a mixture of anionic and nonionic actives. Since both of these detergents contained the same mixture of antiredeposition agents, it is conceivable that the presence of nonionic surfactant improves antiredeposition effectiveness. This is substantiated by the teachings (3) of U.S. Patent No. 3,144,412 which essentially indicates that any antiredeposition system works better in the presence of nonionic surfactant, either alone or mixed with an anionic surfactant, and redeposition on polyester-cotton blends can be minimized by including polyvinyl alcohol in the antiredeposition system.

ACKNOWLEDGMENTS

J. R. Trowbridge contributed many helpful suggestions on the presentation of data. Much of the experimental work was done by Miss Cora Green and the staff of the Practical Laundry Laboratory.

REFERENCES

1. Spangler, W. G., B. R. Schaafsma and H. D. Cross III, JAOCS *42*, 723 (1965).
2. Fort, T., H. R. Billica and T. H. Grindstaff, Textile Res. J. *36* 99, 108–109 (1966).
3. Inamorato, J. T., (Colgate-Palmolive Company), U.S. 3,144,412 (1964).

[Received March 20, 1967]