Experimental Work Comparing the Performance of Wash Bath Additives used in the Aqueous Immersion Cleaning of a Series of Standard Soiled Fabrics

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Abstract

In aqueous cleaning unwanted soil is removed from a textile substrate. For aqueous cleaning to be effective, the removed soil must be held in suspension and prevented from redepositing on the textile's cleaned surface.

This paper reviews literature pertaining to the ability of wash bath additives to remove soil and prevent soil redeposition. The paper discusses the function of anionic and non-ionic surfactants and the use of the soil anti-redeposition agent, sodium carboxymethyl cellulose (SCMC) in textile conservation.

The effectiveness of using anionic, non-ionic and mixed surfactant systems in the presence and absence of sodium carboxymethyl cellulose was experimentally determined. A series of cotton, wool, silk and polyester standard soiled fabrics samples were cleaned under conditions relating to conservation use. To determine the quantity of soil removed and soil redeposited the reflectance values of the fabric samples were measured using a Varian Series 634 spectrophotometer.

The results find wool and silk are successfully cleaned using a non-ionic surfactant while cotton and polyester are effectively cleaned using a mixed surfactant system. The addition of SCMC to each wash bath increased the amount of soil removed and prevented redeposition on cotton, was of little benefit to wool, and marginally improved the cleaning of silk and polyester. The paper postulates that SCMC may in fact be a superfluous agent when used with anionic surfactants but of some benefit to non-ionic surfactants.

Introduction

There are many reasons for removing soil from historic textiles. Soiling can alter the chemical and physical constitution of the textile and if left untreated a variety of mechanisms may lead to fibre deterioration (Timar-Balazsy & Matefy 1993). There are several methods for removing soil from textiles, however, wet cleaning via aqueous immersion is one of the most effective. Wet cleaning utilises water as the solvent and medium to dislodge and carry the soil away. Immersion cleaning serves to improve the visual appearance of the textile, the water acts as a plasticiser for the fibre polymer by reintroducing fibre flexibility and most importantly it may increase the long-term preservation of the textile (Timar-Balazsy & Eastop 1998).

A mix of surfactants and soil anti-redeposition agents may be added to the solvent bath. Other wash bath additives are used for various reasons which will not be discussed in this review. Surface active agents or surfactants are available in different chemical compositions which effect the interaction between the fibres and the soil. A surfactant's ability to remove soil and maintain that soil in suspension varies; conservators correct this problem by adding an anti-redeposition agent to the wash bath. Soil redeposition occurs when the soil removed by aqueous immersion deposits back on the cleaned textile surface (Kissa 1983). The paper investigates the soil removal and suspension capabilities of various surfactants and focuses on the effectiveness of sodium carboxymethyl cellulose (SCMC) as an anti-redeposition agent.

SCMC was chosen for investigation as it is the most popular anti-redeposition agent used by conservators (Timar-Balazsy and Eastop 1998). Current literature agrees that the efficiency of SCMC depends primarily on its ability to adsorb onto certain fibres. This makes it the most effective polymer in preventing soil redeposition on cotton fabric (Broze 1994). Conservation studies to date have focused on the performance of surfactants in the wash bath, but little attention has been given to SCMC and its effectiveness as an anti-redeposition agent.

An experiment was designed to investigate and evaluate several surfactants and SCMC and review their function in the wet cleaning process. The methodology and analysis used reflects current industry standards and conservation practice in regards to wet cleaning. The surfactants were selected to represent non-ionic, anionic and a mixed surfactant system. Four different fabrics – cotton, wool, silk and polyester – were used to illustrate the effect fibres have on the wash bath additives. The author assumes the reader's knowledge of fibre and surfactant chemistry and the effect they have on soil adhesion and removal. Analysis was achieved instrumentally by recording reflectance values on the soiled samples before and after washing using the Varian Series 634 spectrophotometer.

The experimental methodology

An experiment was designed to determine the effectiveness of adding SCMC to the wash bath in the presence of certain surfactants. The fabrics cotton, wool, silk and polyester have been chosen to represent the variety of fibre types encountered by textile conservators. Standard soil, from 3M Australia, was applied directly to each sample in solvent/soil dispersion.

Each sample underwent an aqueous immersion treatment that reflects wash procedures used in conservation to wash historic textiles. The methodology was chosen based on common practice amongst textile conservators with reference to textile industry International and Australian Standards. Half the samples were washed with surfactant alone and the other half were washed with surfactant and SCMC a soil anti-redeposition agent. The temperature, pH, immersion time and mechanical agitation of each bath were kept constant to test the cleaning ability of the surfactant and SCMC.

Wash bath additives

Surfactants have been selected to represent the non-ionic and anionic surfactant groups and include a mixed surfactant system. Orvus WA™ Paste, a primary alkyl sulphate, a standard wash solution (SWS) used by the Australian War Memorial, and Teric G12A7™, an alcohol ethoxylate, were the surfactants chosen for the experiment.[1] [2]

A mixed surfactant system made in accordance with the Australian War Memorial's SWS contains Lissapol N™, a nonylphenol ethoxylate (Synperonic N™), and Hostapon T™, a fatty acid methyl tauride from the secondary alkyl sulphate group of anionic surfactants.
To the solution sodium tripolyphosphate, a sequestering agent, and SCMC are added

Concentrations

The Australian War Memorial recommends wash bath concentrations of 3–3.5 %. At 3% the non-ionic Lissapol N™ was calculated at 0.108% or 1.08 g/L and the anionic surfactant Hostapon T™ at 0.054% or 0.55 g/L. At 3% the SCMC is used at 0.01% or 0.1 g/L. (Table 1)

The surfactants were used at the concentrations as close as possible to their optimal cleaning concentrations. The cleaning ability of surfactants is dependant on the surfactant reaching critical micelle concentration (cmc). The presence of micelles aids the solublisation and soil carrying ability of the surfactant. Timar-Balazsy and Eastop (1998) state non-ionic surfactants reach cmc at 0.05–0.5 g/L, whereas the cmc of anionic surfactants is much higher at 0.5 –3 g/L. The cmc is the starting point for cleaning and, although the minimum amount of sur-

	Australian War Memorial's Standard Wash Solution	Chemical Principles of Textile Conservation (1998)	Shashoua Standard Wash Solution (1996)
Non-ionic	1.08 g/L	0.1–0.5 g/L	0.1 g/L
Anionic	0.55 g/L	0.5–1.0 g/L	_
SCMC	0.05 g/L	0.05 g/L	0.05 g/L
Sequestering agent	1.08 g/L	0.5–2.0 g/L	0.01 g/L

Table 1: Concentrations of wash bath additives used in conservation

factant is often required for textile conservation, the optimal soil removal capabilities of the surfactant are over cmc.

The optimal cleaning concentration of Orvus WA™ Paste has been previously researched by Boring and Ewer (1993), who tested a range of concentrations and found 1% v/v to have optimal cleaning power. Eastaugh (1987) found the non-ionic surfactant Synperonic N™ had not reached maximum cleaning ability at the concentrations she tested. Eastaugh concludes Synperonic N™ is increasingly effective up to 0.6 % v/v (6 ml per 1L) and further research is needed well beyond the cmc. In light of this research the replacement non-ionic surfactant Teric G12A7 ™ was be tested at 0.6% v/v. The Orvus WA™ Paste was used at 1% v/v. The standard wash solution was used at 3% as recommended by the Australian War Memorial.

Anti soil redeposition agent

A low viscosity SCMC is needed for better solubility in water. A low viscosity SCMC from Merck (code 27649. 4N) was used with a degree of substitution (D.S) of 0.65–0.85, suitable for use in conservation wash baths.

In commercial washing powder SCMC makes up 0.5–2% of the detergent, however, the amount of SCMC considered suitable for washing historic textiles according to Smith and Lamb (1981) is 0.005% (0.05 g/L). The concentration 0.005% SCMC was used in the experiment as it reflects the concentration of SCMC used in current textile conservation practice.

Fibres and fabrics

Several different fabrics were required for the experiment to determine the role fibres play in soil removal and surfactant interaction. Cotton, wool and silk were selected as these fabrics are frequently encountered by textile conservators. Cotton fabric was used in this experiment to represent the cellulose group of fibres. Polyester fabric was included to represent the large group of synthetic fibres and offered a comparison between the natural fibres and fibres of synthetic nature.

To measure changes in reflectance and determine the smallest amount of soil redeposited, the fabric samples should be as close to white as possible (AS 2001.4.1:1996). Cream-coloured fabrics were chosen as white wool and silk are difficult to find. The fabrics selected are a plain weave and possess similar weights, thicknesses and thread counts.

Standard soiling

A mixed component soil is available from 3M Australia and is used in the textile industry as an upholstery soil. The Australian Wool Testing Association uses this standard soil to undertake the 'Rapid Soiling Tester' that measures the rate at which carpets become soiled (IWS Test Method 267). The 3M standard soil contains: Peat moss 38.4%, Cement 18.0%, Kaolin Clay 18.0%, Silica 18%, Mineral oil (Nujol) 6.25%, Furnace Black 1.5%, Red Iron Oxide 0.3%.

Sample preparation

The fabrics were divided into eight groups, each with a different wash bath additive. Four of these groups were washed in deionised water with the surfactant. The surfactant baths were replicated with the addition of SCMC. The soiled fabrics were washed in deionised water without surfactant which established a control group. A second control group added SCMC to the deionised water and was used to indicate the soil suspension power of SCMC in the absence of a surfactant. Prior to the experiment the fabrics were washed in hot water and ironed to remove any surface finishes and provide a flat surface for the application of the standard soiling.

The International Standard (ISO 105 J01:1997) stipulates the size of fabric samples should be large enough to suit the method of analysis. The Varian Series 634 spectrophotometer has limited area to insert the samples and for this reason the samples were no wider than 6 cm. The samples were cut into rectangles 6 cm x 12 cm and folded in half around a plastic mount 5.5 cm x 7 cm in size.

Each sample was numbered with a water fast laundry pen. The ink was tested prior to use as a soluble ink could result in the loss of identification and could interfere with the reflectance results.

The method chosen for the application of particulate soil was suggested by Thomas Klaas, the Technical Director at Testfabrics. When applying standard soil to fabrics the only standardised aspects are that of consistency in application, substrate and soil media. Application methods were tested and it was found that using the dry soil without dispersive medium produced an uneven coating easily removed from the fibre surface. Acetone (CH_3COCH_3) was found to be a suitable solvent as it dissolved very little of the soil (by weight) and the dispersion created was evenly distributed onto the textile surface. A 3:1 soil to solvent ratio had the best working properties and covered the surface evenly.

The soil solution was painted onto the surface of the fabric using a Mylar™ template to restrict the boundaries of the soiled area and to improve uniformity amongst the samples. The Mylar™ template was used to keep the remaining unsoiled area of the sample as clean as possible and to concentrate the soil in a designated area of 2 x 4 cm.

The fabric samples were laid in rows on a clean surface with the right side up and the numbers visible. Templates were aligned on the surface of the samples and held in place with a small glass weight. The soil was weighed, placed in trays, and individually added to the beaker and mixed with acetone. A stiff natural bristle paint brush was used as it readily took up the dispersion and using several even strokes the dispersion was applied.

As the samples have to slot into the spectrophotometer the samples were mounted on plastic cards made from white Corex™ board made from polyethylene plastic. This size card allowed ease of handling without touching the fabric and prevented movement of soil from the soiled areas to clean areas. A 1 cm area at the top of the card was used for labeling and handling the samples. A number was given to each fabric sample which corresponded with the number on the card. The fabric was wrapped around the card with the soiled area of fabric on the front and the clean area on the reverse. The fabric was held in place with double-sided tape. Eight different wash baths were needed including the two control groups. Each wash bath was replicated for all four fabric types. The methodology for each wash was repeated three times, allowing an average to be calculated from the results which required a total of 96 samples.

Determining soil removed and redeposited

To determine the soil removed and redeposited on a textile by a wash bath the reflectance readings must be taken prior to washing and again after washing (Kissa 1984).

The colour change in samples as a result of washing can be recorded with a spectrophotometer or reflectometer (AS/NZS 4146: 2000, ISO 105-A04: 1989, ISO 105-J01: 1997). Don Hampshire at the Australian Wool Testing Association recommends the spectrophotometer for determining soil removed and redeposited on washed textiles. The spectrophotometer is more widely used in textile testing than the reflectometer due to greater sensitivity and accuracy of readings (Hampshire 2001).

An optimal wavelength is selected when working with a spectrophotometer enabling further readings of the samples to be made at the same wavelength. This is only possible if the difference between the reflectance data for any one sample remains relatively constant at this wavelength. In conservation studies using spectrophotometers Eastaugh (1987) selected the wavelength 460 nm and Shashoua (1990) selected 500 nm for their analysis. An initial test was carried out between 400 nm and 760 nm at 20 nm intervals and revealed the reflectance values were not constant between 400 nm and 500 nm for the unsoiled area of the sample. Testing showed that minimal deviation for this machine fell between 520 nm and 640 nm and the wavelength 560 nm was selected for the reflectance readings.

To record the data, a minimum of three readings was taken per side to gather three similar values with a deviation of no more than 0.5%. The mean value was then recorded and the other values were disregarded.

Wash bath methodology

The aqueous cleaning was undertaken at a constant temperature of 25°C and at pH 7, using deionised water in all baths and all rinses. The wash time, amount of agitation and number of rinses was kept the same for all samples. The aim of the experiment was to test the ability of the surfactant and SCMC in the removal and suspension of soil and not the effect of temperature or other variables, and for this reason the conditions were kept constant. The aqueous immersion cleaning method is a combination of popular procedures used by textile conservators and takes into consideration industry standards.

To cover the fabric sample with 2 cm of water, the volume needed for each bath is 300 ml. The ratio of liquid in a wash bath is important to suspend the soil and allow movement of the fabric. In laundering, a satisfactory ratio of water to fabric is 10:1, and this applies to the wash and rinse baths (AS/NZS 4146, 200). The samples in this experiment weighed between 0.36 and 0.76 grams and 300 ml of water was used in the wash bath. Using a greater ratio of water to fabric in each bath allowed a larger volume of water and surfactant to maintain the soil in suspension.

Shashoua (1990) found a 30 minute soaking time resulted in maximum soil removal, however, if the time was increased, noticeable weakening of the fibres occurred. In a follow up investigation Shashoua (1996) concluded immersion time and mechanical action such as sponging or running water should be kept to a minimum due to the damaging effects they had on historic textiles. A decision not to mechanically interfere with the samples was made to test the cleaning ability of the wash bath additives and therefore the press and release methods using a sponge was not employed.

The samples were immersed in the wash bath solution for 20 minutes. The samples were soaked for the first 10 minutes, followed by 5 minutes agitation by rocking the bath and allowing the water to move freely across the fabric's surface. The samples were then soaked for another 5 minutes and removed from the bath and laid on clean Mylar™. The bath water was drained and the rinse water added with a total rinsing time of 15 minutes.

The temperature of the bath is very important in washing and rinsing as it effects the performance and solubility of the surfactant and soil removal increases with increasing temperature. In commercial laundering, temperature is varied depending on fibre type and generally exceeds 30°C. As high temperatures can be considered detrimental to some historic textiles, wash bath temperature is often chosen to suit the fibre type and the condition of an individual textile.

A temperature of 25°C was selected for the wash and rinse baths. This temperature is considered mid-range for the fibre types in the experiment and is not too high to be used when washing historic textiles.

Three rinses followed the wash bath. The rinse water was be added at 25°C and the pH of the water again adjusted to neutral. Each rinse bath was be 5 minutes in duration with 1 minute of agitation by rocking the bath. At least three rinses were necessary to remove the higher proportion of soil present in the wash solution (AS/NZS 4146, 2000).

After rinsing, the samples were placed on the side of the bath to drain for 2 minutes. The samples were then placed on a Mylar™ sheet to air dry. Blotting paper or other absorbent material will move soil away from the samples and would not give a true indication of the cleaning ability of the wash bath additives.

Once dry, the samples were lightly ironed from the back to remove all creases which would create shadowing and hinder reflectance readings (AS/NZS 4146, 2000). The samples are then re-adhered to the double-sided adhesive tape.

Reflectance data

The following equations will be applied to the data. The reflectance data is used directly to obtain the soil removed (%SR) values. Percentage of Soil Removed:

$$\frac{Yt - Yo}{Yw - Yo} \times \frac{100}{1}$$

Yt = value of the soiled area, washed
Yo = value of soiled area, unwashed
Yw = value of unsoiled area, unwashed (AS/NZS 4146: 2000)

The degree of intrinsic graying Δ**G** (soil redeposited) will be calculated using the following equation:

$$\Delta G = Y_0 - Y_1$$

Y_0 = the arithmetic mean of cleaned area before washing expressed to one decimal place.
Y_1 = the arithmetic mean of the cleaned area after washing expressed to one decimal place. (AS/NZS 4146: 2000).

		Control	Orvus	SWS	Teric
Cotton					
%SR	Surfactant	4.9	10.5	15.7	13.5
	Surfactant + SCMC	9.6	12.9	17.3	15.3
SRD	Surfactant	- 0.2	- 1.0	- 0.1	1.0
	Surfactant + SCMC	- 0.4	- 0.9	- 0.4	0.8
SILK					
%SR	Surfactant	1.6	8.7	4.4	14.2
	Surfactant + SCMC	1.8	7.2	8.0	22.6
SRD	Surfactant	- 0.4	- 0.6	- 0.7	0.7
	Surfactant + SCMC	- 0.1	- 0.5	0.0	0.5
WOOL					
%SR	Surfactant	2.7	2.4	6.0	7.1
	Surfactant + SCMC	1.4	3.6	4.5	6.1
SRD	Surfactant	0.2	0.9	0.3	1.2
	Surfactant + SCMC	0.2	0.3	0.2	1.1
POLY					
%SR	Surfactant	24.3	48.6	62.7	34.5
	Surfactant + SCMC	23.9	38.2	33.4	51.3
SRD	Surfactant	- 1.2	- 1.5	0.8	1.0
	Surfactant + SCMC	- 1.6	- 0.7	0.4	0.4

Table 2: Results calculated from reflectance readings

The difference in reflectance values of the soiled proportion of the sample before and after washing will be used to calculate the soil removed (%SR). The degree of intrinsic graying or the soil redeposited (SRD) was calculated from the difference in reflectance of the unsoiled area before and after washing. The results for soil removed (SR%) and soil redeposited (SRD) are listed in Table 2.

Soil removed and soil redeposited

Cotton substrate

On cotton the percentage of soil removed was increased by the addition of SCMC with all surfactants. The most effective surfactant for soil removal and no soil redeposition on cotton was the standard wash solution. Teric G12A7™ had good soil removal results but failed to hold that soil in suspension. The addition of SCMC reduced the amount of soil redeposited.

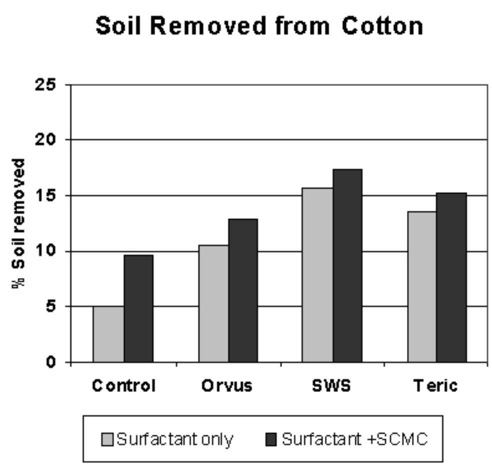

Figure 1: Soil removed from cotton

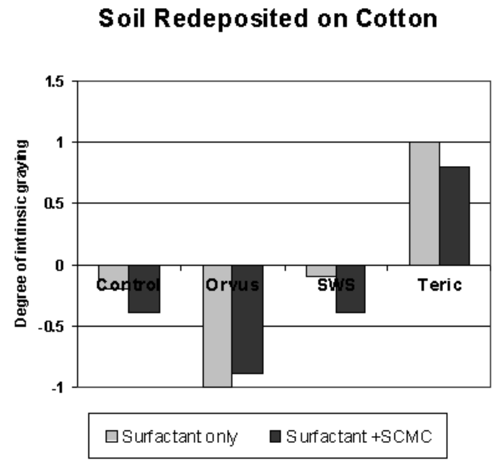

Figure 2: Soil redeposition on cotton

Wool substrate

The percentage of soil removed from wool was low when compared with the other fabrics. The most soil removed was with TericG12A7™ , closely followed by the standard wash solution. With the exception of Orvus WA™ Paste, SCMC hindered soil removal when added to all wash solutions. Soil redeposition occurred in all wash baths with the smallest amount of redeposition in deionised water and the most with Teric G12A7™. The addition of SCMC was of some benefit to all wash solutions in maintaining the removed soil in suspension.

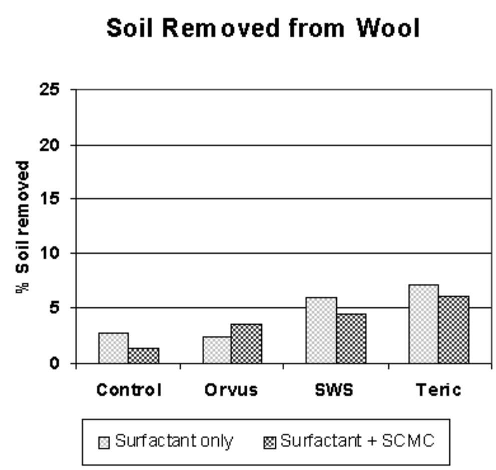

Figure 3: Soil removed from wool.

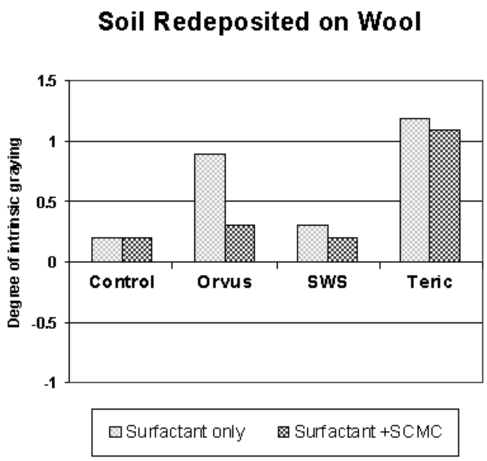

Figure 4: Soil redeposited on wool.

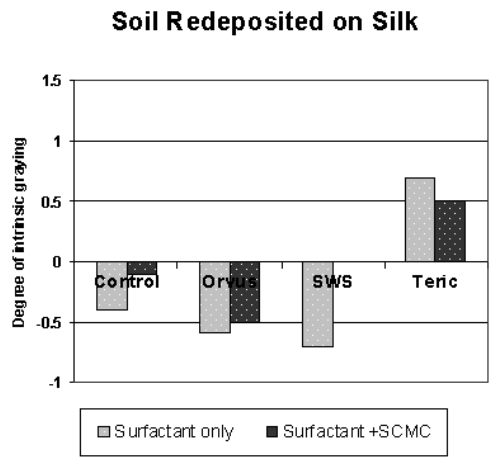

Figure 6: Soil redeposited on silk.

Silk substrate

The most effective surfactant for removing soil from silk was Teric G12A7™ with soil removal improving when combined with SCMC. Soil removal was increased with the addition of SCMC to the standard wash solution, whereas Orvus WA™ Paste was hindered by the presence of SCMC. As with cotton the soil redeposition on silk only occurred with the non-ionic surfactant Teric G12A7™. The addition of SCMC marginally reduced the amount of soil redeposited with this surfactant.

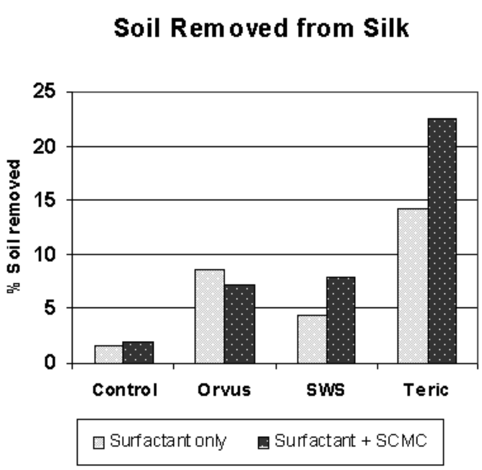

Figure 5: Soil removed from silk.

Polyester substrate

The percentage of soil removed was greater from polyester than any other fibre with the best results using the standard wash solution in the absence of SCMC. Teric G12A7™ was the only surfactant that benefited from the addition of SCMC. Soil redeposition did not occur with deionised water and Orvus WA™ Paste. The addition of SCMC to Teric G12A7™ and the standard wash solution improved the soil redeposition results.

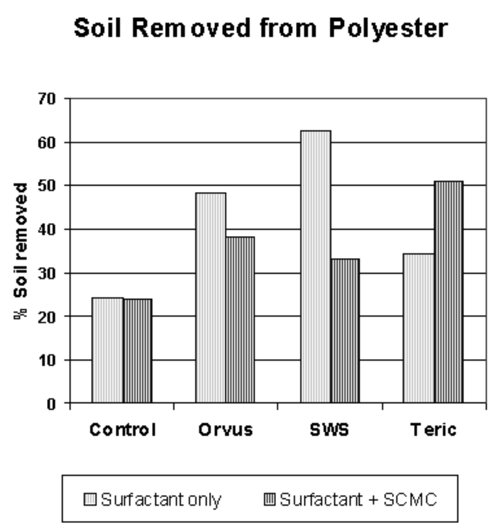

Figure 7: Soil removal from polyester.

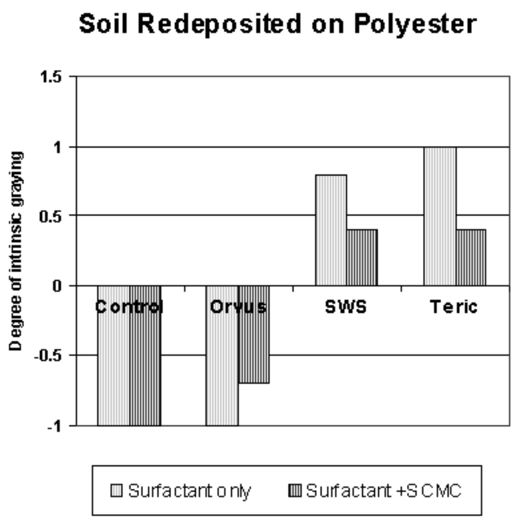

Figure 8: Soil redeposited on polyester.

Summary of results

Soil removed

The highest percentage of soil removed from silk and wool was in the Teric G12A7™ wash bath. For cotton and polyester it was the standard wash solution that proved to be the most effective cleaner. The soil removal results indicate that Teric G12A7™ and the standard wash solution were the surfactants that benefit most from the addition of SCMC.

The addition of SCMC to the standard wash solution actually reduced soil removal from polyester and wool and increased the soil removed from silk and cotton. In the Orvus WA™ Paste wash baths the addition of SCMC decreased soil removal from silk and polyester, whereas addition of SCMC clearly increased soil removal in Teric G12A7™ from cotton, silk and polyester.

Soil redeposition

The figures illustrate the degree of intrinsic graying or the amount of soil redeposited on the clean surface of the fabric. Soil redeposition occurs when the surfactant or SCMC fails to maintain the removed soil in suspension. The results indicate that the soil redeposited was greatest with Teric G12A7™. The best results were achieved using Orvus WA™ Paste with no soil redeposited on cotton, silk or polyester.

The standard wash solution prevented soil redeposition on cotton and silk but not polyester or wool. The effect of the addition of SCMC is difficult to ascertain, as the results were not consistent.

Discussion

Fibres

Polyester fabric had the highest percentage of soil removed, followed by silk and cotton and, lastly, wool. Polyester is a continuous filament fibre similar to silk; the soil does not occlude along the surface of the fibres or the surface of the yarn. This would explain the large percentage of soil removed from these samples. In contrast, wool fibres are shorter in length with epidermal scales protruding from the surface, providing many places for soil particles to occlude. This contributes to wool having the lowest amount of soil removed in the experiment. The silk and polyester fabric had slightly higher thread counts than the wool and cotton. A higher thread count and tighter weave enables the soil particles to sit of the surface of the fabric and a looser weave enables the soil particles to occlude in the matrix of the fabric which makes them more difficult to remove and for this reason may have an effect on the results.

Surfactants

An area for concern is the adsorption of surfactants onto textiles. Alkyl sulphates and sulphonates react with positively charged amino end groups in wool and silk (Walker 1995). For this reason, anionic surfactants should not be used to wash wool and silk. The anionic surfactant Orvus WA™ Paste chosen for the experiment showed very low soil removal from wool with soil redeposition. The cleaning power of Orvus WA™ Paste was slightly better on silk with no soil redeposited. The results support literature advising against the use of anionic surfactants to wash wool and silk as they are not as efficient cleaners as non-ionic surfactants.

Orvus WA™ Paste when used to wash cotton and polyester again only showed average soil removal results, but it was a good surfactant for maintaining the soil in suspension. The washing ability of Orvus WA™ Paste could be improved by using temperatures greater than 25°C which would improve its solubility. Using Orvus WA™ Paste at 1% v/v is above its cmc, which supports the literature that suggests anionic surfactants have good soil carrying capabilities above cmc (Timar-Balazsy & Eastop 1997). Further research could be undertaken into the optimal temperatures to use Orvus WA™ Paste to clean cotton or polyester fabrics.

The non-ionic surfactant Teric G12A7™ was used at 0.6% and showed excellent soil removal results when used to wash silk and polyester, and good results with cotton and wool. The results support the claims that non-ionic surfactants are better than anionic surfactants at cleaning synthetic fabrics in the presence of oily soil (Schick 1966). The ability of Teric G12A7™ at maintaining the soil removed in suspension was poor. Schick (1966) recommends the use of non-ionic surfactants at above their cmc and advises to avoid rinsing for long periods at high temperatures; possibly a 15-minute rinsing time was too long for Teric G12A7™. The experiment shows some excellent results using Teric G12A7™ and further research is needed to determine the suitability of the surfactant as a conservation product and as an alternative to the alkylphenol ethoxylates.

Standard wash solutions are preferred by many textile conservators for washing textiles. There are many advantages to using a mixed surfactant system, as even a 50/50 molar mix of anionic/non-ionic surfactant has the solubilisation and soil carrying capacity of the average of the two pure surfactants (Scamehorn 1986). A mixed surfactant system has the advantage of the non-ionic surfactant's surface activity and ability to penetrate a variety of soils and the anionic surfactants ability to solubilise and carry different soils. The standard wash solution in the experiment had excellent cleaning results on cotton, polyester and wool. The ability for the detergent to maintain soil in suspension and prevent redeposition was good on cotton and silk, but average on wool and polyester.

The effect of SCMC

The addition of SCMC improved soil removal on the cotton samples. The other fabrics generally did not benefit from the addition of SCMC, and in many cases its presence in the wash bath reduced the surfactant's ability to remove soil. Further research is needed into SCMC and its interaction with different surfactants and why detergency is improved or hindered. SCMC reduced soil redeposition on cotton in all baths except those using Orvus WA™ Paste. This supports the literature that suggests SCMC forms bonds to cellulosic fibres to prevent soil redeposition.

SCMC benefits the surfactant Teric G12A7™ on each fibre type except wool, reducing the amount of soil redeposited. SCMC is an anionic polymer and Teric G12A7™ a non-ionic polymer; the combination of the two may be of some benefit to the wash bath. SCMC is of little benefit to Orvus WA™ Paste and only marginally beneficial to the standard wash solution in terms of preventing soil redeposition.

Conclusions

The effectiveness of adding SCMC to the wash bath not only benefits soil redeposition but is effective at increasing the soil removed from cotton fabric. The results indicate that adding SCMC to wash baths for wool, silk and polyester may in fact reduce the soil removal capabilities of the surfactants. The results indicate addition of SCMC is most beneficial when used with the non-ionic surfactant Teric G12A7™, and of little benefit to the anionic surfactant, Orvus WA™ Paste and the standard wash solution as the soil carrying capabilities of these surfactants are already very good.

In conclusion, SCMC is consistently effective as a wash bath additive for soil removal and suspension when used to wash cotton fabric. SCMC used in conjunction with a non-ionic surfactant, such as Teric G12A7 ™, with good cleaning capabilities aids the surfactant in maintaining the soil in suspension thus preventing soil redeposition.

Endnotes

1. A nonylphenol ethoxylate (Synperonic N™) was included in the experiment but the results and discussion have been omitted from this paper as this surfactant is no longer used in textile conservation. The author would like to note that the cleaning and soil carrying capabilities for Synperonic N™ were the lowest of all the surfactants tested.

[2] The War Memorial's SWS is made up of the following additives in 500 mls of deionised water:
20 g sodium tripolyphosphate
20 g Lissapol N™
10 g Hostapon T™
2 g sodium carboxymethyl cellulose

Keywords
Aqueous immersion cleaning, sodium carboxymethyl cellulose, surfactants, soil redeposition, soil removed

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Acknowledgements

I would like to thank the Australian National University, in particular Fred Chow whose expertise and spectrophotometer made this research possible. I would like to thank Peter Smith at Perkin-Elmer for his time and John Nguyden at 3M Australia for donating the standard soil. I would especially like to thank Gina Drummond for her support and encouragement.

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