EVALUATION OF METHODS OF APPLYING OIL TO BEDCLOTHES AND PRACTICAL APPLICATION OF THE SELECTED METHOD

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Thomas & Van den Ende (1941) and Puck and his collaborators (Puck, Hamburger, Robertson & Hurst, 1945; Puck, Robertson, Wise, Loosli & Lemon, 1946) have shown that the application of small amounts of oil to bedclothes reduces the quantities of dust and bacteria liberated during bedmaking. Joyce Wright in her first investigation (Wright, Cruickshank & Gunn, 1944) found that oiling bedclothes was, consequently, effective in reducing the incidence of cross-infection, but this was not confirmed in her later work (Wright, Begg & Smellie, 1947), or by Krugman & Ward (1951). Barnard (1952), however, has recently shown that cross-infection can possibly arise by interchange of bacteria in blankets during laundering. Oiling of bedclothes may, therefore, be a very useful hygiene measure.

Most investigators of methods of applying oil to bedclothes have followed the general procedure of treating them with a white oil emulsion during the laundering process. Various types of emulsions have, however, been used. Thomas & Van den Ende (1941) prepared their emulsions by adding self-emulsifiable oils to the last cold-water rinse in the laundry process. They preferred to use translucent emulsions, which are more stable, and to employ anionic emulsifying agents, such as sulphated castor oil, petroleum sulphonates, and alkyl sulphates. Harwood, Powney & Edwards (1944), of the British Launderers Research Association, evolved procedures by which the treating emulsions were completely exhausted of oil so that better control of the amount deposited on the bedclothes was obtained and no oil was wasted. Their procedure for woollens was to treat with a positively charged emulsion, obtained by diluting a stock emulsion prepared by means of a cationic emulsifying agent, while cotton articles were impregnated by the mutual coagulation of negatively-charged (anionic) and positively-charged (cationic) emulsions. The importance of thorough washing and rinsing to prevent 'build-up' of oil and to remove absorbed soaps, which may prevent uniform oiling, was emphasized. Bayley & Weatherburn (1945) investigated the B.L.R.A. process, and found that oil exhaustion was increased by reducing the emulsifier concentration to the minimum required for stable emulsions, and also that traces of soaps remaining after washing prevented complete oil exhaustion owing to their reversal of the charges on the emulsion droplets. They therefore suggested the insertion of a 'souring' operation in the laundering cycle. Puck *et al.* (1946) reverted to the Thomas & Van den Ende method in principle, and tried various emulsifying agents. They found that a non-ionic, self-emulsifiable oil was most suitable. The U.S. Navy Medical Research Unit (1946) considered that the latter method could

be improved by again introducing a cationic agent, in the form of an added solution, to the bath.

Preliminary experiments have been made in this laboratory to find the most simple, reliable and cheap method suitable for general use.

PRELIMINARY EXPERIMENTS

Methods similar to those of Puck *et al.* (1946) and the U.S. Navy Medical Research Unit (1946) were examined first, and then, mainly from economic considerations, a third method, resembling the Thomas & Van den Ende (1941) method and employing an anionic, self-emulsifiable, oil was also investigated.

The general procedure was as follows:

A 10 g. portion of cloth was inserted into a 16 oz. bottle and covered with 200 ml. water. The required amount of self-emulsifiable oil was added from a burette with swirling to form the emulsion, and the bottle stoppered and mechanically shaken for 30 min. The emulsion was poured off, and the cloth suspended in an oven at 50° C. overnight to allow it to drain and dry. The dry cloth was then extracted with petroleum ether in a Soxhlet apparatus in the usual manner to give its oil content. Corrections were applied for natural oil throughout, and other compounds, when found to be significant.

Method A

Self-emulsifiable oil blends were prepared using a technical grade of low viscosity white mineral oil and different concentrations of polyglycol mono-oleate (containing six glycol units) as the non-ionic emulsifying agent. The specification to which the white oil conformed is shown in Table 1. Strips of blankets and sheets were chosen for the woollen and cotton cloths. The amount of oil added was 3 % by weight on the weight of the cloth.

The effect of emulsifier concentration on emulsion stability and deposition efficiency is shown in Table 2.

Table 1. *Specification for white oil*

Specific gravity at 60° F./60° F.	Flash point (° F.)	Redwood viscosity at 70° F. (sec.)	Pour point (° F.)	Colour (WOMA)
0·850 to 0·860	290 min.	90–105	−20 max.	4 max.

Table 2. *Deposition from emulsifiable oil containing decreasing amounts of emulsifying agent (polyglycol oleate)*

Polyglycol oleate in emulsifiable oil (%, v/v)	Emulsion stability	Oil deposited on blanket strip	Oil deposited on sheet strip
10	Very good	0·3	—
7½	Fair	0·9	—
5	Unstable, rapid creaming	1·4	1·0
2½	Very unstable, rapid oil separation	Not tested	Not tested

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It will be seen that (*a*) the more unstable the emulsion the greater was the deposition and (*b*) the maximum deposition efficiency with the woollen strip amounted to only about 45 % and with the cotton strip to only 33 %. Observation (*a*) confirms other investigators (e.g. Bayley & Weatherburn, 1945). It is, of course, limited by considerations of non-uniform impregnation and precipitation of oil on the sides of the treating bath. The 5 % polyglycol oleate blend was therefore adjudged to be most suitable.

Method B

In addition to the 5 % polyglycol oleate blend, as in method A, increasing amounts of the cationic agent Fixanol C (cetylpyridinium bromide) as a 5 % aqueous solution were also introduced. The amounts of oil deposited are shown in Table 3.

Table 3. *Deposition from non-ionic, emulsifiable oil, plus 5 % Fixanol C solution*

Weight of Fixanol C added (g.)	Oil deposited on blanket strip (%)	Oil deposited on sheet strip (%)
Nil	1·4	1·0
0·025	1·7	1·4
0·05	2·6	1·8
0·08	2·7	1·2
0·09	3·0	—
0·12	2·5	—

It will be observed that the addition of 0·09 g. Fixanol C (i.e. 0·9 % on the blanket weight) increased the deposition efficiency in the case of the woollen strip from about 45 to 100 %. In this experiment, the emulsion reverted to perfectly clear water, giving, as noted by the U.S. investigators, a visual indication of the 100 % impregnation found by analysis. However, in the case of the sheet strip, quantitative deposition again could not be obtained, no end-point was detected, and the maximum deposition efficiency was only 60 %.

The appearance and texture of the blanket and sheet strips containing 3 % and 1·8 % oil respectively were indistinguishable from those of the same strips before oiling.

Variables in Methods A and B

Various factors concerning both methods were briefly investigated in subsequent experiments.

(*a*) *Reproducibility*

Repeat experiments with 3 % oil, using the 5 % polyglycol oleate blend as in the method A, gave depositions of 1·35 and 1·51 % oil, and with 6 % oil, values of 3·2 and 3·7 % oil on the blanket strip. Replacing with the sheet strip and using 6 % oil depositions of 2·2 and 1·9 % oil were obtained. Deposition by method A was therefore considered to be reasonably constant with fabrics of similar condition.

(*b*) *Blanket quality*

The blanket used in the foregoing experiments was about 3 years old. Using strips from an obviously 'fleecier' new blanket and applying the polyglycol oleate blend, a deposition of 2·1 % oil, instead of the 1·4 % previously, was obtained. This showed that the oil was deposited largely through mechanical entrainment in the fibres and the greater the 'pile' of the blanket the greater is the deposition. Using method B with the new blanket strip, it was found that only 0·02 g. Fixanol C per strip was required for complete deposition as against the previous 0·09 g., i.e. the amount required was inversely proportional to blanket quality as would be expected from the previous finding.

(*c*) *Soaps in blanket*

Solvent extraction to remove adsorbed soaps, etc., before oil treatment reduced the Fixanol C requirement from 0·09 to 0·065 g. per 10 g. blanket. Method B was, therefore, sensitive to the presence of soaps in blankets.

(*d*) pH

Impregnation at pH 7–10 required 0·09 g. Fixanol C, but at pH 4–6 only 0·04 g. Fixanol C per 10 g. blanket strip was required to give 3 % oil deposition. Varying the pH, however, did not affect the deposition on sheet strips, which remained essentially as found previously.

(*e*) *Temperature*

The effect of temperature on deposition efficiency was found to be negligible.

(*f*) *Type of cationic agent*

Method B was repeated using solutions of Fixanol V.R. (tetradecylpyridinium bromide) and Cetavlon (cetyl trimethyl-ammonium bromide) in place of Fixanol C. Neither of these cationic agents was better than Fixanol C.

Method C

Since non-ionic emulsifying agents are relatively expensive, impregnation with a self-emulsifiable oil containing a cheaper anionic emulsifying agent (i.e. refined petroleum sulphonates) was also investigated. A white oil blend containing 7% Petromor Pale A (refined petroleum sulphonates, Manchester Oil Refinery (Sales) Ltd) possessed similar emulsion characteristics to those of the 5 % polyglycol oleate blend, and was selected for tests as in methods A and B. Results were as shown below:

(1) Deposition from 3 % oil treatment of blanket strip: 1·1 %.
(2) Deposition from 6 % oil treatment of blanket strip: 2·8 %.
(3) Fixanol C required to increase (1) to 3 % per 10 g. strip: 0·09 g.
(4) Fixanol C required at pH 4 and 6 to increase (1) to 3 % per 10 g. strip: 0·04 g.

It was concluded that the performance of this anionic self-emulsifiable oil was very similar to that of the non-ionic oil.

Assessment of methods

The average costs of oiling blankets and sheets with 3 % oil by the three methods was calculated to be as follows:

Method	Blanket	Sheet
A	2½*d.*	3*d.*
B	4*d.*	4*d.*
C	1½*d.*	2½*d.*

The cost of method B would be proportionately reduced if it could be operated satisfactorily under acid conditions. This possibility was dismissed, however, owing to the complications involved.

Conclusions

Methods A and C could therefore be summed up as being easy to operate and, although somewhat wasteful of oil, relatively cheap to use—especially method C. Method B, using a cationic agent, on the other hand, would require closer control, care in the removal of soaps, and, although more efficient and less wasteful of oil, would be quite expensive to use.

Method C using the self-emulsifiable oil containing an anionic emulsifying agent was therefore chosen for further practical trials in the hospital laundry.

PRACTICAL TRIALS

The procedure was as follows:

The dirty articles and test pieces were weighed, washed, and rinsed thoroughly. They were then covered in the washer with cold or lukewarm water. Agitation was started, and the required amount of oil poured gradually into the outer compartment of the washer. With woollen articles, the wash wheel was then run for 8 min. on a 2 min. agitate/1 min. rest basis, whilst with cottons it was run for a full 5 min., without stopping, after all the oil had been added. The wash-wheel was then stopped, the waste liquor drained off, and the articles hydroextracted and dried in the normal manner. The amount of oil deposited was estimated by solvent-extraction of test pieces as previously.

After due consideration, it was felt that 1½–2 % oil deposition instead of 3 % should be aimed at. This value corresponded with that used by the U.S. investigators, and was more in line with our views from experience of dust-suppression by oiling in the cotton industry, where considerably smaller percentages are effective.

The results obtained with average quality materials are tabulated in Table 4. Oil deposition was therefore reasonably consistent. The following additional observations were made:

Drying

Drying methods were varied; no significant loss of oil by volatilization occurred with any of the usual drying methods.

Table 4. *Laundry tests*

Material	Oil added (%)	Oil found on test pieces (%)
Blankets	2	1·6
Blankets	2	1·6
Blankets	2	1·5
Blankets	2½	1·8
Sheets	6	2·2
Sheets	6	2·0
Counterpanes	4	2·1
Sheets	5½	1·9

Quality of blankets

It was observed by varying the qualities of the blankets and test pieces treated that blankets of poor quality retained only about 1 % oil instead of 1½–2 %. In mixed loads as expected, preferential absorption by the better quality blankets occurred. This variation in absorption, however, was probably proportional to requirements regarding dust and bacteria suppression, and was not therefore considered important. The same variation in any case would doubtless arise whatever method of oiling was used.

Removal of oil

Hospital blankets are generally only lightly soiled and only a gentle washing process is usually applied. The same procedure applied to oiled blankets was found to remove only about 60 % of the oil present. Increasing the concentration of detergent and adding some Crex (sodium sesquicarbonate) in accordance with the B.L.R.A. washing formula, however, removed 80 % in a single wash and 100 % in a double-wash process.

WARD TRIALS

A brief experiment in a ward indicated that the numbers of bacteria liberated during bedmaking could be substantially reduced by applying 2 % oil by this method to blankets and counterpanes only; this will be described by Dr Lecutier in a later paper.

CONCLUSIONS

Laboratory examination of three methods of applying oil to bedclothes showed that the use of an anionic, self-emulsifiable oil, as described above, was to be preferred as being simple, effective, and cheap.

Practical trials in a hospital laundry showed that the method gave satisfactory, consistent results, and a brief ward trial showed that it was effective in the suppression of bacteria.

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