

ORIGINAL ARTICLE

IN VITRO SKIN PERMEATION OF DETERGENTS AND DETERGENT-BASED DECONTAMINATION MIXTURE

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Summary

The purpose of this study was to assess the ability of selected detergents (althosan MB 50%, triton X) and one commercial decontamination mean (Argos™) to permeate the pig skin, which could indicate a potential toxic side effect of mass casualty decontaminants. A method of static diffusion cells and UV spectrometry was used to evaluate the skin permeation. All tested agents did not permeate the skin in detectable amounts as 5% water solutions. In concentrated form, triton X and Argos™ did not permeate the skin whereas althosan MB 50% shown specific permeation rate of 6.134 $\mu\text{g}\cdot\text{cm}^{-1}$ in 24 hours.

Key words: Tenside; diffusion cell; skin permeation; triton X; althosan MB; benzalkonium chloride; Argos™

INTRODUCTION

Detergents and detergent-based mixtures are commonly used as additives to water for mass decontamination as an emergency response to mass chemical industrial accidents or terrorist attacks [1, 2]. A generic method for mass casualty decontamination involves a whole body wash with water and/or detergent-based washing solutions. Optimization and evaluation of new detergent-based decontaminants was done as a part of our work in the EU (Executive Agency for Health and Consumers) ORCHIDS pro-

ject (www.orchidsproject.eu). Detergents are usually considered as safe with no or minor acute toxic effect. Indeed, for topical skin application, no acute toxic effect was found in selected detergent and detergent-based solutions (own unpublished data).

In this study we focused on the ability of selected detergents and one commercial decontamination mean to permeate the skin, which could potentially indicate a toxic side effect of mass casualty decontaminants.

METHODS

Chemicals

Detergent althosan MB (50% benzalkonium chloride) was purchased from ChemProtect corp., triton X (polyethylene glycol p-(1,1,3,3-tetramethylbutyl)-phenyl ether) was purchased from Sigma Aldrich

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Ltd. (Czech Republic). Detergent mean Argos™ (containing e.g. sodium alkylethersulphate, sodium alkylbenzenesulphonate, cocamide DEA) was obtained from Health Protection Agency (United Kingdom). Phosphate buffered saline (pH 7.6) was used as a receptor fluid.

Skin permeation experiments

Static diffusion cells were used for detergent permeation experiments as described previously [3, 4]. Samples of lateral thoracic skin (thickness of 500 µm) were derived from white domestic Landrace pigs (*Sus scrofa domestica*; female; b.w. 35 kg). Althosan MB and triton X detergents and

Argos™ decontamination mean were allowed to permeate the skin for 24 hours, each in six permeation cells as 5% water solutions (6 cells) or non-diluted concentrates in the produced form (6 cells) under an infinite dose of 1.0 ml/cell. The amounts of agents in the receptor fluid were evaluated 24 hours post-exposure using a UV spectrophotometer (UV/VIS Helios Alpha, Unicam, ThermoSpectronic). Absorbance in the UV spectrum was measured in the specific wavelength of the maximal peak of a single agent. Quantification was performed according to a calibration curve for each detergent (fig. 1) and the amount of permeated agent was evaluated in µg.cm⁻¹.

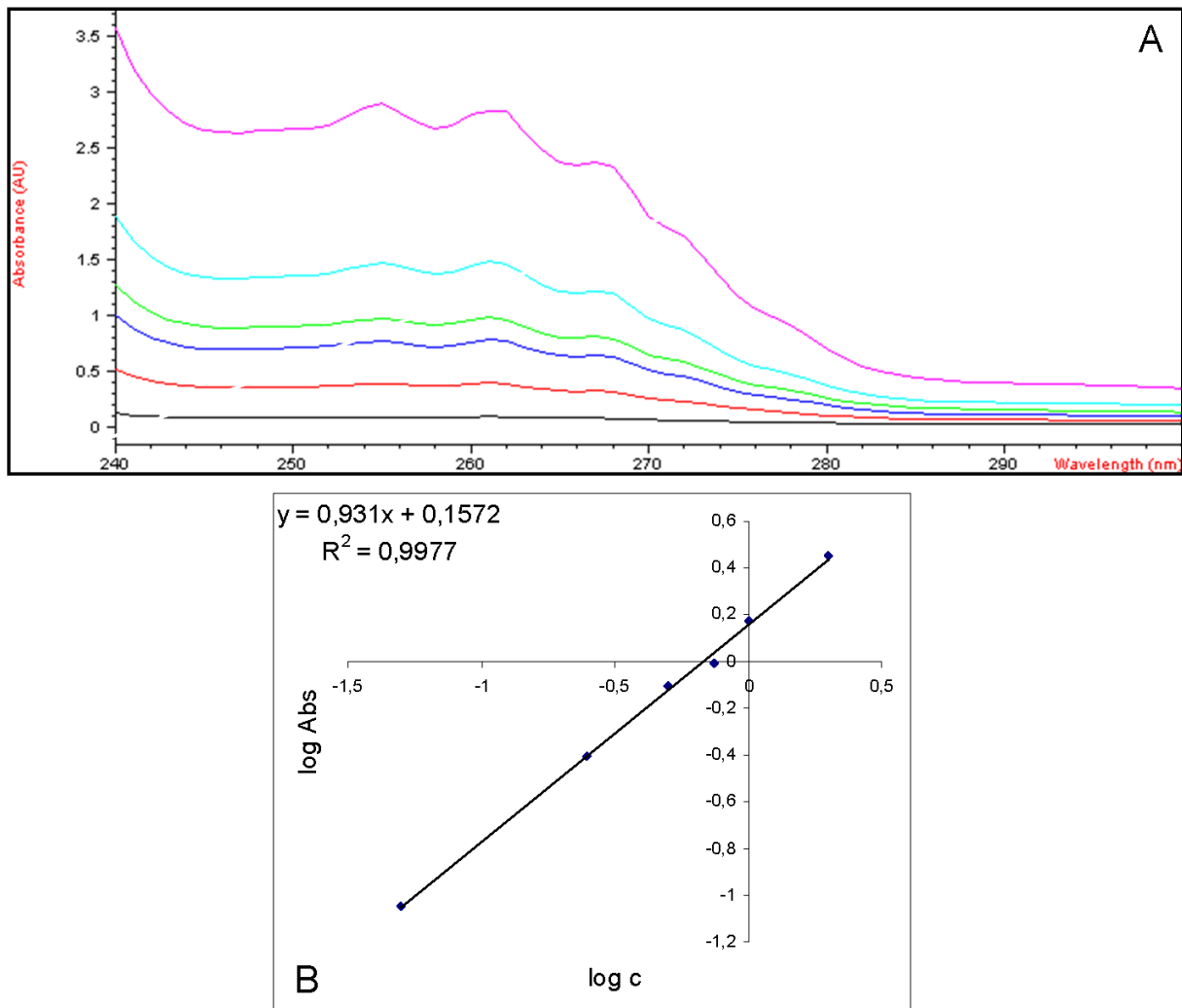


Figure 1. UV spectrum of Argos™ as a phosphate buffered saline solution (A) and the calibration curve obtained for Argos™ (B) under specific wavelength of 261 nm. Argos concentrations = 0.05, 0.25, 0.50, 0.75, 1.00 and 2.00%. Detection limit ~ 0.2%. Similar spectra were obtained for triton X (277 nm) and althosan MB (263 nm) with limits of detection 0.03% and 0.025%, respectively.

RESULTS AND DISCUSSION

Both tested detergents and the decontamination mean did not permeate the skin as 5% water solution under the concentrations detectable for UV spectrometry. As a concentrate only althosan MB 50% permeated the skin with a rate of 6.134 $\mu\text{g}\cdot\text{cm}^{-1}$ in 24 hours (Table 1). Benzalkonium chloride (althosan MB 50%) presents the highest lipophilicity (log Kow = 1.9) among cationic surfactants [5] and thus an affinity with the skin is considered. On the other hand, nonionic surfactant triton X (log Kow = 1.97) did not permeate the skin in this study. The ability of surfactants to permeate the skin has already been shown in anionic sodium lauryl sulphate (log Kow = 1.6) [6, 7, 8] agent that is commonly used as a compound of liquid soaps and washing solutions.

Detergents are also currently considered as skin permeation enhancers of other agents, including drugs, pollutants and toxic compounds [5, 9, 10, 11]. The enhancing effect is probably due to a deleterious impact of detergents on the natural skin barrier which means skin delipidation, irritation and membrane fluidization [5, 12, 13] and/or increasing of skin hydration [5] which leads to higher permeation rates [4]. Thus, an expected toxic effect of detergents is related to the mentioned characteristic causing mainly contact dermatitis [6] and a potential enhancing effect of other toxic co-permeants, e.g. heavy metals [14].

According to our results, there is no evidence for a severe acute toxic effect of detergent based skin decontaminants, especially when applied topically as a water solution for a short time period.

Table 1. Skin permeation of detergents althosan MB 50%, Triton X and mixture Argos™. Specific wavelength used in UV spectrophotometry is shown (Abs).

| detergent/mixture | Abs (nm) | permeation 24 h (mean \pm SEM) | |
|-------------------|----------|----------------------------------|--|
| | | 5% water solution | concentrated |
| althosan MB 50% | 263 | undetectable | 6.134 \pm 0.345 $\mu\text{g}\cdot\text{cm}^{-1}$ |
| triton X | 277 | undetectable | undetectable |
| Argos™ | 261 | undetectable | undetectable |

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