PRELIMINARY EVALUATION OF NOVEL SURFACTANT-BASED DECONTAMINANTS FOR SKIN EXPOSURE TO PHORATE: A SIMULANT OF THE VX NERVE AGENT.

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INTRODUCTION

Organophosphorus nerve agents, such as VX, pose an extreme risk due to their high dermal toxicity, environmental persistence, and rapid systemic absorption. Timely and effective decontamination is crucial for reducing exposure and minimizing health effects.

We performed a preliminary in vitro evaluation of two novel surfactant-based formulations (University of Alcalá) intended for shower-based decontamination following VX exposure, using ^{14}C-phorate as a safer physicochemical simulant.

MATERIAL AND METHODS

Experiments followed OECD 428 guidelines using static skin diffusion cells with porcine skin and ^{14}C-labelled phorate (Chilcott et al., 2019; Matar et al., 2022**).**

A 10 µL droplet of ^{14}C-phorate was applied to the skin, and decontamination was initiated 60 min post-exposure using an ORCHIDS-style protocol:

a) no decontamination (control);

b) warm water shower (90 s);

c) 0.5% v/v Formulation 1 (1 min) + water rinse (30 s);

d) 0.5% v/v Formulation 2 (1 min) + water rinse (30 s).

Each protocol was followed by active drying with a microfibre cloth (n = 6 diffusion cells/group).

Data are mean ± SD; comparisons were performed using Kruskal–Wallis followed by Dunn's multiple-comparison post-test.

RESULTS AND DISCUSSION

- ✓ **Both surfactant formulations significantly reduced the bioavailable dose (receptor fluid + skin surface + skin) versus untreated controls, with decontamination efficacies of 93 ± 48% (Formulation 1, $p < 0.05$) and 96 ± 45% (Formulation 2, $p < 0.01$), whereas water alone achieved 88 ± 35% and was not significant (Fig 1).**
- ✓ **Water-only decontamination showed a rinse-in ('wash-in') effect, with approximately two-fold higher receptor-fluid recovery/transdermal penetration than untreated controls; both surfactant formulations mitigated this effect.**
- ✓ **Autoradiography/ImageJ showed that both formulations significantly reduced lateral spreading compared with controls ($p < 0.05$), whereas water did not (Fig 2).**
- ✓ **Across the three shower decontamination arms, the largest recovered fraction was consistently captured by the microfibre cloth (~20–40%), underscoring active drying as a key contributor; Formulation 2 yielded ~two-fold higher cloth recovery than Formulation 1, although this difference was not statistically significant.**

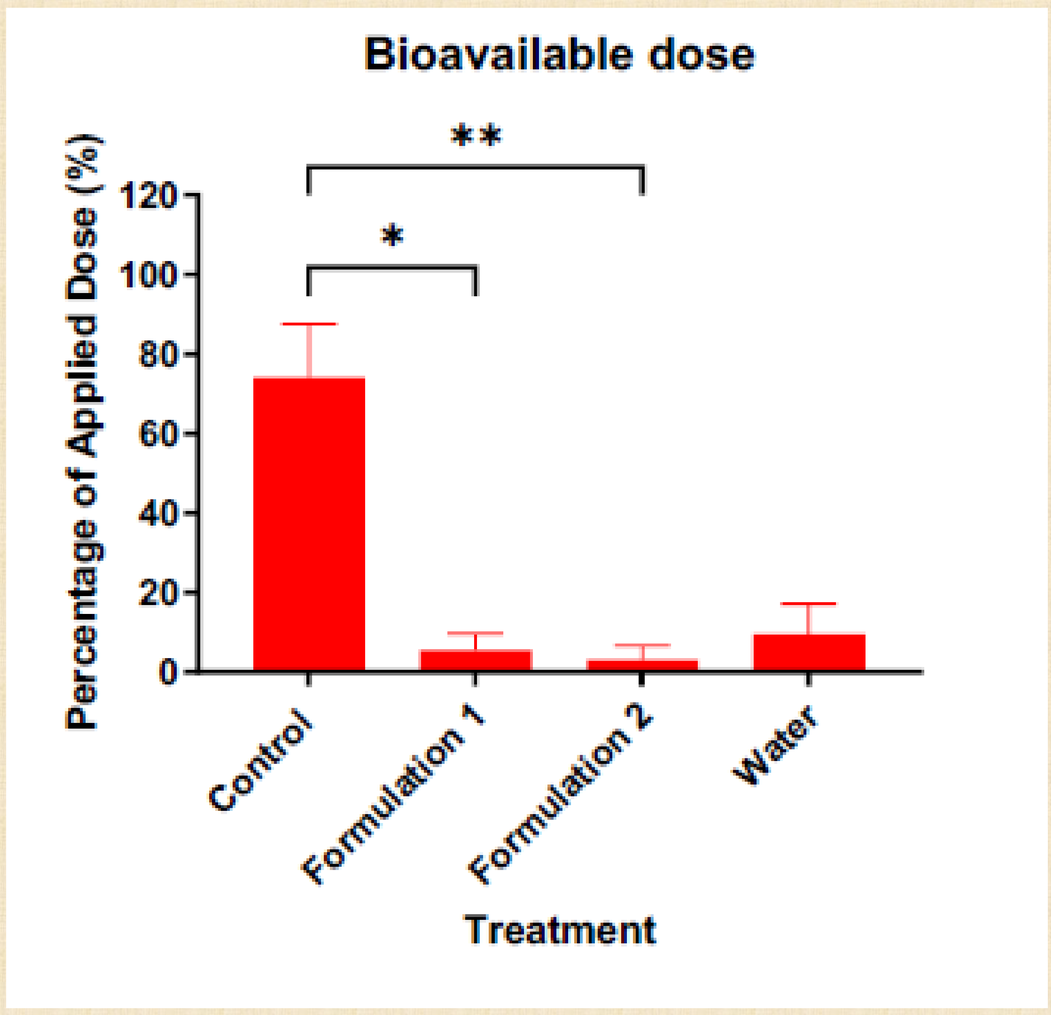

Fig 1. Bioavailable dose consisting of receptor fluid, skin surface and skin. All points are mean ± standard deviation of *n*=6 diffusion cells. Asterisks indicate a statistical significance when compared to the control (* $p \leq 0.05$ and ** $p \leq 0.01$).

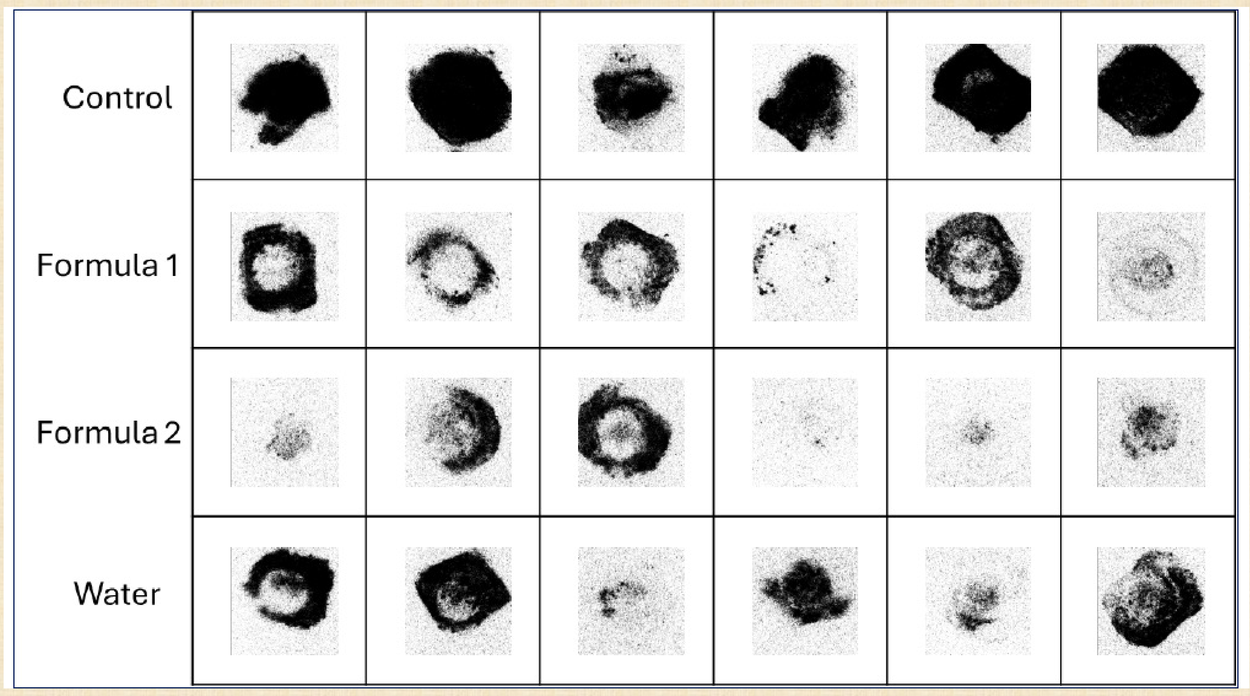

Fig 2. Skin surface spreading images of 14C-phorate (PHR) were acquired at the end of the experiments (24 hours post-exposure). A 10 µL droplet of ^{14}C-PHR was applied to the skin surface. Decontamination was conducted at 60 minutes post exposure following a technical decontamination protocol using either Formulation 1, Formulation 2 or clean water (flow rate of 0.6 mL min^{-1} cm^{-2}).

CONCLUSIONS

As this was a preliminary *in vitro* study using a VX simulant and porcine skin, further work should test operationally realistic scenarios, additional agents/simulants, and formulation performance under field-relevant conditions.

These initial results support further testing of surfactant-based technologies as rapid and effective tools for chemical incident response and highlight their potential for future field deployment.

REFERENCES

Chilcott, R. P., Larner, J., Durrant, A., et al. (2019) 'Evaluation of US Federal Guidelines (Primary Response Incident Scene Management [PRISM]) for Mass Decontamination of Casualties During the Initial Operational Response to a Chemical Incident', Annals of Emergency Medicine, 73(6), pp. 671-684.

Matar, H., Stevenson, S., Chilcott, R. P. and Morrissey, K. (2022) 'Development of a Next Generation Military Skin Decontaminant: Initial Efficacy Studies of Zirconium Hydroxide', Dermal Absorption and Decontamination: A Comprehensive Guide: Springer, pp. 169-181.

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