

The Benefits of Activated Charcoal Cloth with Silver on Odour Control and Bacterial Endotoxin Binding



Lorraine Nisbet, David Greenhalgh, Breda Cullen, Sam Broadbent, Steve Foster Systagenix, Gatwick, UK

INTRODUCTION

Elevated bacterial bioburden in wounds may not only lead to delayed healing but more critically to a wound infection, which has significant consequences for the patient. However, bacterial colonization preceding a wound infection can have negative effects for both the wound and for the patient; these include production of bacterial endotoxins and the generation of malodour.

Bacterial endotoxin is the Lipopolysaccharide (LPS) component of the cell wall of Gram negative bacteria and is released during bacterial replication and lysis. Some treatments of infection may also induce release of these bacterial endotoxins with subsequent detrimental effects which may include delayed wound healing, as they have been shown to decrease fibroblast proliferation *in vitro* and *in vivo*. Endotoxins have been shown to reduce collagen production leading to decreased tensile strength in wounds as well as an increase in the expression and release of pro-inflammatory cytokines which further contributes to a prolonged inflammatory state.

Malodour is generally attributed to the presence of anaerobic bacteria due to their ability to degrade tissue proteins and lipids generating odour causing molecules such as Hydrogen Sulphide.

Thus, removal of bacteria from the wound is extremely important, not just to prevent wound infection but also to deal with these secondary effects.

In previous studies, activated charcoal cloth with silver has been shown *in vitro*, to bind bacteria and endotoxins, which are drawn out of the wound exudates and onto the cloth by strong electrostatic charges. As the silver is non-releasing, it has been demonstrated that the combination of silver and activated charcoal cloth (ACC) can bind and destroy bacteria and their endotoxins within the dressing, preventing them from returning to the wound. In this study we wanted to determine if the presence of silver provided any additional benefits to the activated charcoal cloth in eliminating odour.

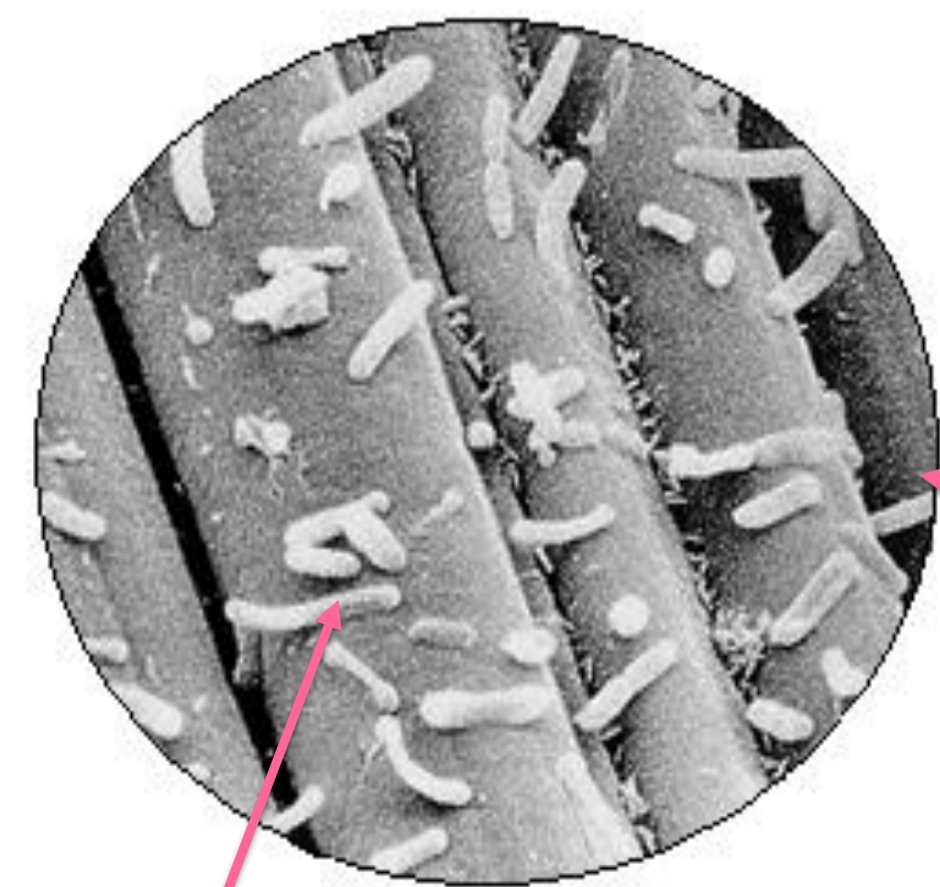
BINDING OF BACTERIA

Method

The ability of silver containing activated charcoal cloth to bind bacteria was assessed by scanning electron microscopy (SEM).

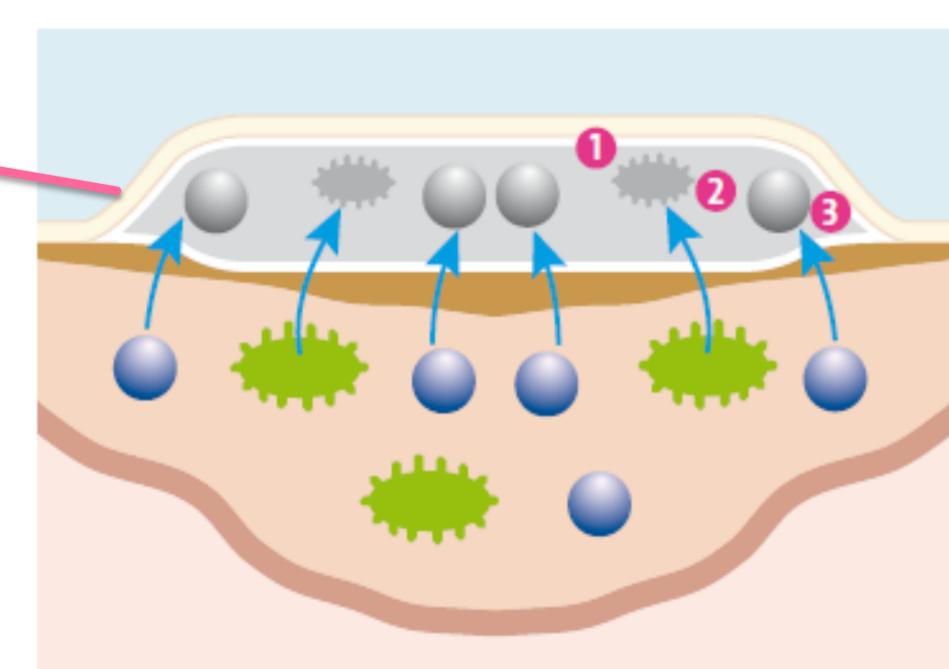
Results

Scanning Electron Microscopy (SEM)



Pseudomonas (10⁶ inoculum)

Action resulting from the combination of charcoal & silver in a wound dressing



- 1 Activated charcoal traps bacteria in the dressing
- 2 Silver kills the bacteria¹
- 3 Activated charcoal adsorbs odour particles/bacterial toxins²



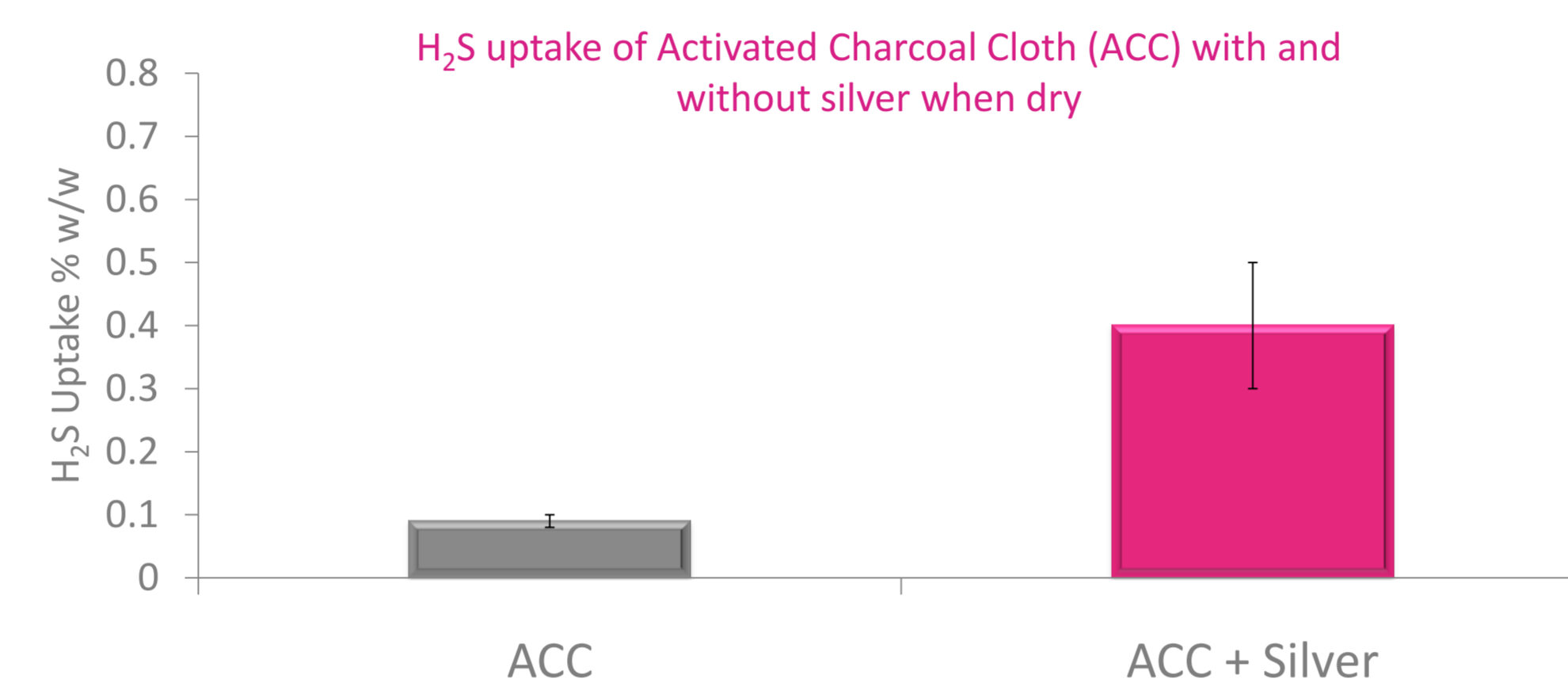
ODOUR ADSORPTION

Method

Fifteen 25mm discs of activated charcoal cloth with and without silver were tested. A gas stream containing 25ppm Hydrogen Sulphide in 20% Methane, 80% Nitrogen was passed through the filter at 500ml/min, 1bar and the breakthrough time to 1ppm was recorded. The method was repeated with samples pre-wet in PBS.

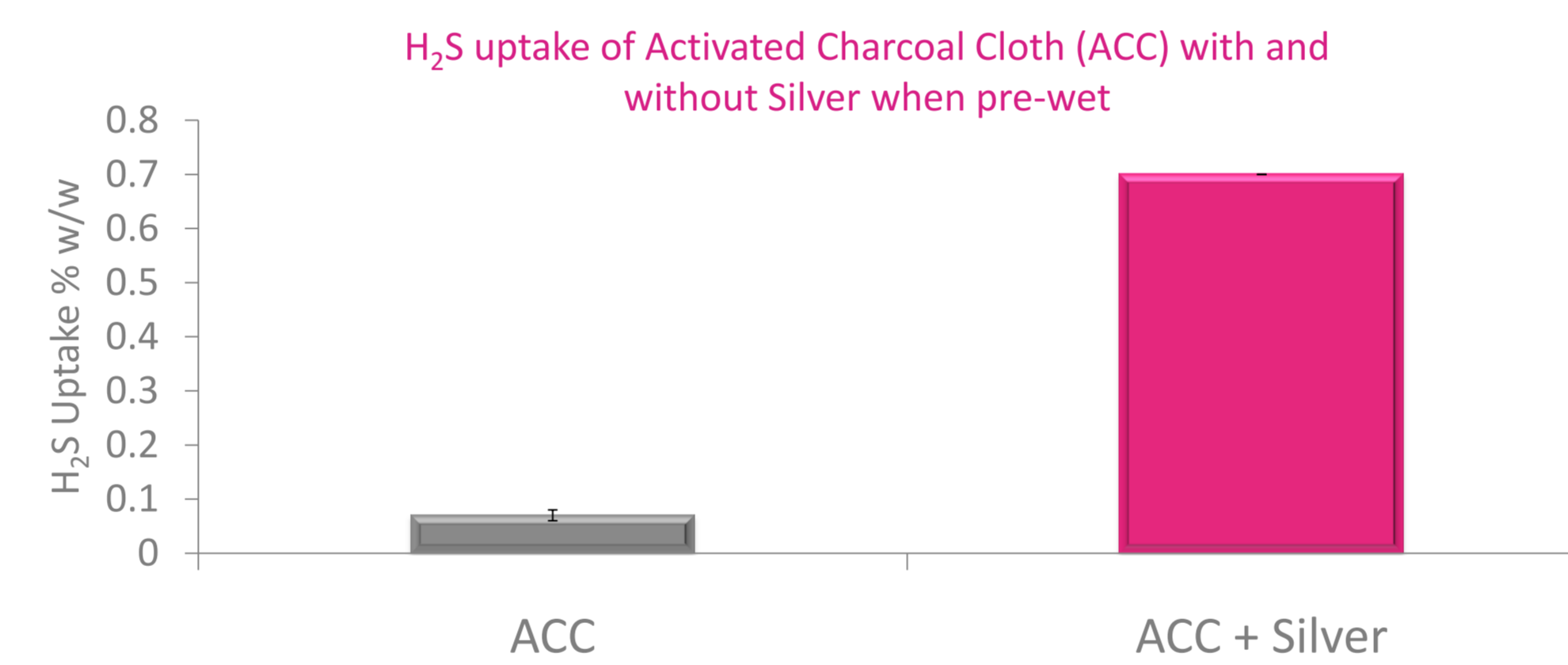
Results – Dry

On average the dry ACC + silver test material adsorbed up to 0.31% (w/w) more odour particles than ACC alone (p=0.000).

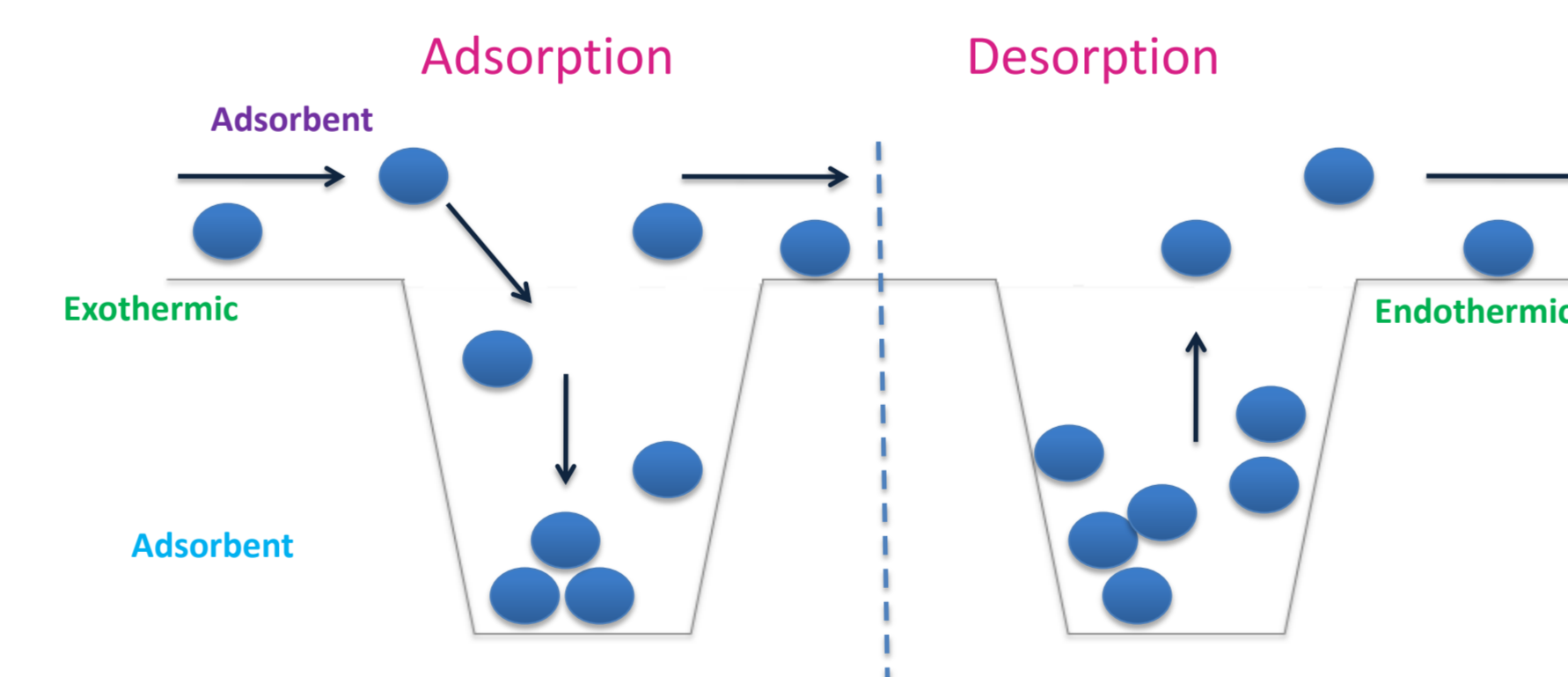


Results – Pre-wet

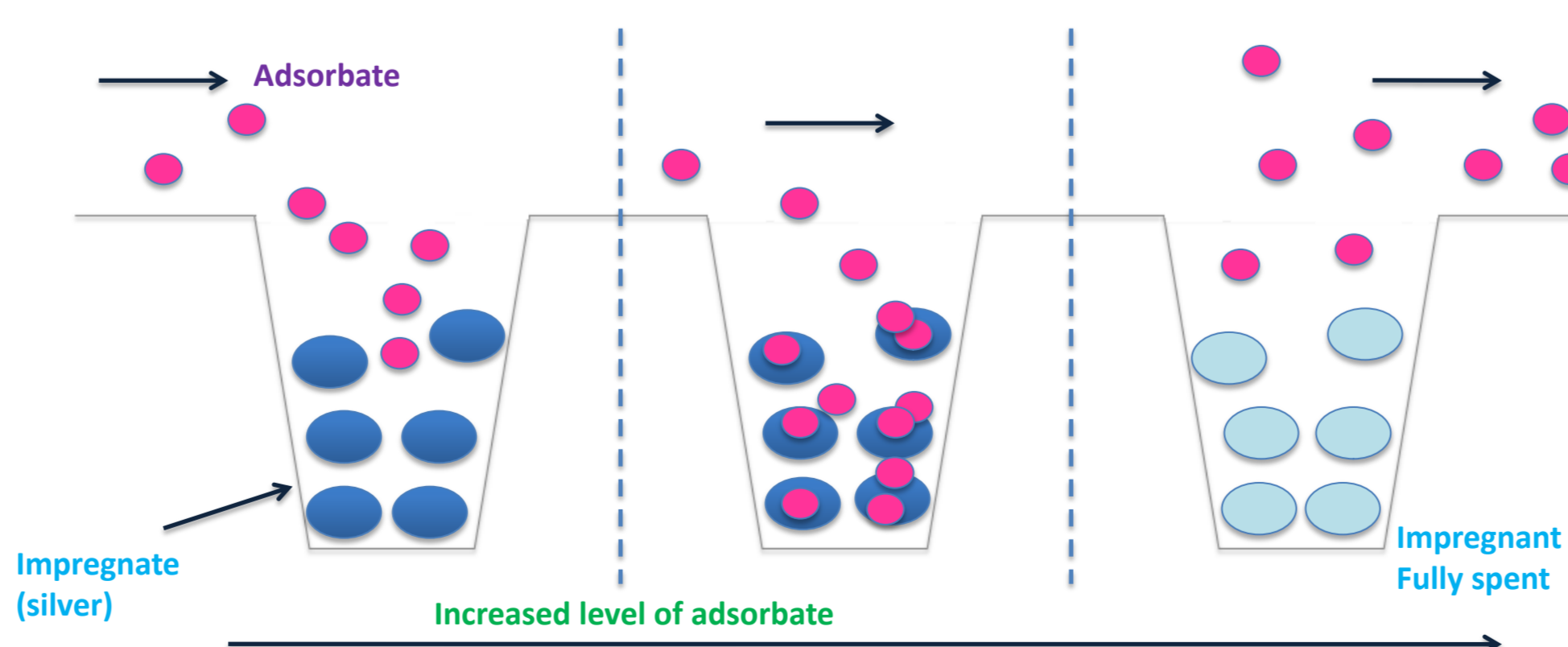
On average the pre-wet ACC + silver test material adsorbed up to 0.63% (w/w) more odour particles than ACC alone (p=0.000).



Why does ACC + silver trap more odour particles?



- ACC without silver adsorbs chemicals by PHYSISORPTION.
- There is no chemical reaction at work here; the contaminant is adsorbed to the carbon surface by the adsorptive forces (the Van der Waals forces).



- ACC with silver adsorbs inorganic chemicals by CHEMISORPTION while still retaining the capability of organic chemical adsorption through PHYSISORPTION.
- With chemisorption there is a chemical reaction at work between the adsorbate and the impregnate that enhances the inorganic capacity of the ACC.³

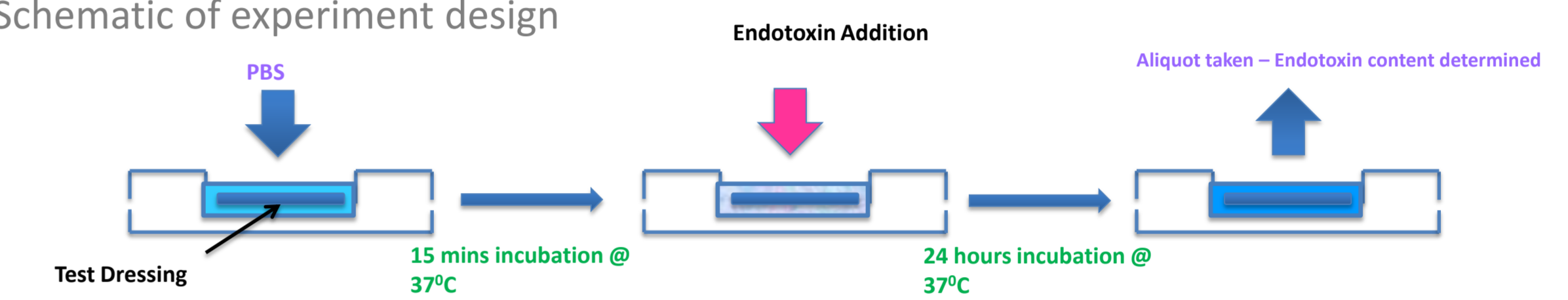
ENDOTOXIN BINDING

Method

Six samples (2.5mmx2.5mm) of ACC + Silver and gauze (control) were pre-wet with phosphate buffered saline for 15 minutes at 37°C, while shaking. The samples were then incubated in a known concentration of *E. coli* endotoxin O55:B5, for 24 hrs at 37°C, without shaking. This endotoxin is a bacterial metabolite often found in chronic wounds. Six control solutions were also prepared in the same way but without any test samples, containing only the endotoxin at the same initial concentration as that used with the test samples. These samples underwent the same procedure as the test samples.

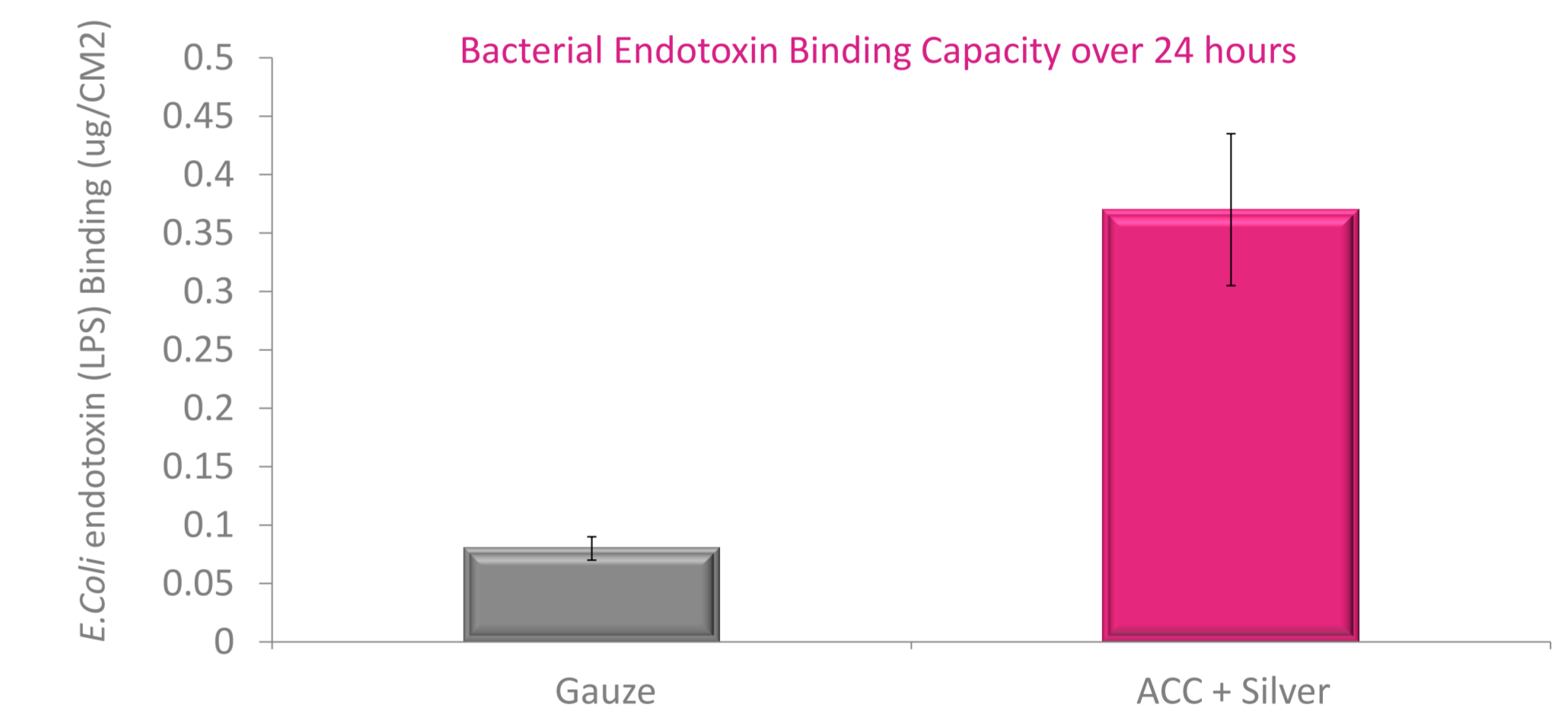
The amount of endotoxin remaining in solution after incubation was determined using a quantitative gel-clot LAL assay.

Figure 1: Schematic of experiment design



Results

An analysis of the endotoxin levels indicated a significant difference between the binding ability of the silver containing activated charcoal cloth (ACC) and gauze (p=0.001), with the silver containing ACC adsorbing over 3 times more endotoxin per weight of cloth and over 4.5 times more endotoxin per surface area. Based on these results, the silver containing ACC (ACC + silver) is effective at binding bacterial endotoxins, therefore removing them from the wound, helping in the management of infected and critically colonized chronic wounds.⁴



DISCUSSION

Our results demonstrate that ACC + silver has the ability to reduce the level of bacterial endotoxin due to the binding properties of the activated charcoal cloth, which has also been shown to bind bacteria by SEM.

Silver is a well known antimicrobial and has been demonstrated *in vitro* and *in vivo* to reduce the levels of bacteria which can cause wound infection and malodour, but the presence of silver within the ACC has been shown to provide an additional benefit of improving the odour adsorbing properties of the cloth by chemical interaction. The combination of the high surface area of the cloth and silver is better at odour control than ACC alone.

Our results demonstrate that ACC + Silver significantly improves the uptake of H₂S, when compared to ACC without silver. This indicates that the presence of silver is beneficial in odour control.

CONCLUSION

Based on these *in-vitro* results, activated charcoal + silver could help in the management of critically colonized chronic wounds, by binding the bacteria and their endotoxins as well as helping to reduce malodour.

References

1. Russell AD et al. Antimicrobial activity and action of silver. Progress in Medicinal Chemistry.31, 351-370. Elsevier Service 1994
2. Price PE et al. J Wound Care, 9(2):93-95
3. Systagenix data on file, April 2011
4. Systagenix data on file, 2003.

