Sulfur Mustard (SM) is a vesicant (blistering) agent that was widely used in WWII, and was more recently used in Iraq by Saddam Hussein. The mechanisms by which sulfur mustard creates injury are thought to involve proteases (and likely other inflammatory agents), which illustrates significant heterogeneity in the biochemistry of chemical and thermal burns. Exposure of skin to sulfur mustard (also often called HD or SM) is thought to disrupt the balance between basement membrane protein synthesis by keratinocytes and their degradation by proteases. This disturbance causes a loss of adherence between epidermis and dermis due to more protein degradation than synthesis. This effect is observed macroscopically as vesication. Mortality resulting from direct SM exposure is relatively low, but blistering precipitates victims to secondary bacterial infection, which represents the greatest hazard to SMA victims.

This research is the result of a US Army SBIR solicitation for a treatment that provides a moist wound healing environment combined with fluid handling, antimicrobial protection and protease inhibition while delivering nutritive factors and growth factor to stimulate healing. We previously reported upregulated tissue proliferation in chemically insulted tissue culture models. The research project concluded with a wound healing study using a NIMBUS-SAP pig model, chemically injured with sulfur mustard by liquid exposure as detailed and analyzed below.

Antimicrobial dressings. Antimicrobial dressings are of particular utility in protecting patients with vesicant injuries, since these injuries make the patient more susceptible to bacterial infections. The base material used to prepare dressings was incorporated with antimicrobial agent. The NIMBUS-SAP antimicrobial superabsorbent dressing (a proprietary non-teaching superabsorbent dressing material prepared from a rayon base) has been shown to be effective against Pseudomonas aeruginosa, identified by CDC as one of the most common burn pathogenic organisms, for at least 7 consecutive days. (Figure 2).

Experimental Treatments

Topical dressings were treated with rayon gauze. Treatment dressings. All three treatment dressings are based on NIMBUS-SAP antimicrobial superabsorbent dressing base NIMBUS-SAP dressing, NIMBUS-SAP dressings mixed with doxycycline and NIMBUS-SAP dressings mixed with vitamin C and E. The NIMBUS-SAP superabsorbent dressing base NIMBUS-SAP dressing, NIMBUS-SAP dressings mixed with doxycycline and NIMBUS-SAP dressings mixed with vitamin C and E were all integrated, and the previously published growth factor.

Experimental protocols included pathophysiological evaluation based on established observation parameters. In addition to the clinical observation, histological examinations were performed on tissue excised and either preserved in formalin or flash frozen in nitrogen.

Injury Model. Battle vesicle Institute used a previously developed injury model with an established exposure protocol, treatment administration, and tissue collection procedures. Exposure were performed by placing 400uL of undiluted HD (sulfur mustard in liquid form) onto a PTFE filter paper disc, which was applied onto the target surface for 8 min. In this place by placing the dressing on day 1 after the animals were sacrificed and tissue collections were selected for evaluation.

Histology. The main macroscopic feature of all sites was the presence of necrophage, indicating formation of the wound. All sites had re-established the epithelial layer covered with stratum corneum, but matured by epithelium varied greatly: NIMBUS-SAP + doxy + vitamins + EGF sites re-established a thicker epithelial layer, compared to untreated gauze. Inflammatory cell infiltrates were prominently present in all dermal layers of the control tissue, in most part of the panniculus dermata of the NIMBUS-SAP treated tissue, and to a lesser degree in the tissue protected by NIMBUS-SAP + doxy + vitamins + EGF. Control dressings demonstrated loosely organized and entangled collagen fibrils, consistent with scar formation, whereas the NIMBUS-SAP + doxy + vitamins + EGF showed a very well ordered deposition of collagen (see Fig. 8 and magnified view presented in Fig. 9 comparing with control).