Antimicrobial Effects of a Borate-Based Bioactive Glass Wound Matrix on Wound-Relevant Pathogens

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INTRODUCTION

Colonization of pathogens in wounds significantly inhibits wound healing and is a major factor in the failure of wounds treated with skin grafts and skin substitutes. Synthetic materials such as bioactive glass are known to have antimicrobial effects and are becoming commercially relevant as the next generation of skin substitutes [1-2]. The antimicrobial effects of a borate based bioactive glass matrix on nineteen wound relevant pathogens was studied using the in-vitro AATCC 100 test method[3].

METHODS

A total of 19 microbial strains, including five Gram-positive, five Gram-negative, four yeast, and five mold strains of clinical significance were investigated. All microbial strains were stored as 20% glycerol stocks at -80°C. Bacteria and yeasts were streaked on tryptic soy agar (TSA) plates and stored at 4°C up to two weeks. However, mold stocks were stored for up to four weeks at 4°C. A total of 312 borate bioactive glass wound matrix samples from two separate lots were studied for antimicrobial activity.

Antimicrobial efficacy of the borate based bioactive glass wound matrix was determined according to a modified version of AATCC TM100-2019[4]. The samples were placed in individual sterile 100 mm x 15 mm Petri dishes, followed by the addition of 6 mL of SWF, and then transferred to a stationary humidified incubator at 37°C (bacteria and yeast) or 25°C (mold) for 7 days to precondition.

The remaining samples were incubated for an additional 1 day, 4 days or 7 days, then transferred individually to 50 mL centrifuge tubes containing 30 mL of D/E broth for sonication, recovery, and plating as described above. Each material was evaluated in triplicate, and the experiment was performed once per species. The 7 day model was used because the advanced skin substitute model for care is typically 7 day applications.

DISCUSSION

The cell count of each organism was reduced at seven days indicating the borate based bioactive glass matrix not only reduced the viable cell count, but the cell count did not recover during the seven-day period indicating a sustained reduction in pathogenic activity. Based on the present results, the use of a borate based bioactive glass matrix as a pathogenic barrier should be considered as a tool for combating pathogenic colonization and infection in acute and chronic wounds.

RESULTS

The reduction of viable gram negative and gram positive bacteria and yeasts at 4 and 7 days post culture onto the borate based bioactive glass matrix was significant (> log 4) in most cases. Mold counts were reduced (< log 2) during the seven-day assessment indicating that mold viability and mold reproduction was inhibited.

Log reduction of test microorganisms in bioactive glass wound matrix at t+1 d, 4 d, and 7 d. Data are presented as log (CFU/sample). Reduction was calculated relative to the same material at t=0. Average reductions greater than 4 logs are emboldened and shaded.

Category	Species and Strain	REDUCTION (log CFU/sample) t = 1 d	t= 4 d	t= 7 d
Gram positive	*B. subtilis* ATCC 6633	2.02	**6.22**	**5.86**
	E. faecium ATCC 51559	0.20	2.61	3.43
	S. aureus ATCC 6538	2.85	**6.69**	**6.69**
	S. aureus USA300	0.39	3.46	**6.15**
	S. pyogenes ATCC 12344	**6.93**	**6.93**	**6.93**
Gram negative	*A. baumannii* AB5075-UW	1.44	**5.56**	**6.02**
	E. cloacae ATCC 13047	1.31	**5.97**	**5.97**
	E. coli ATCC 8739	**4.02**	**6.22**	**6.22**
	K. pneumoniae ATCC 4352	1.62	**6.00**	**6.00**
	P. aeruginosa ATCC 27312	**6.32**	**6.32**	**6.32**
Yeast	*C. albicans* ATCC 18804	0.22	**5.88**	**5.88**
	C. auris AR-0384	0.07	0.92	2.71
	C. krusei ATCC 14243	2.33	**6.43**	**6.43**
	C. tropicalis ATCC 13803	0.71	**5.84**	**5.84**
Mold	*A. brasiliensis* ATCC 16404	0.83	0.92	2.13
	C. lunata ATCC 14595	-0.15	0.21	0.21
	C. herbarum MYA-4682	0.25	0.49	1.62
	F. dimerum AATCC 16553	0.27	1.06	1.49
	T. mentagrophytes AATCC 28145	0.11	0.19	0.27

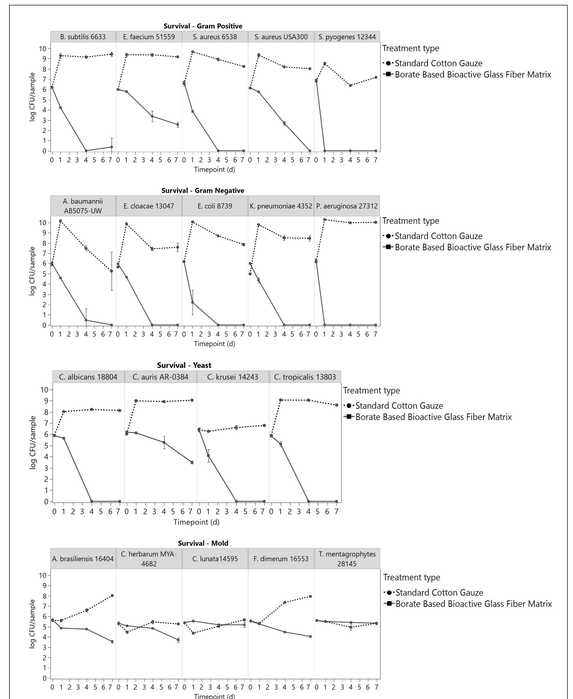

Figure 1. Log survival of test microorganisms in bioactive glass wound matrix vs. standard cotton gauze at t=0, 1 d, 4 d, and 7 d. Data are presented as log(CFU/sample).

References:

1. Jung S, Day T, Boone T. et al. Anti-biofilm activity of two novel, borate based, bioactive glass wound dressings; Biomed Glasses 2019; 5(1) 67-75.
2. Drago L, Toscano M, Bottagisio M, Recent evidence on bioactive glass antimicrobial and antibiofilm: a mini-review; Materials 2018; 11(2) 326.
3. Jung S, Schultz G. et al. Antimicrobial effects of borate based bioactive glass wound matrix on wound-relevant pathogens; J Wound Care 2023; 32(12) 763.
4. AATCC TM100-2019. Test method for antimicrobial finishes on textile materials: assessment of antibacterial activity finishes on textile material, 2019.