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PREPARATION AND PROPERTIES OF SILVER ANTIMICROBIAL NONWOVENS

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Abstract

The presentation will be on a cation-exchange-based development of silver antimicrobial nonwovens from (a) the sodium salt of carboxymethylated cotton, and (b) commercially available calcium alginate dressings that should be effective for burn wounds. From the behavior of antimicrobial release and the suppression of bacterial proliferation, it was apparent that the dressings containing silver antimicrobial agent would protect the wound surfaces from microbial invasion and effectively suppress bacterial proliferation. Isopropanol/water medium works equally well, and is an option.

Introduction

We prepared carboxymethylated cotton nonwovens by treating nonwovens with caustic soda and monochloroacetic acid in 80/20 to 90/10 ethanol/water medium (Fig. 1). Ethanol/water preserved the fibrous form of nonwovens and imparted the properties of improved moisture-regain, high bound water, and high swellability. It is feasible to create an antimicrobial product through a chemical reaction whereby sodium cations of sodium carboxymethylated cotton are partially replaced by the cations of the microbial agent such as silver nitrate. The carboxylate group of carboxymethyl nonwovens, in an ionized salt form, is primarily responsible for the development of antimicrobial Ag/Na-carboxymethyl nonwovens. Similarly, by cation exchange, antimicrobial products can also be made from commercially available (four) calcium/sodium alginate dressings using silver nitrate in an ethanol/water medium.

Antimicrobial Products for Burn Patients

Burn wound infections are the primary source of morbidity and mortality in burn patients with the third and fourth degree burns. Burn injury disrupts both the normal skin barrier and many of the host defense mechanisms that prevent infection, so that burn wounds are susceptible to colonization and infection by the multitude of environmental microorganisms with which the human body normally coexists. The burn patient thus remains vulnerable to invasive microbial infections of all kinds until complete epithelialization has occurred. Topical antimicrobial therapy remains the single most important component of wound care in all hospitalized burn patients. A burn specialist selects an appropriate antimicrobial agent for a given clinical setting. In this presentation, we have limited our discussion only to antimicrobials containing silver cation.

Experimental

Preparation of Antimicrobial Products

Antimicrobial carboxymethylated cotton nowovens were prepared with silver nitrate by post treating carboxymethylated nonwovens in 85/15 ethanol/water. Carboxymethylated nonwovens were first treated with acetic acid to make cellulose in free acidic form to facilitate the subsequent cationic exchange. They were treated with 2.0 to 3.0 g glacial acetic acid (in 85/15 ethanol/water) for 40 minutes to 4 hours at room temperature, squeezing excess ethanol and drying in an oven at 50 ° C (122±3°F) followed by a treatment with the alcoholic solution (85/15 ethanol/water) of 0.1% to 0.2% silver nitrate for 40 minutes to 12 hours at room temperature, squeezing excess solution, washing with ethanol and drying, Table I.

Evaluating Antimicrobial Property

The evaluation of the antimicrobial properties of the samples was done at North American Science Associates (NAMSA). NAMSA used AATCC 30, Dow Corning Shake Flask Test Method 0923 to determine the antimicrobial activity of silver/sodium carboxymethyl gauze sample #113. Gram-positive *Staphylococcus aureus* (ATCC 6538) and Gram-negative *Klebsiella pneumoniae* (ATCC 4352) organisms were used in the test. The Dow Corning Shake Flask challenges the product with one organism and effectiveness is determined after one, and twenty-four hours of incubation. The inoculums ranged from 1.8×10^4 to 2.0×10^4 cfu/ml. Percent kill is determined after a specified incubation of one hour and twenty-four hours.

Results of Antimicrobial Evaluations

The NAMSA test determined that antimicrobial property of carboxymethylated (CM) nonwovens is effective against both Gram-positive (*Staphylococcus aureus*) and Gram-negative (*Klebsiella pneumoniae*) organisms (Table II). The sample practically destroyed the bacteria in an organism count of <10 CFU/ml as compared to the control organism count of 1.3 million/ml. Similar antimicrobial effectiveness was observed on Ag-alginates produced from Kaltostat (ConvaTec), Algisite (Smith and Nephew), Curasorb (Tyco Health Group), and Sorbsan (Bertek Pharmaceutical).

Conclusions

Antimicrobial dressings should be effective for burn wounds. Upon ion exchange, it was possible to obtain (a) Ag/Na carboxymethylated cotton antimicrobial nonwovens from the sodium salt of carboxymethylated nonwovens, and (b) Ag/Ca/Na alginate nonwovens. (Please note that no burn patients have actually been treated with these dressings.)

Table 1. Preparing Antimicrobial Ag/Na-CM-Gauze.

Step 1:
2.0 to 10.0 g of carboxymethyl nonwovens was acidulated for 45 minutes to 4 hours in acetic acid. (2-3g glacial acid in 1 liter solution of 85/15 ethanol/water) and dried at 50 °C.

Step 2:
2.0 to 10.0 g acidulated carboxymethyl nonwovens were treated for 45 minutes to 4 hours in the 0.1% Silver Nitrate solution in 85/15 ethanol/water, squeezing the excess solution, washing in ethanol and drying in an oven at 50 °C.

0.1% silver nitrate solution was prepared as follows:

100.0 ml	(0.5%) silver nitrate solution
400.0 ml	Ethanol
500.0 ml	Total solution

Table 2. Antimicrobial Activity on Ag/Na carboxymethyl cotton (Data by: NAMSA).

Staphylococcus aureus

	Organism Count (CFU/ml)			Percent Reduction	
Sample Identification	**Zero Time**	**One Hour**	**24 Hour**	**One Hour**	**24 Hour**
#113-AG	1.8×10^4	< 10	< 10	99.95	99.95
Control	1.9×10^4	2.0×10^4	2.9×10^4	NR	NR

Klebsiella pneumoniae

	Organism Count (CFU/ml)			Percent Reduction	
Sample Identification	**Zero Time**	**One Hour**	**24 Hour**	**One Hour**	**24 Hour**
#113-AG	2.0×10^4	< 10	< 10	99.95	99.95
Control	1.9×10^4	2.1×10^4	1.3×10^6	NR	NR

NR= No Reduction.

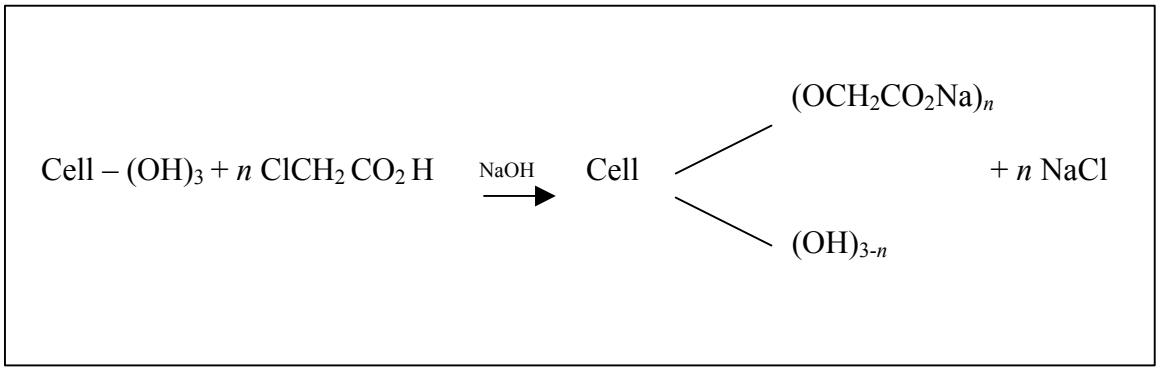

Figure 1. CM Reaction.