DEVELOPMENT AND PERSPECTIVE OF MODERN WOUND DRESSING – ANTIBACTERIAL EFFECT OF SILVER

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1. Introduction

Nowadays the item of the wound care is the very discussed topic among doctors, patients and the broad public as well. Among very problematic and the most often abounded wounds belong decubits, varicose ulcers, various skin wounds and complicated burns.

2. Healing and wound care

The basic step of the successful healing of these wounds is the complex cure that comprehends not only the exteriour therapy but also the prevention of risk factors and the following monitoring of a wound after healing. Unfortunately there is no universal wound care or one therapeutic wound dressing for fast and good cure. [1] The wound care has to observe the real healing process of the organism. The regeneration of tissue passes through several phases. [1] They temporally overlap and influence themselves so it do not jump or isolate someone. In the first phase (called exudative) a bleeding is stopped and a cleanning process of the skin is runnig. In second phase (called proliferant) is creatted a missing tissue and in the last phase (called epithelization) is the new tissue covered by a novel skin.

Spontaneously the cascade of healing processes occurs only when the basic fyziological conditions are filled, e. g. there is optimal temperature and moisture, plenty of nutrients and oxygen etc. If we pass the wound care from the medical aspect (major surgery, dosage of antibiotics), it is important to ensure above-mentioned optimal healing conditionals. From this occasion traditional healing methods are replaced by advanced wound dressings. [2, 3, 4] Types of wound dressings are presented in Tab. 1. Materials and designs of wound dressing are derived from the application conditions [2], these are summarized in Tab. 2.

Table 1 : The categories of traditional and advanced wound dresings.

Traditional dressing	**Advanced dressing**
Gauze	Alginates
Lint	Hydrogel
Wadding	Hydrocolloids
Plasters	Foam dressing
	Film dressing

Table 2 : The functionality of traditional and advanced wound dressings.

Traditional dressing	**Advanced dressing**
Exudate absorption	Keep a moist environment
Haemostatis	Remove exudate and necrotic tissue
Antisepsic	Keep temperature constaant
Protection from infection	Oxygen permeable
Wound covering	Protection from infection
	Easy to handle
	Non-traumatic at the dressing change

2.1 Infection

Among the most frequent complications in the treatment belong a critical colonization of the wound by microorganisms and a breakout of a following infection that usually requires systemic antimicrobial treatment. [5] The infecting organism, or pathogen, interferes with the normal functioning of the host and can lead to chronic wounds, sepsis, gangrene, loss of an infected limb and even death. The most common bacterial skin pathogens are *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Streptococcus pyogenes*, *Enterobacter aerogenes*, *Escherichia coli* etc.[6]

2.2 Antiseptic wound dressing

Several advanced dressings, which are intended for the treatment of infected ulcerous wounds, contain various antiseptic agents to stifle the infection in the wound.[7] A variety of antimicrobial textiles and dressings are reported, employing different approaches like surface coating by quarternary ammonium salt, antibacterial fibre by graft polymerization, by treatment with pottassium iodine solution, microencapsulation etc. [8]

The application of silver as the antiseptic has become very popular today as well.[9] Silver has been used for centuries to prevent and treat a variety of diseases. [10] The antibacterial activity of silver has found a range of applications because its toxicity to human cells is considerably lower than to bacteria. This metal iont is active against a wide spectrum of microorganisms without a creating of a bacterial resistance. The most widely documented uses are prophylactic treatment of burns and water disinfection. [10] Silver appears to kill microorganisms instantly by blocking the respiratory enzyme system (energy production), as well as altering microbe DNA and the cell wall. [11] In the case of the advanced dressing, silver ionts are gradually released from this dressing and kill dangerous bacteria in the wound. [2, 11]

In our study we focus on a development of therapeutic textiles with silver too. We are following up the effect of silver, which is closely imobilized on the textile carrier by sol-gel method in a form of siloxan complex.

3. Experiments

3.1 Preparing of textile samples

For experimets were used different textile materials, e.g. cotton, viscose and polyester woven fabric. Onto these fabrics were deposited the particles of silver by the polysiloxan bridges. The samples were prepared by a technology dip-coating, shown on Fig. 1, from a solution of precursors. The solution contained carrier TEOS, 10% $AgNO_3$ and other necessary additions (HNO_3, resolvent etc.). Then the treated surfaces were fixed by 180 °C for 5 minutes.

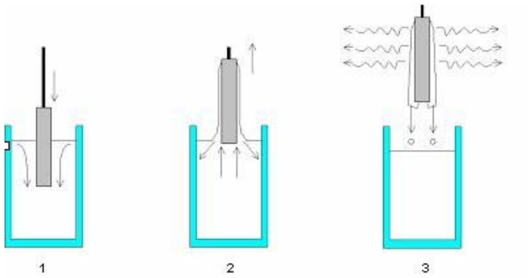

Figure 1. Scheme of method dip-coating, 1 – dip the substrate into the sol of precursors, 2 – take out the substrate from sol, 3 – evaporation of resolvent from substrate surface

3.2 Antibacterial test

Bacterial cultures used for testing: *Staphyloccoccus aureus, Enterococcus faecium, Streptococcus pneumoniae, Escherichia coli, Klebsiella pneumoniae, Proteus mirabilis, Pseudomonas aeruginosa, Acinetobacter baumannii.*

From several bacterial culture was prepared a suspension with the concentration 10^8 CFU/ml. This suspension was used for seeding the agar plates. Small samples 15 x 15 mm of treated textiles were placed on top of the seeded medium. After overnight incubation at 37 °C zones of inhibition (hallo zone) were measured. Fig. 2, 3.a, 4.a show the seeded agar plate with samples after 24 hours incubations.

1 3

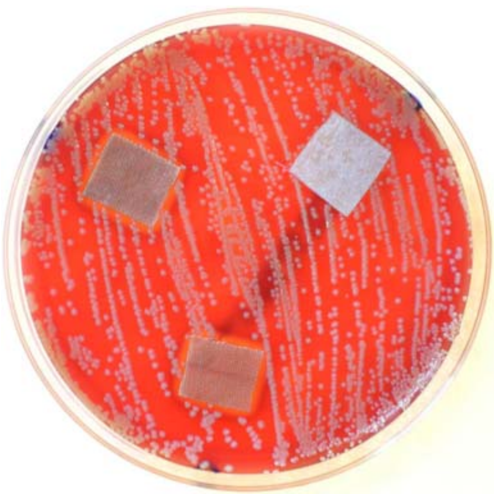

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Figure 2. Antibacterial activity of treated textile samples against *Staphylococcus aureus*
1 – cotton , 2 – viscose, 3 – PES sample

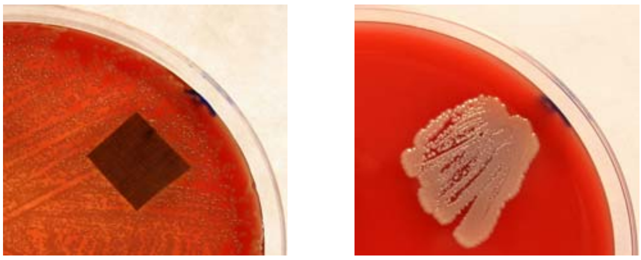
Then the samples were put away from the agar plate and were wiped off this place. These bacterial were seeded to new agar plate and then incubated with the same conditionals mentioned-above. The growth of bacteria was evaluated, see Fig. 3.b, 4.b.

4. Results and conclusion

In this study was tested the antibacterial effect of textiles, which were treated with silver by sol-gel method. The silver is closely immobilized on the textile fabric by polysiloxan complex. Antibacterial effect was observed only for cellulosic material. The effect of polyester samples was inconsiderable. This fibre has not appropriated properties for this treatment and applications.

a b

Figure 3. Detail of treated cotton samples against *Pseudomonas aeruginosa*,
a - hallo zone, b – bacteria from the wipe



a b

Figure 4. Detail of treated cotton samples against *Staphylococcus aureus*,
a - hallo zone, b – bacteria from the wipe

From experiments it is appreciable, that silver immobilized on the textile cellulosic substrate has a good bacteriocidal effect for the wide spectrum of gram-negative bacteria. The term bactericidal effect means that the bacteria in contact with this samples were killed or significantly reduced. At tested gram-pozitive bacteria there is located only a bacteriostatic effect. In this case the growth of bacteria was inhibited. In real use this means new possibilities for the local therapy of complicated skin wounds.

Acknowledgements

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