Sebastian Buhl, Sebastian Käs, Alexander Stich, Sabine Gruber and Clemens Bulitta*

Comparison of the effectiveness of different antimicrobial surface technologies

Abstract: The risk of infection via microbiologically contaminated surfaces has already been demonstrated by other publications. In this work two different antibacterial surface technologies transition metalloacids (AMiSTec) and TiO2/AgNO3 (Health Complete) were compared regarding feasibility as well as their advantages and disadvantages. The examination of the antimicrobial activity was assessed according to the JIS Z 2801. We could demonstrate that all of our tested samples showed a strong antimicrobial activity (>log 3 germ reduction) in the JIS experiments. Furthermore this strong antibacterial effect could be shown already after <30min incubation and at low light intensity (approx. 300 Lux) for the $TiO_2/AgNO_3$ samples. Both technologies provide a high potential for an improved infection control for example in a high risk environment like operation rooms or intensive care units.

Keywords: antimicrobial surface, infection control, infection

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1 Introduction

The scopes for the improvement of the infection control measures in the patient environment are manifold. The proper use of cleaning and disinfection (C & D) has always been the key to maintaining a good hygienic standard for hospitals. However, the reduction of the microbial load is not limited to cleaning and disinfecting measures only. Recently antimicrobial surface technologies like nanosilver, transition metal acids or photocatalysis come to the fore in terms of hygienic improvements.

A lot of research has been done in the past with the antimicrobial effect of metals and metalloxides. There are already publications available that show a positive effect of copper surfaces in intensive care units reducing nosocomial infection rates. [1] The antimicrobial activity of the metal ions e.g. of silver is attributed to the fact that the vital functions of microorganisms are disturbed by the metal ions. Ionized silver is highly reactive and leads to structural changes in the bacterial cell wall and nuclear membrane. Silver also denaturates bacterial DNA and RNA and inhibits bacterial replication. [2] Another more recent antimicrobial technology depends on acidic coatings. Therefore transition metalloacids the so-called Lewis acids act as catalysts for the conversion of water into $H3O^+$. The protons/H^+ ions released at the interface block enzymes in the cell wall of microorganisms, which interferes with the transport function of the blocked enzymes. Furthermore, it is assumed that protons/H^+ ions impair cell structural strength as well as damage the membrane structure. [3] Also photocatalytic coatings are described in the literature extensively. The effect of this antimicrobial technique relies in our case on the activation of crystalline TiO_2. This leads to the formation of reactive oxidative species (ROS) that are considered as the main products of photocatalytic reactions. [3+4]

2 Material and methods

The antimicrobial activity as well as the effectivity of the antibacterial technologies was analysed via bacterial effectiveness and comparative studies. The procedure is based on the JIS Z 2801 as a standard technique for the examination of antibacterial surfaces. The active components were applied to the test samples via the electrospray technique for $TiO_2/AgNO_3$. For the AMiSTec technology the samples were coated with the appropriate varnish. According to this triplicates of test samples are inoculated with a given concentration of bacteria ($2,5 – 10x10^5$) and are incubated for 24 hours at 35°C with a humidity of >90%. After that the samples are washed and the viable colonies are detected by plating. Antimicrobial ineffective surfaces serve as a negative control. The activity of the surfaces can be calculated by comparison with an antimicrobial inactive surface (Fig. 1). This was done with different incubation times and different light intensities to obtain results for the reaction kinetics and the influence of the luminosity to the antimicrobial effectivity.

***Corresponding author: Prof. Dr. Clemens Bulitta**: Technical University of Applied Science Amberg-Weiden, Hetzenrichter Weg 15, Germany, e-mail: c.bulitta@oth-aw.de, +49 (961) 382-1620, +49 (961) 382-2620

Sebastian Buhl, Sebastian Käs, Alexander Stich, Sabine Gruber: Technical University of Applied Science Amberg-Weiden, Hetzenrichter Weg 15, Germany

The antimicrobial activity is calculated according to the formula:
Activity = [log(A/B)]
A=Average of CFU/ml of plates without antimicrobial coating
B= Average of CFU/ml of plates with antimicrobial coating

Antimicrobial activity	Germ reduction (log CFU)
none	< 0,5
light	≥ 0,5 to 1
significant	≥ 1 to < 3
strong	≥ 3

Figure 1: calculation criteria for antimicrobial activity

3 Results

The experiments were performed with five different compositions of the AMiSTec components (Amistec A-E). We could demonstrate that all of our tested AMiSTec samples showed a strong antimicrobial activity (>log 3 germ reduction) in the JIS experiments. (Figure 2)

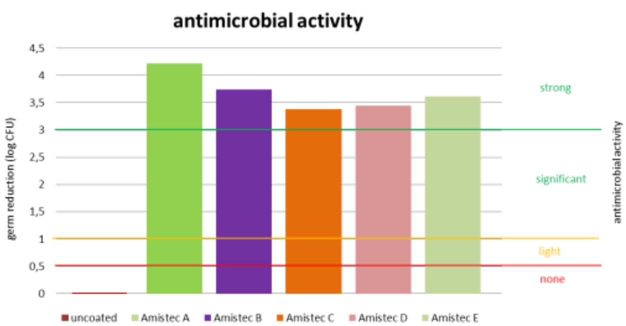

Figure 2: germ reduction of the tested AMiSTec samples

Similarly the three different TiO_2/$AgNO_3$ samples had a strong antimicrobial effect in the standard JIS setting after 24 hours incubation. In order to clarify the minimal period needed for a strong antibacterial effectivity of these coatings, the incubation time was reduced stepwise down to 0.5 hours. The evaluation of the reaction kinetics showed a full activity of the samples already after 30 minutes incubation time. The Health Complete surfaces showed this activity also at low light intensities (approx. 300 Lux). (Figure 3+4)

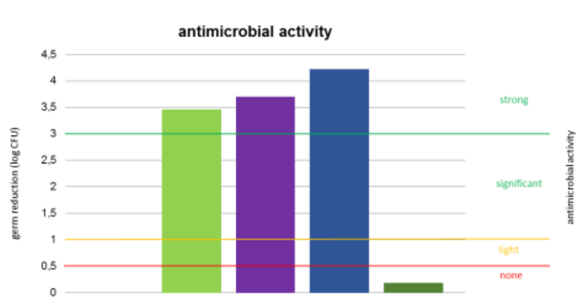

Figure 3: Germ reduction of Health Complete samples

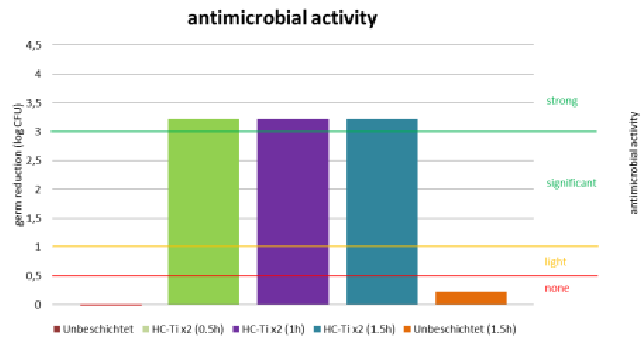

Figure 4: Reduction kinetics of samples

4 Discussion

All of our Test samples showed strong antimicrobial activity in the standard JIS test procedure. The testing of shorter incubation times (>15min) and lower light intensities should be performed subsequently to receive further information about possible thresholds. These experiments should be repeated with the AMisTec specimen accordingly.
The AMisTec technology can be easily included in a wide range of materials (plastic, varnish, etc.). Both technologies can also be applied on surfaces after production via the electrospray technique. Because of this advantage the products do not have to be designed and produced as antimicrobially active products in advance, but can be antimicrobially "retrofitted"/coated. This allows a broad range of applications to various products and components.
A possible next step could be to investigate potential synergies of the technologies to create more efficient and flexible solutions.
Nevertheless it is to discuss how far these results can be transported into real life situations. Further experiments should be developed in order to obtain more realistic predictions for the influence of the technologies on patient near surfaces. This requires experiments and studies in a clinical environment. The electrospray procedure for application of the antimicrobially active substances has substantial advantages to conduct such studies, as a retrofit is possible.

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Author's Statement

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