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Medical Textiles and Skin Equivalents

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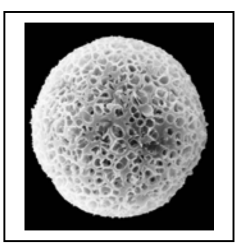
ABSTRACT

In recent years the cooperation between physicians, surgeons, microbiologists, physiologists and textile scientists has produced a multitude of innovative applications for textiles, especially in the medical field. The results are promising textile-based solutions for the health service, so called medical textiles. This article tries to cover some future aspects of medical textiles as well as how to improve the performance of these upcoming fabrics.

Keywords: innovative applications, textile-based health services

<u>The future of medical textiles</u>

Medical textiles are an increasing market. The background of this development is the increasing life expectancy and the challenges, which are resulting thereof for the medicine and the technology that goes with it. Already in 2040 the amount of people over 60 years in Europe will amount to 40 % of the entire population. In 1980 only 22 % of the Europeans belonged to this age group [1]. Textiles are forming an absolutely ideal interface between man and the health service and it is necessary to make use of the possibilities, which they are offering. Innovative medical textiles may for example take care of important functions, which up to now were covered by the doctor during a consultation (analysis) or by prescribing medicine.



In the future nanocapsules will medically functionalize textile fibres as sensors or drug depots

The spatial separation of doctor and patient opens the field of the „telemedicine“. The decisive role of medical textiles in telemedicine is based on the fact, that sensors and telecommunication systems, which are integrated into the clothing, gather medical values of the patient and deliver them to the treating doctor, hospital or a medical surveying station respectively an emergency centre. Here the data is being evaluated.

However, the reverse way is also conceivable, in that the medicine is being administered according to the medical advice by special drug-releasing textiles or integrated electronics. This allows a permanent medical surveillance and provision of medical care especially for older and chronically ill persons, without time-consuming and cost-intensive visits to the doctor or hospital stays. This technology allows a complete health surveillance even outside of the own flat, which leads to an enormous gain in safety and quality of life.

Telemedicine is thus a key factor to lower rocketing costs in the public health service [2] without concessions regarding the quality level. First precursors of „intelligent textiles“ (i-wear) are already being presented on expert meetings today. For example, the so-called „life shirt“ with fundamental functions for health surveillance: Heart sounds, respiratory rate as well as the body posture are being recorded. All information is gathered and transmitted to a doctor. But so far the „life shirt“ is an extremely unwieldy and expensive prototype [4]. However, within the next few years new innovative key technologies as the microsystem technology (MST) and the nanotechnology will help to reduce health-parameter-surveying sensors and drug-applying units to the size of a fibre diameter or even smaller [3]. This produces varied possibilities of a textile-based medical biometry, which is, so far and with the existing technology as the „life shirt“, impossible or hardly to accomplish.

At the Hohenstein Institutes skin equivalents are used to evaluate the functions of medical textiles

The „intelligent clothing“ of the future will also be equipped with integrated micro-sensors, which help to survey the most important general health parameters as body temperature, blood pressure, respiratory sounds and heart sound or will „report“ changes of the state of health. In principle a well-directed control of biosignals is also imaginable, for example in the case of illness. Thus nanosensors applied to textiles could help to establish signs of illness, as for example enzyme concentrations in case of cardiac diseases, increased blood sugar level of diabetes patients or cholesterol values and nitric oxide concentration in case of strokes or Alzheimer's disease. Hence, patients could be monitored much more intensively during their illness. Biosignals also include drugs of which the blood and tissue concentration is being surveyed by analytical medical textiles or being administered and controlled by textile-integrated, miniaturised injectors.

However, initially a textile-based medication by drug-releasing, nanocapsules-coated textiles shall be achieved. Nanocapsules are tiny hollow capsules of different materials with a diameter of the 10.000 part of a millimeter, in which drug and treatment cosmetic can be integrated and applied to the wearer during wear. Intensive research is presently carried out in the field of these drug depots on textile fibres. Drug-delivering applications in form of textiles covered with “smaller” microcapsules, which are about a 1000 part of a millimeter, are presently available on the market as T-shirts or stockings. These encapsulated drug depots already release substances like vitamin C or aloe vera [5, 8].

Sensors integrated into the clothing have clear advantages in comparison with conventional systems: Implanted sensors and drug depots require costly operations and well-tolerated materials, as they hold the risk of an undesirable immune response of the body due to a lack of biocompatibility. Moreover, external measuring and analysis systems assume a high degree of discipline of the patient, as reliable data can only be obtained under strict obeying of the guidelines, as for example the point in time of the measurement. Textiles on the other hand are being worn up to 24 hours a day and thus work regardless of the wearer's state of health.

<u>How to prove medical textiles with skin equivalents.</u>

However, the additional functions of medical textiles listed above, must be provable. That's why the textile research institutes like the Hohenstein Institutes are not only working intensively on the development of innovative clothing, but also on the development of test systems, to verify the function of the medical textiles and to optimise them. An interesting test system, on the market, that may help to clear this topic are human in-vitro skin-organ cultures, so-called skin equivalents [7, 9]. This bio-engineered skin, grown in the lab using small samples of human cells, has been on the market since 1997 and since then has shown major pros: The main advantage of a skin equivalent, that it corresponds to a large extent in function and reaction with the human skin. While such artificial skin was originally developed to help treat burn victims [11] and other patients, it and other engineered tissues are gaining new cachet as alternatives to animal testing for some basic research and drug-development tests [10]. Engineered tissues like skin equivalents are uniform from sample to sample whereas animal or human excised skin have biological differences that can affect test results. Thus, skin equivalents have the advantage of yielding test results that are easier to reproduce from lab to lab. Taken together, because of its similar cellular structure and behavior as normal living skin, skin equivalents are an ideal in vitro model for the cellular analysis of the interactions between skin and textiles.

Presently prototypes as the „life shirt" are unwieldy and expensive, however, the application of nano sensors will revolutionize technology within the next few years.

Photo: Vivometrics

Today, for instance, skin equivalents are the only test system which allow an adequate mechanical in vitro imitation of the physiological textile/skin interactions (even while humans sleep textiles either rest or mechanically move across the skin). Hence, an experimental set up using skin equivalents can be used to study the major question of drug-delivering textiles: the transfer of substances from the textile into the skin, as well as their consecutive skin care or skin penetrating effects.

Apart from drug delivery by medical textiles, the development of textiles in general opens another question, namely whether the textile itself or textile-derived irritating substances elicit skin rashes like contact dermatitis [15]. In contrast to certain cell culture systems, skin equivalents have the advantage that they allow to detect both, the –rather few- mechanical (e.g. wool-irritations) irritations and textile-derived irritations due to release of irritating chemicals as well.

There is good evidence that cellular parameters of inflammatory reactions from skin equivalents triggered or initiated by chemicals are e.g. the amount of released mediators like MTT, LDH, or interleukins [6,14]. These substances are good quantitative and qualitative indicators of the grade of an irritation [13]. Histology allows to study morphologic changes, differentiation processes, cell proliferation, DNA damage or repair mechanisms. Several immunoassays are presently on the market to evaluate metabolic cell reactions of skin equivalents. Even the production of reactive oxygen species in keratinocytes can be detected with fluorogenic substances like dihydrorhodamin 123. Other groups use skin equivalents, mounted in between a Franz diffusion chamber, to study the penetration behaviour of allergens, haptens or irritating substances [7,12].

conclusion:

There is no doubt, that medical textiles will play an important role in the future. Moreover, additional fields of application will result regarding personal wellness: Ranging from the surveying of the body functions during sport to the application of cosmetic and treatment agents via the textile. Test system based on skin equivalents will help to develop future medical textiles as an interesting test system to proof the various functions of upcoming medical textiles, or as a standardized and reproducible method to study textile-derived skin disorders. They are a versatile tool to study both, specific and unspecific parameters of cellular reactions elicit by skin/textile interactions.

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