ABSTRACT

The history of the textiles is as old as the history of human civilization. Ancient records show that textiles made from the natural fibers were used in various medical application. Textiles were used as filters for medicine preparations, casts, Splints and bandages for wounds care etc.

It is an established and a documented fact that, the skin is one of the largest organ that the human body possess. It plays a crucial role as a protective barrier from the external environment and also prevents external noxious agents such as all type of microbes from getting inside the body. It also maintains the internal environment of the body by the mechanism of regulation of water and electrolyte balance in the body, this leads to thermoregulation of the body as well. Hence it is crucial, that the skin remains intact so that the designated functions of skin are performed in an uncompromised manner. The body has higher chance of getting infected when the skin is damaged, due to any cause (mechanical injuries, ulcers, burns, neoplasm or surgical trauma). Whenever this happens the resources of body are wasted in fighting them all.

The conventional olden method of managing the wounds were to try and take them from wet stage to dry stage. The conventional dressings were constructed in such a way that they were supposed to dry the wounds completely. This concept has changed in modern science of wet to moist dressings. With the advanced progress of technology, invention of new techniques and new materials, the old understanding has changed and also majorly accepted all around. New approach lays stress on need of moist wound conditions for better healing. These new generation dressings are engineered for handling specific wound conditions that suit the dynamic process of wound healing. Today's dressings are designed to address various levels of exudates and infection conditions. Moist wound facilitates epithelialization of wound. Also water soluble essential substances that are

vital for the healing of wound like the amino acids, sugar, and electrolytes, are available for new cells formation only in the wet and moist form of wound.However,in terms of moisture balance, the wound should be kept moist but not highly wet and flooded with exudates. High level of exudates built up lead to maceration of the wound. Maceration causes erosion of the healthy skin boundary of the wound well and hampers the wound healing and wound closure.

However, the moist and warm dressing may act as favorable conditions for the microbial proliferation. The warmth of body, wetness in wound and the presence of nutrients for the microbial proliferation in the wound can act as a breeding ground for the microbes and lead to spread of infection.Microbial proliferation may lead to prolong inflammatory stage and cause infection. It may even lead to acute wounds getting converted to hard-to-heal chronic wounds.

Wound healing gets complicated further, where the body is under immune compromised condition. The body conditions like diabetics hinder the normal healing of wound. This lead to the formation of chronic wound, which is highly infected and difficult to heal. Such infected wounds are breeding ground for pathogens that build a colony in the wound site with the strong protein film called biofilm. Biofilm is very difficult to be eliminated by the use of topical or systemic antiseptics and antibiotics. Such wound may lead to bone infections that progresses rapidly in the bone marrow and if unattended, may ultimately lead to amputation of body part.

The available and most widely used substrates like gauze materials, mostly cotton are too ineffective to manage the exudates load of chronic and highly infected wounds. They get loaded with exudates soon. Nonwoven pads or sponge are prone to have basic disadvantage of keeping the reservoir of exudates on wound bed that leads to the wound bed getting wider on account of degradation of skin of wound well. Frequent dressing changes causes frequent traumatization of wound by peeling the newly formed wound surface and also increases the cost of wound management.

In this study, attempt is been made to obtain this combination of properties of moisture management, Infection management and then specific target based biofilm elimination.

In this research as a first objective, a 3 dimensional (3D) hydrocellular knitted antimicrobial functional material (fabric) which acts as an advanced foam dressing is developed. It can be categorized as Hydrocellular dressing; wherein the porous spaces in fabric structure facilities quick absorption of exudates by capillary action. It is a flexible and stretchable structure. The material being polyester, is highly biologically neutral, cheap and easily available and also accepted by medical regulators across the globe as a safe material to contact the wound surface. This dressing is with an effective antimicrobial technology, that is cross bonding and cross polymerizing and further it is of non-leaching and non-depleting. The compound used is generally referred as Quaternary Ammonium Salt (QAS). This Technology has good biocompatibility as seen in the study and also has unique physical rupture of microbial kill that prevents the formation of superbugs unlike the leaching compounds used widely in current generation dressings. This material had more than 99.9999 % of microbial kill for a broad spectrum of microbes within 24 hours. The material also had a good effectiveness of almost 100 % bacterial kill for about 28 days when it was tested for 7 days ,14 days and 28 days in the study. The material exhibited 90 to 100 % elongation for 100 N force used in repetitive load elongation cyclic loading both in wales way and coarse way. The leachability analysis of the cross bonded QAS was studied in the presence of both polar and non-polar solvent and the study proved that the cross bonded antimicrobial material was non-leachable.The Moisture management property of dressing was extensively studied by AATCC 195 test method with comparator dressings based on foam and nonwoven fabric technology and results proved that the OMMC index of fabric was 0.6033(Grade4) making it an excellent material for exudate handling.

Further, the method of construction of drug loaded hydrogel dressing and optimization of the composition to have maximum swelling and effective strength and elongation along with release properties is also discussed in detail in this research work. This topic helps in understanding the drug delivery mechanism that is needed when specific drug or growth promoter is needed to be released in the dressing. Comparator studies in rats with dressing like CMC dressing, Enzymatic gel and PHMB based dressings showed that the developed dressing was able to contract wound by 83 % as against PHMB which did only 39 % wound contraction.

As a part of next objective, the composite dressing is constructed by combining the two textile fabrics i.e Hydrocellular wound dressing fabric and the drug loaded hydrogel dressing. This was done to take advantage of swelling of the gel based dressing to have good wound debridement needed for necrotic wound and also to have specific antibiofilm properties by target eliminations of biofilms in the wound. As per study this composite dressing served as an excellent wound dressing material for chronic and necrotic wounds due to the synergistic effect of the two dressings.

Composite dressing exhibited more than 99.99 % microbial reduction in 30 mins and was effective for a period of 7 days for its antimicrobial activity. The dressing exhibited 90.8 % kill rate for drug resistant strains like MRSA within 10 mins. The moisture vapor transmission rate when compared with foam based dressing and 8 ply cotton gauze dressing was seen to be around 4 gms versus around 3 gms for gauze and around 1.8 gms for foam dressing over 24 hrs. Animal studies with sham control showed that the dressing was able to heal the wound significantly better based on the histopathology scores. Studies were conducted on diabetic wounds on rats to prove the efficacy of composite wound dressing. Debridement data obtained by analysis of the used dressing at 20-micron on SEM images showed significant amount of dead and necrotic cells carried by the dressing during the usage period, which is an essential requirement for healing chronic,

necrotic wounds. It was also seen in the study that, the formed biofilms are disrupted due to the precise action of the antibiofilm agent to the tune of 99.99 %.

The developed dressing was evaluated for biocompatibility in terms of cytotoxicity, skin sensitization, Intracutaneous reactivity and acute systemic Toxicity. All of them were approved for the developed material to be used as a safe dressing on breached skin .

Being efficacious for 28 days in the study period proved that the need of repetitive wound dressing changes can be brought down with this concept of dressing. The imported high end advanced wound dressings are beyond the reach of common persons and hence a Hydrocellular dressing material discussed in this study can surely be an easy and affordable solution in the hands of care providers. It is not only cost effective in terms of its material cost but it is also a cost effective solution when entire wound management cost is considered. The developed Hydrocellular composite fabric dressing material can be used as a long lasting dressing for wound management in diabetic wounds. Such wound dressings material can change the quality of life of diabetic wound patients especially in developing world, where cost of healthcare and access to advanced wound care dressings is beyond the reach of larger public.