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Editorial

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Innovation of Wound and Burn Care Dressings from Traditional to Nonwoven Polymeric Scaffolds

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Health care professionals often come across patients inflicted with exuding wounds and burn injuries which get infected with broad range of micro-organisms because wounds often provide a favourable environment for the colonization of microbes. *Staphylococcus aureus* and *Trichophyton rubrum* are the most common pathogens which are responsible for skin and nail infection.[1] Some deep wounds and burns damage the underlying structures like muscle, tendon, blood vessels, nerves, and bone which need persistent medical care to prevent systemic infection and loss of organ function.[2] Sometimes, aggressive wound infection can cause septicemia and death. The remit of this editorial is to highlight the innovation of biocompatible nanofiber dressings for the localized delivery of antiseptics, antibiotics and growth factors which promote wound and burn healing.

Figure 1 depicts 3 generations of dressings used for wound and burn healing. Traditional dressings consisted of cotton swabs and gauze dressings for managing the chronic and highly exuding wounds over centuries. This practice subsequently led to the development of advanced wound and burn care dressings for the localized delivery of therapeutic products and the modern nonwoven polymeric wound care scaffolds. Advanced antimicrobial wound care dressings or bioactive dressings are comprised of a wide variety of materials such as sodium alginate, ionic silver, chitosan, hydrocolloid, foam, gel or paste, molecular iodine, and have been marketed for several years. The fabrication of modern and novel biocompatible dressings which incorporate bioactive wound healing materials like growth factors are summarized in Table 1.[3] Growth factors help to repair the damaged tissues and promote healthy cellular growth.

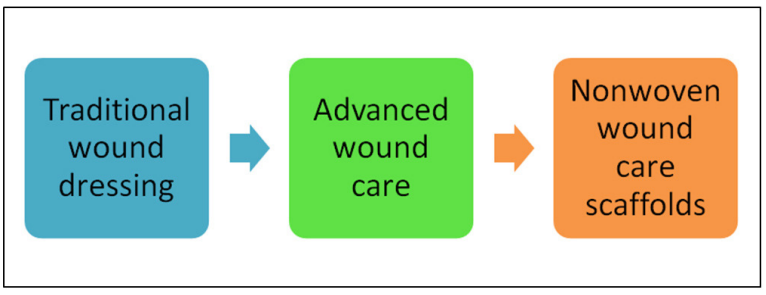

Figure 1: Three generations of dressings for wound and burn care.

Examples of a number of modern dressings containing antimicrobial agents and their manufacturers are shown in Table 2.[4] Incorporated antiseptic and anti-inflammatory agents are slowly released at the wound surface. Because of its effectiveness against a broad range of micro-organisms, silver is included in many wound and healthcare products. Silver nanopar-

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Growth factor or cytokin	Effect on wound	Current status
Transforming growth factor β	Re-epitheliasation	Initial studies in venous ulcers encouraging
	Neovascularisation	
	Increased granulation tissue and collagen	
	Reduced scar formation	
Platelet derived growth factor	Re-epithelialisation	Licensed for the treatment of neuropathic diabetic foot ulcers
	Neovascularisation	
	Increased granulation tissue and collagen	
Fibroblast growth factor	Re-epitheliasation	Biological effects in pressure ulcers demonstrated to date
	Neovascularisation of a provisional matrix	
Interleukin 1 β	Healing of infected wounds	Currently under trail for pressure ulcers
Granulocyte macrophage-colony stimulating factor	Improved healing in acute wounds	Pilot studies in infected diabetic foot ulcers encouraging

Table 1: Examples of growth factros in wound healing.

Dressing Name	Antimicrobial ingredient	Dressing Format	Manufacturer
Acticoat absorbent	Ionic silver	Calcium alginate	Smith & Nephew, Inc., Largo, FL, USA
Actisorb Silver 220	Ionic silver and activated charcoal	Silver impregnated activated charcoal cloth	Johnson and Johnson Wound Management, Somerville, NJ, USA
Arglaes	Ionic silver	Transparent film or powder	Medline Industries, Inc., Mundelein, IL, USA
Aquacel AG	Ionic silver	Hydrofiber	Convatec, Skillman, NJ, USA
Contreet H	Ionic silver	Hydrocolloid	Coloplast Corp., Marietta, GA, USA
Contreet F	Ionic silver	Foam	Coloplast Corp., Marietta, GA, USA
Iodosorb	Molecular iodine	Gel or paste	HealthPoint Ltd., Ft. Worth, TX, USA
Silvasorb Antimicrobial Silver Dressing	Ionic silver	Hydrogel sheet or amorphous gel	Medline Industries, Inc., Mundelein, IL, USA
Kerlix AMD Gauze	PHMB	Gauze	Tyco Healthcare/Kendall, Mansfield, MA, USA

Table 2: Examples of antimicrobial dressings.

ticles release silver ions in sustainable form to maintain desired concentration for antimicrobial, anti-inflammatory, and wound healing activity, while minimizing the toxic effect of silver. Silver accelerates healing of injured tissue through antimicrobial, anti-inflammatory, and antioxidant effect. The emergence of bacterial resistance to silver and its potential to induce cross-resistance to antibiotics has also been reported.[5] In cell culture experiments done with human mesenchymal stem cells, silver ions were found to be much more toxic than silver nanoparticles.[6] However, despite of these risks, the use of silver-containing dressings (e.g. hydrofiber dressing, polyurethane foams and gauzes) is increasing in wound and burn care products.

Currently, the development of a variety of biocompatible dressings are the focus of attention of biomedical researchers.[4,7] These dressings serve as vehicle for the promising delivery of wound or burn care ingredients or even allogenic cells which may provide a specific wound healing benefit. Further, the dressing acts to maintain a locally moist environment needed for wound healing.

Biocompatible and biodegradable polymer micro- and nano-fiber devices fabricated from nanofiber materials with sizes less than 1 μm or 1 nm are especially useful in the field of medicine because these nanomaterials tend to replicate the molecular components of *in vivo* cellular and bimolecular environment. The synthetic and natural nanofibers of biodegradable and biocomatible polymers are good career vehicles for targeted drug delivery in wound or burn care as well as anti-cancer drugs. Also, the nanofiberous devices are beneficial for burn and wound healing due to their large surface-area-to-volume ratio, high porosity, improved cell adherence, cellular proliferation and migration, as well as controlled *in vivo* biodegradation rates. The large surface area of polymer nanofiber dressings not only allows increased close interaction of therapeutic agents and exchange of O_2 and CO_2 with tissues, but also provides a mechanism for sustained release and localized delivery of antiseptic remedies, analgesics, and growth factors needed for burn and wound healing. In addition, the high porosity of nanofiber dressings permits diffusion of nutrients and removal of waste products from the application site. With all these attributes and functions, nanofiber devices promote wound and burn healing. Owing to their multifaceted properties, the nanofiber dressings created from both natural and synthetic polymers have attracted the attention of surgeons, physicians, biomedical researchers, and industry. Their envisioned potential applications are due to the optically

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transparent functional materials and nano-composites required for making scaffolds to grow stem cells, wound healing dressings and mats, transdermal patches, targeted drug-delivery systems, tissue compatibility and biodegradability, improved cell adherence, and relatively lower manufacturing cost.[8-11]

Several studies and experimental evidence suggest that nanofibers with diameter range of 50-100 nm have a great potential for making nanofiber dressings for wound care due to their large surface area, high porosity, and small pore size. Nonwoven nanofibrous scaffolds or patches for wound care have shown to produce skin substitutes with optimal cellular organization, proliferation and to reduce wound contraction. As the skin provides perfect protection from external environment, therefore for wound care, an ideal wound dressing should be compatible with skin and native tissue, should have the capacity to provide thermal insulation, gaseous exchange, and to help drainage and debris removal thus promoting tissue reconstruction processes. Further, an ideal dressing should be biocompatible and not provoke any allergic or immune response reaction, protect the wound from secondary infections, and should be easily removable without causing trauma.[12-18] A variety of wound and burn care dressings in the form of foam, membranous and nonwoven materials with natural or synthetic polymers, as well as combination of both, and impregnated hydrogels are being investigated by researchers worldwide.[19,20] In addition, nanofibrous biodegradable polymers impregnated with wound healing materials are also under investigation.[21-24]

In summary, it's estimated that the global wound care products market is expected to reach $18.3 billion by 2019 from $15.6 billion in 2014.[25] Such, dollar figures suggest that sophisticated and innovative wound care dressings would form a significant part of the total medical devices market. Therefore, continued attention of the biomedical researchers and industry is needed to address the opportunities and challenges posed by wound and burn healing products and to improve the quality of patient care.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

1. Nguyen DT, Orgill DP, Murphy GF. *The Pathophysiologic Basis for Wound Healing and Cutaneous Regeneration Biomaterials for Treating Skin Loss*. Chap 4. Cambridge/Boca Raton, FL, USA: Woodhead Publishing (UK/Europe) & CRC Press (US); 2009: 25-57.

2. Wikipedia, the free encyclopedia. Wound healing Web site. https://en.wikipedia.org/wiki/Wound_healing. Accessed November 29, 2016.

3. Harding KG, Morris HL, Patel GK. Science, medicine, and the future: Healing chronic wounds. *BMJ.* 2002; 324: 160-1633. doi: 10.1136/bmj.324.7330.160

4. Harcup JW, Saul PA. A study of the effect of cadexomer iodine in the treatment of venous leg ulcers. *Br J Clin Pract.* 1986; 40: 360-364. Web site. http://europepmc.org/abstract/med/3542001. Accessed November 29, 2016.

5. Percival SL, Bowler PG, Russell D. Bacterial resistance to silver in wound care. *J Hospital Infection.* 2005; 60(1): 1-7. doi: 10.1016/j.jhin.2004.11.014

6. Kittler S, Greulich C, Diendorf J, Koller M, Epple M. Toxicity of silver nanoparticles increases during storage because of slow dissolution under release of silver ions. *Chem Mater*. 2010; 22: 4548-4554. doi: 10.1021/cm100023p

7. Ormiston MC. Controlled trial of iodosorb in chronic venous ulcers. *Br Med J (Clin Res Ed).* 1985; 291(6491): 308-310. doi: 10.1136/bmj.291.6491.308

8. Habibi Y, Lucia L, Rojas O. Cellulose nanocrystals: Chemistry, self-assembly, and applications. *Chemical Reviews.* 2010; 110*:* 3479-3500. doi: 10.1021/cr900339w

9. Siro I, Plackett D. Microfibrillated cellulose and new nanocomposite materials: A review. *Cellulose.* 2010; 17: 459-494. doi: 10.1007/s10570-010-9405-y

10. Visakh P, Thomas S. Preparation of bionanomaterials and their polymer nanocomposites. *Waste and Biomass Valourization.*

ISSN 2996-5942 Open Journal http://dx.doi.org/10.17140/PLMOJ-1-e002

2010; 1: 121-134. doi: 10.1007/s12649-010-9009-7

11. Klemm D, Heublein B, Fink HP, Bohn A. Cellulose: Fascinating biopolymer and sustainable raw material. *Angewandte Chemie Int*. 2005; 44: 3358-3393. doi: 10.1002/anie.200460587

12. Morin RJ, Tomaselli NL. Interactive dressings and topical agents. *Clin Plast Surg.* 2007; 34(4): 643-658.

13. Lloyd LL, Kennedy JF, Methacanon P, Paterson M, Knill CJ. Carbohydrate polymers as wound management aids. *Carbohydr Polym*. 1998; 37: 315-322. Web site. http://agris.fao.org/agris-search/search.do?recordID=US201302913136. Accessed November 29, 2016.

14. Mulder M. The selection of wound care products for wound bed preparation. *Prof Nurs Today.* 2011; 15(6): 30-36. Web site. http://www.pntonline.co.za/index.php/PNT/article/viewFile/563/850. Accessed November 29, 2016.

15. Harding KG, Jones V, Price P. Topical treatment: Which dressing to choose. *Diabetes Metab Res Rev*. 2000; 16(Suppl 1): S47-S50. doi: 10.1002/1520-7560(200009/10)16:1+<::AID-DMRR133>3.0.CO;2-Q

16. Morton LM, Phillips TJ. Wound healing update. *Semin Cutan Med Surg*. 2012; 31(1): 33-37. doi: 10.1016/j.sder.2011.11.007

17. Wittaya-areekul S, Prahsarn C. Development and in vitro evaluation of chitosan-polysaccharides composite wound dressings. *Int J Pharm*. 2006; 313(1-2): 123-128.

18. Boateng JS, Matthews KH, Stevens HN, Eccleston GM. Wound healing dressings and drug delivery systems: A review. *J Pharm Sci*. 2008; 97: 2892-2923. doi: 10.1002/jps.21210

19. Zahedi P, Rezaeian I, Ranaei-Siadat S, Jafari S, Supaphol P. A review on wound dressings with an emphasis on electrospun nanofibrous polymeric bandages. *Polym Adv Technol.* 2010; 21: 77-95. doi: 10.1002/pat.1625

20. Gultekin G, Atalay-Oral C, Erkal S, et al. Fatty acid-based polyurethane films for wound dressing applications. *J Mater Sci Mater Med.* 2009; 20: 421-431. doi: 10.1007/s10856-008-3572-5

21. Vaseashta A, Erdem A, Stamatin I. Nanobiomaterials for controlled release of drugs and vaccine delivery. *Mater Res Soc Symp Proc.* 920; 2006: 143-148. Web site. https://www.cambridge.org/core/journals/mrs-online-proceedings-library-archive/article/nanobiomaterials-for-controlled-release-of-drugs-and-vaccine-delivery/A7B20086ED5E0DC405AF9AC53C103962. Accessed November 29, 2016.

22. Dai XY, Nie W, Wang YC, Shen Y, Li Y, Gan SJ. Electrospun emodin polyvinylpyrrolidone blended nanofibrous membrane: A novel medicated biomaterial for drug delivery and accelerated wound healing. *J Mater Sci Mater Med*. 2012; 23: 2709-2716. doi: 10.1007/s10856-012-4728-x

23. Losi P, Briganti E, Costa M, Sanguinetti E, Soldani G. Silicone-coated non-woven polyester dressing enhances reepithelialisation in a sheep model of dermal wounds. *J Mater Sci Mater Med.* 2012; 23: 2235-2243. doi: 10.1007/s10856-012-4701-8

24. Nguyen TTT, Ghosh C, Hwang S-G, Tran LD, Park JS. Characteristics of curcumin-loaded poly (lactic acid) nanofibers for wound healing. *J Mater Sci.* 2013; 48: 7125. doi: 10.1007/s10853-013-7527-y

25. Mateescu M, Baixe S, Garnier T, et al. Antibacterial peptide-based gel for prevention of medical implanted-device infection. *PLoS One.* 2015; 10(12): e0145143. doi: 10.1371/journal.pone.0145143