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Wound Healing Nano-Bandages

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Abstract: ***The world today is changing in view of healthcare products. Easy treatments and cheap products are the need of the hour considering the populations around the world and their economic conditions. Products which are feasible and environmental friendly should be developed and marketed for common people. Wound healing is one of the major concerns in the field of healthcare. Despite the development of nanotechnology various materials for wound dressings are available in the markets which do not fully satisfy the requirements of an ideal wound bandage. It is the need of the hour to design wound dressings in the form of nano-fibres which can address such problems simultaneously, thus developing improved wound management, creating an easy solution for severe wounds, and decreasing death rate induced by severe infections and bleeding.***
Keywords: Nanofibers, wound, infections, diseases, healing

I. INTRODUCTION

Today nanotechnology are been widely used to label a variety of products in different fields be it be food, pharmaceutical or any other materials. The future world will be of nanotechnology. These terms more often appear in the news and advertisements. Polymers are a major area of research in todays' scenario of nanotechnology field; they have managed to greatly improve our society.

Polymers contain highly desirable characteristics such as high strength or modulus to weight, toughness, resilience, resistance to corrosion and lack of conductivity, despite of being comparatively cheap (Fig-1). Such characteristics make them perfect entities for their utilization in various applications; such as in biomedical devices, health care, food, agriculture, catalysis, electronics, environment, renewable energy or textiles.

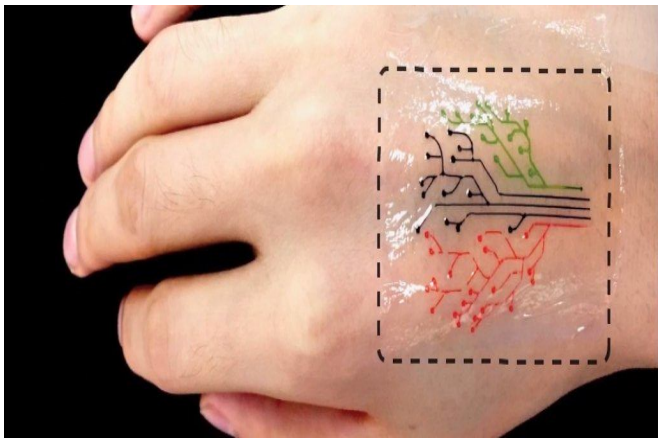

Fig 1 Picture depicting nano-fiber bandage

Human skin is a protective barrier to many bacterial infections, but damage to the skin allows these infective micro-organisms to enter in the human body. Normally, our immune system kills the bacteria and allows the wound to heal. However, certain infection can overcome the immune system and lead to serious diseases. Antibiotics are commonly used to treat microbial infections, but may take some time honing to the extent of infection.

The nanofibers are soft materials consisting of two parts. The first component kills bacteria and the other has elastic properties mimicking human skin, forming a patch similar to the skin to cover the wound and provide a suitable environment for wound healing. In addition, these nano-bandages are biodegradable, means that they are naturally absorbed by the skin during treatment.

Many scientists have been demonstrating the wound-healing capacities of the nanofibers, in mice with wounds infected by bacteria. The nanofibers showed the best healing ability compared to the normal commercially available products which included fast removal of bacterial infection, decreased wound size, and decreased wound-closure time.

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The main aim of polymer researchers when developing novel health-care products are to lower the spread of infections. The search for new more efficient antibiotics is continuously increasing. However, antibiotic-resistant bacteria are becoming a great threat to human health mainly due to the abuse and the improper use of antibiotics.

The skin in Human body acts as a protective barrier to bacterial infection, but any damage to the skin allows bacteria to enter. Normally, the bacteria are killed by our immune system which allows wounds to heal. However, certain infection can overload the immune system and lead to severe diseases. Antibiotics are commonly used to treat heavy bacterial infection, but bacteria can develop drug resistance due to high exposure.

Wound healing is a specific biological process in relation to the general phenomenon of growth and tissue regeneration. This paper is not intended to describe the details the physiology of wound healing, but to understand the basic processes related to wound the reader is referred to the texts and literatures for detailed scientific expositions. [1] [2]

Wound healing process is a series of interdependent and overlapping stages in which a variety of cellular and matrix components act together to replace the lost tissue.[3] [4] The wound healing process has been reviewed and described by Schultz[2] as having five overlapping stages which are described as haemostasis, inflammation, migration, proliferation and maturation phases.[Fig-2]. Wound healing formulations (dressings) and novel technologies developed to date focus on one or more of these aspects of the natural healing process [5] that are summarized briefly below.

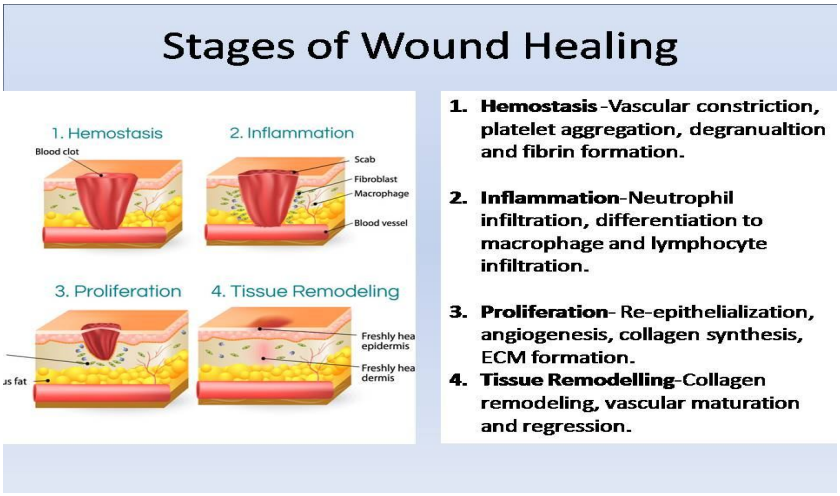

Fig 2 Various phases of wound healing

II. NANO-FIBERS: A PROMISING WOUND HEALERS

The nanofibers are soft materials consisting of two parts. The first component kills bacteria by damaging their surface structures and disrupting their normal activities. The second component has elastic properties mimicking human skin, forming a skin-like patch to cover the wounds and provide a suitable environment for wound healing. These nanofibers are usually biodegradable, meaning that they are naturally absorbed by the skin during treatment. To demonstrate the wound-healing capacities of the nanofibers, mice with wounds infected by drug-resistant bacteria were treated with both nanofiber and a commercial wound dressing product. The nanofibers showed the best results in healing ability which included fast removal of bacterial infection, decreased wound size, and decreased wound-closure time compared to the commercial dressings.

Although such experimental studies have being showing that the nanofibers can enhance healing abilities of wounds based on experiments on small wounds in mice. Dressings of such variety work by releasing antibiotics slowly from nanocapsules embedded onto the bandage which are usually catalyzed for action by the presence of disease-causing pathogenic microorganisms. These type of dressing will also change colour when the antibiotics are released, alerting the healthcare professionals about the presence of infection. Such efforts are an important step in treating burns patients, especially children, where secondary infections lead to lethal diseases like toxic shock syndrome.

Modern methods focus on the use of synthetic polymers and biopolymers, in the form of hydrogels [7], thin films [8], and Nano fibrous scaffolds [9]. Many wound healing medicines have toxic effects on various other organs of the body which is usually termed as side effects. To reduce such events and to increase the effect of medicine; such topical bandages may be helpful and concerted efforts may be required for inventing better drug delivery nanofibre bandages for speedy recovery of patients.

Treatment method	Mechanism of action	Limitations
Tetracyclines		
Minocycline	Inhibition of MMP-1, -2, -3, -8, and -9, and iNOS[41]	Gastrointestinal toxicity;[44] possibility of development of antibiotic-resistant strains of bacteria[43]
Doxycycline	Inhibition of MMP-1, -2, -8, and -9[35,42]	Development of antibiotic resistance[43]
Chemically modified tetracyclines (CMTs)	Inhibition of MMP-1, -2, -3, -8, -9, -10, -11, -13, MT-MMPs, and neutrophil elastase[42–44]	Not well studied
Silver-containing agents		
Silver nitrate, silver sulfadiazine	Antimicrobial properties;[53] reduction of infection[53]	Inactivation by chloride ions present in wound exudate;[53] cytotoxicity[54]
Silver nanoparticles	Antimicrobial properties;[53] reduction of infection;[53] anti-inflammatory properties and decreased activity of gelatinases (mainly MMP-9)[36]	Possible cytotoxicity[55]
Collagen dressing agents	Functions as alternative substrate for MMPs and neutrophil elastase;[38,61] possibility addition of bioactive components to the dressing agent[58]	Optimal collagen source and bioactive components not elucidated
Negative pressure wound therapy (NPWT)	Increased formation of granulation tissue and wound bed preparation, faster reduction of wound area, increased cell proliferation and reduction of edema;[68,69] possible reduction of levels of MMPs[69]	Mechanisms responsible for observed effects not well understood[67]
Superabsorbers	Reduction of MMP activity by absorption of exudate and chelation of Zn^{2+} and Ca^{2+} ions[71,72]	General rather than specific effect

Fig 3 Table depicting various limitations of Treatment pharmaceuticals. [6]

III. FUTURE NEEDS FOR WOULD DRESSINGS

In todays scenario most wound dressings are limited in the form of fast degradation, weak adhesiveness and absorption, lack of total drug release properties, poor air permeability, as well as not being able to prevent protein adhesion onto the wound dressing surface. Despite the development of nanotechnology various materials for wound dressings does not fully satisfies the requirements of an ideal wound bandage. It is the need of the hour to design wound dressings which can address such problems simultaneously, thus developing improved wound management, creating an easy solution for severe wounds, and decreasing death rate induced by severe infections and bleeding.

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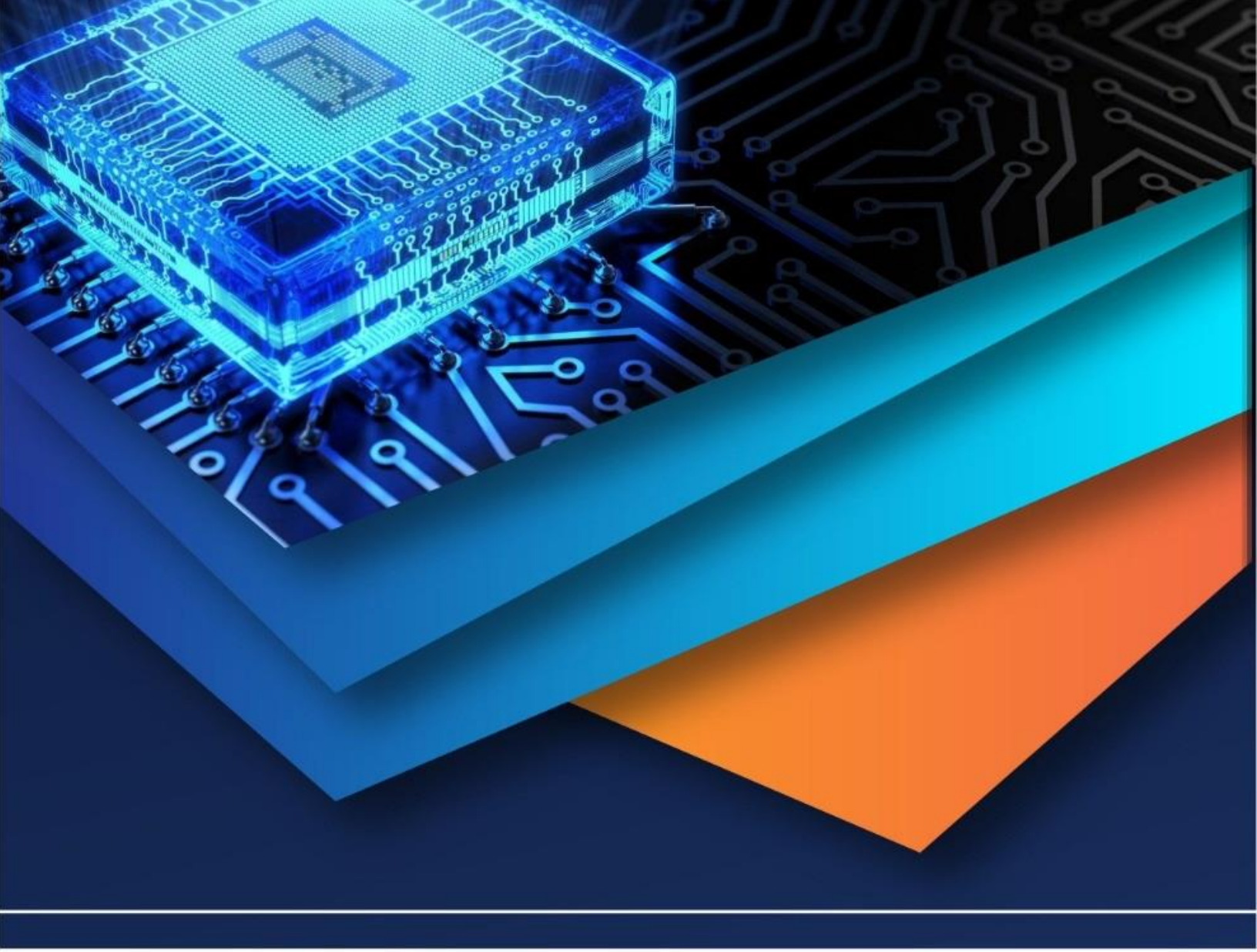

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