Journal Homepage: -www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI:10.21474/IJAR01/12163
DOI URL: http://dx.doi.org/10.21474/IJAR01/12163

RESEARCH ARTICLE

ROLE OF ELECTROSPUN NANOFIBERS IN WOUND DRESSING EFFICIENCY

Jayandra Bushion, Shweta Kailash Pal and Subhashini S
Department of Biotechnology School of Bioengineering SRM Institute of Science and Technology.

Manuscript Info

Manuscript History
Received: 15 October 2020
Final Accepted: 19 November 2020
Published: December 2020

Key words:-
Nanofibers, Wound Dressing, Nanofibers Types

Abstract

Explaining the classification of nanofibers based on its wound dressing application. Properties and efficiency of different nanofibers.Effective techniques involved and different process carried out in the process of dressing wounds. Various techniques used along with different nanofibers for treating wounds. Wound healing process and the effects on with different nanofibers was briefly explained. Nanofibers made of different polymer blends have different properties in wound dressing and with the incorporation of different materials with it have different effects and wounds are explained. The paper helps in explaining the nanofibers that has particular effect on wounds and the polymer blend which are left to work and study on wound dressing.

Introduction:-

Nanofibers can be broadly classified as uniaxial nanofiber, coaxial nanofiber, triaxial nanofiber Due to their simple geometry, nanofibers of uniaxial were manufactured through simple electrospinning technique for their less processing parameters to monitor modified electrospinning rather than other. Different polymer blends have different effects on the wound with or without incorporation of various particles in it. They are even tested for their antibacterial activity and their assays which explain the wound healing activity of the nanofibers. The nanofibers possess various activities with the incorporation of various particles in it and also without incorporation. They can be incorporated with plant extract or various other chemicals to improve the process of wound healing than the traditional healing. Due to the size and the property of the nanofibers there can be change in the ability of wound dressing under Uniaxial nanofiber it is further divided as polymer nanofiber, polymer blend nanofiber, Biological molecule loaded nanofiber, Drug loaded nanofiber, Hybrid nanofiber. UNI-axial drug loaded nanofiber is again divided as chitosan based nanofiber, PVA loaded nanofiber, PCL based nanofiber, and PLA based nanofiber and other. Coaxial nanofiber is also sub-divided as polymer nanofiber, biological molecule loaded nanofiber, and drug loaded nanofiber, hybrid nanofiber. The nanofibers with checking the physical and chemical test can be further used for wound dressing. With the nanofibers the efficiency of the wound dressing can be improved than the traditionalhealing process and with the advanced process we can eliminate the contamination and the effective treatment of the wounds can be improved.

Uniaxial Polymer Nanofiber:

D.Li studied the layer-by-layer stacked films of Electrospinning nanofibers as uniaxially aligned arrays. He used electrospinning as a simple and scalable process for producing nanofibers as uniaxially aligned arrays over broad regions With different formulations and characteristics, modified electrospinning offers a simple and versatile way to produce uniaxially aligned nanofiber.(D.Li, 2004)

Corresponding Author:- Dr. Subhashini S
Address:- Department of Biotechnology School of Bioengineering SRM Institute of Science and Technology.

L.Y.Kossovich Laboratory tests of an advanced wound dressing made of chitosan nanofiber were developed and tested and this newly developed dressing, concluded for II-III burns and donor wounds, allows quick self-regeneration of wounded skin layer compared to the traditional healing process. It also provides protection from infection and with the application of novel nanofiber dressing it prevents discomfort from dressing removal or adjustment. Decreased tissue healing time and quicker recovery of patients following surgery has been observed. (L.Y.Kossovich, 2010)

Nanofibers Polymer Blend:
Zhang et al. for improved wound healing manufactured electrospun chitosan / PVA nanofibers. The cells replication and adhesion verifies the Nanofiber scaffold biocompatibility. The greater capacity of prepared nanofibers to absorb blood was observed to speed up homeostasis and tissue regeneration by the rapid healing wound. (Zhang, 2019)

The Polyhydroxybutyrate (PHB) blend and PVA was prepared by Ashraf et al. (50:50) nanofibers and also nanofibers of single polymer, as they are miscible polymers that demonstrate outstanding compatibility, relevant proliferation of cells. The PVA concentration in the blend can be promoted by tuning eg, cells are inhibited by human keratinocytes cell line and dermal fibroblast cells promoted by PVA/PHB (50:50) (Ashraf, 2010)

According to the SEM micrograph PVA / Novel matrix for wound dressing, the PEG/ PVA and PVA / PPG blends produced by Aytimur et al. were higher in colonisation compared to PVA / PEG (75:25) Vs. E. PVA / PPG (50:50) as well as PVA / PEG (50:50) (Aytimur , 2015). The biomimetic poly (glycolic) was developed by Park et al. chitin nanofiber /acid/PGA scaffold blend, yet gap in the chitin and PGA solubility parameters. The analysis of immiscibility and degradation shows cm3/2) within 45 days, the total degraded the PGA content, decrease in chitin in the material (25-75 percent) causes the value of degradation to be depleted. (30-13 days), while PGA / Chitin coated bovine serum albumin A satisfying candidate for cell att was (25:75) (K.E. Park, 2006)

Biological molecule loaded nanofiber:
Towards the human body there is perfect cell adhesion affinity and observed proliferation in biological molecule embedded nanofibers. The L-ascorbic acid 2-phosphate (VC-2-p) - loaded silk fibroin nanofiber was prepared by Fan et al. Post-treatment nanofiber mat the unstable fibre Stable I to Silk II. SF loaded by VC-2 p imparts the release of SF nanofibers mat VC2-p- loaded (60-70 % in 20 min) was also observed from L929 cells and also noted. (Fan, 2012)

The manufacturing has been shown by Xie with a new nanofiber electrospun scaffold which is aligned radially fibres and its possible use as a dural core substitutes showed the dural fibroblasts are made on radially aligned Scaffolds.There were elongated nanofibers and its migration into the center of the scaffold accelerated significantly. With the advancement of a standard extracellular matrix structure such as collagen type I, rapid regeneration and development of neodura is possible. Together, their findings suggest that nanofibers can fix dural defects radially aligned as an artificial dural substitute, and alternatives often occupy a distinctive, enticing role in the neurosurgical community. (J. Xie, 2010)

Satish et al., concentrated manufacture of Triiodothyronine loaded PCL for chronic wound healing because Triiodothyronine is Tissue-recognized hormone in spite of beginning release of around 70 ng, repair of the remaining the sustained release (40-50 ng / day) was from day 1 to day 4. FITC's picture showed the uniform distribution of the distribution of the Hormone Triiodothyronine (Satish, 2015)

Investigated by Kang et al. to stop the exogenous microorganism, the inflammatory stimulated response of nucleic acid PCL-poly (ethylenimine) the Co-polymer Electrospun and pristine are also used to boost, they were treated with methanol to scavenge the capacity of nanofibers to achieving strongly cationic nanofibre topology. Treated with methanol compared to non-methanol, nanofibers exhibit reduced wettability relative to Nanofibers under care (Kang, 2014)

Extracellular imitation of the built-in collagen / PCLL bioactive glass nanoparticles biomatrix of Scaffold nanofibrous was studied by Gao et al.. The wound recovery research shows that on the 7th day, 60 % and on the 14th day, 90 % to PCL/collagen scaffolding day 7, 50 % and 14th day, 80 %, bioactive collagen / PCL-incelerated recovery of glass nanoparticles. The cell proliferation thesis also shows that in embedded collagen/PCLL bioactive glass nanoparticles, higher numbers of endothelial cells proliferate on day 3.(Gao, 2017)

Polylactide-polyglycolide Electrospun (PLGA)/collagen nanofibers have been documented by Liu et al. to bio minimize membranes of extracellular for use in dressing wounds with rise in content of collagen and the decrease in as-spun nanofiber of wound area (5 % in 21 days), the fibre diameter of PLGA /collagen nanofibers decreased lower than that of commercial dressing (15 % in wound area of as-spun nanofiber) Twenty-one and gauze (20% in 21 days) (Liu, 2010)

Chitosan was prepared by Cai et al. as chitosan, Nanofibers of silk fibronin confer biodegradability, biocompatibility, and antibacterial properties. The SEM shows that a rise in chitosan presence decreases the radius of the fibre and the inclusion fibronin of silk improves the characteristics in mechanical (MPa 1.3–10.3). (Cai, 2010)

Murine fibroblast attachment and proliferation of cells verified the nanofiber in Invitro MTT assay by chitosan /silk fibroin and l effects of antibacterial in Silk /chitosan Nanofibers Fibroin with increased gram positive chitosan content (S.aureus bacteria) and gram negative (E.coli) Ma et al. studied the water touch angle of BG-loaded G / C-loaded G / C in the wettability analysis because of high bioactive glass content,water has been raised, while the water intake potential was lowered and the quality of bioactive glass was also higher, improves mechanical characteristics. The higher resistance of Bioactive Glass (BG) to A. Viscosus, and. The presence of ZnO and CuOO compared to the commercially available 45S5 Bioglass ® is primarily due to *E.coli*.(W. Ma et al, 2014)

Dai et al. also studied gelatin nanofibers incorporating curcumin, since ancient times in Asian countries, curcumin has been well known for its antimicrobial activity, but it also has limitations, such as low absorption, instability and hydrophobicity. In order to counter this, curcumin was combined with curcumin to improve wound hydrophobicity. The gelatin filled with crosslinked curcumin extracts the curcumin sustainably, rather than without a cross-linked blend, for recovery. The wound closure behavior study reveals that wound closure recovery studies with minimal gelatin/curcumin (2%) were smaller compared to pristine gelatin (10 %)(Dai, 2017)

Li et al. registered constant TPGS vitamin E and palmitate vitamin A the successfully applied source of vitamin E and vitamin A respectively in the gelatin nanofibers, as the size of nanofibers is decreased as the increased content of vitamins. Initial release analysis of vitamin A confirms initial Release to burst (20% in 8 hours) and then release to sustain (64% in 60 hours) Vitamin E, on the other hand, displays beginning release and later .Efficient packing of Vitamin E fibres Resistant E-coli and S-aureus growth and gelatin filled with vitamins Compared with nanofiber, the greater wound healing potential is enabled by nanofiber. Disinfectant gauze and cast film that are commercially available (Li, 2016)

Chhabra et al. attempted Gelatin / poly-methyl vinyl doping of zinc oxide Matrix of ether-alt-maleic anhydride (PMVE / MA) for electrospun output the durability of the nanofiber scaffolds were assured by nanofiber and by crosslinking vapours of glutaraldehyde. The study of antibacterial suggests that many E-coli bacteria conform the The pristine PMVE/MA nanofibrous mat adheres to the scaffold surface relative to MA/nZnO-PMVE Nanofibrous mat adheres to the scaffold surface relative to MA/nZnO-PMVE (Chhabra, 2016) The effectiveness of the gelatin / nanohydroxyapatite (Gel /CA / nHA) for wound dressing with composite Nanofibrous scaffold was tested by Samadian et al. The higher content of nanohydroxyapatite reduces the most tensile strength of the scaffold and the transmission rate of Gel /CA scaffold water vapour has declined a rise in the tensile strength of the scaffold content of nanohydroxyapatite. 66.26 ± 1.91 percent in 7 days and 93.56 ± 1.6 percent in 14 days for Ca/ Gel + 25 mg nHA is the maximum wound closure obtained and this composition also encourages collagen formation (Samadian, 2018)

Uniaxial Drug Loaded Nanofiber:

Drug-loaded chitosan-based nanofibers:

Charernsriwilaiwat et al studied the Nanofiber swelling decreases (111.96-96.67%) whilst raising the quality of α - mangostin (1-3 percent by weight) and these swelling characteristics burst of alpha-mangostin results in nanofibers. CS-EDTA / PVA nanofiber show filled with the alpha-mangostin GM extract an inhibition of bacteria against bacteria (Charernsriwilaiwat et al, 2013)

The application of chitin for wound dressing with nanocrystals reinforced chitosan / PEO nanofibers were tested by Naseri et al. The analysis of water vapour transmission reveals that the chitin nanocrystal addition decreases the rate of transmission of water vapour of Chitosan / PEO loaded by ChNC (1290 g m- Compared to pristine chitosan / PEO (1353 g m−2 day−1), but compared to pristine chitosan / PEO (1353 g m−2 day−1), It is possible to solve this

even though crosslinking, genipin solution reduces the surface area by crosslinking the nanofibers with the problem (59-35 m2 g−1)(N. Naseri, 2014)

The latest metronidazole has been recorded by Zupancic et al. Chitosan / PEO nanofibers are loaded for local wound infection management. Drug release review of chitosan / PEOO filled with 15 percent metronidazole Nanofiber displays a burst release of 60% in 10 minutes, followed by 95% in 10 minutes. This could be attributed to very strong chitosan / PEO swelling in the next 2 hours. (1000 % in 1 h) nanofibers (Zupancic, 2016) study of Drug release 1 % PEO/CS filled with cefazolin (10:90) Nanofiber suggests that the actual release of the burst and then the management of the release of the It is may be of the lower concentrations of cefazolin and hydrogen, And exerts a drug-chitosan affinity. Analysis of swelling reveals that 1% CS / PEO filled with cefazolin (65% in 24h) swells more.

A flawless PEO /CS (58% in 24 hours) (Sadri, 2017) the environmentally safe route with embedded chitosan/polyvinyl alcohol (PVOH) for wound dressing was studied by Abdelgawad et al. Glutaraldehyde was crosslinked into nanofibers. The research on opioid releases the immersion test for 7 day indicates that the crosslinking time has been improved. The release of Ag+ ion results in a reduction. (Abdelgawad, 2014)

Sadri et al. tested wound dressing on Chitosan / PEO nanofibers mat applied to the eco-friendly green tea extract. In order to improve its hydrophilicity. Chitosan / PEO nanofiber added by GT exhibits antibacterial substances action against bacteria that include gram-positive and gram-negative bacteria 6 mm and 4 mm inhibition region, respectively (Sadri , 2017)

Nanoparticles of silver integrating PEO /Chitosan nanofibers scaffold were reported by Annur et al. Antibacterial nanofiber property observed in silver nanoparticle, 1% wt. AgNO3 pictures of SEM combining chitosan / PEOO3 Nanofiber suggests the fibre diameter reduces by 30 percent in 1.5 minutes care of post-plasma. The antibacterial analysis indicates that 2 percent by weight Chitosan / PEO nanofiber (0.38 mm) built-in AgNO3 exhibit Higher inhibition zone relative to pristine chitosan / PEO nanofiber (1.01 millimetres) (Annur, 2015)

Ali et al. added loaded Phenytoin (Ph) Nanofibers PEO/chitosan for wound healing rapidly. Phenytoin's observed entrapment efficiency above 94 percent and t Ph-loaded pluronic starting burst release Nanomicelles is exposed by the release of drug analysis (20 % in 2 h), while Ph-loaded release is sustained (20 % in 2 h), PLGA NPs are lecithin-coated (33 % in 48 h) (Ali et al, 2016)

PVA based drug loaded nanofibers:
Mohammadi et al. studied PVA mixture and Gum tragacanth as biodegradability, wound dressing by electrospun scaffold, Non-toxicity and Fibroblast cell gum tragacanth biocompatibility promotes adhesion and Proliferation. The electrical system was stopped by increased viscosity area from extending the fibre and thereby growing the diameter from 140 to 210 nm (Mohammadi, 2013)

Jiang et al. made octyl-containing Methoxycinnamate (OMC), Silica nanocapsules (SiNCs) Amphiphilic Octenidine (OCT), Peppermint Oil (PO), with additional UV attached PVA nanofibrous mat for wound dressing defence. Analysis of TGA reveals encapsulation of content was 65 percent, while the potential content was 60 percent. In improved dispersion UV absorption of SiNCs-OMC and SiNCs-OMC Antibacterial testing has shown that SiNC-PO / OCT has 99% tolerance. K-12 and B-Subtilis against E-coli (Jiang et al, 2016)

Augustine et al., manufactured Electrospinning embedded PVA nanofibers with silver nanoparticles the Wound Wrapping Treatment Procedure Capacity for water uptake. The analysis indicates that pure PVA nanofiber swelling (800 percent in 6 h) was observed. Nanofibers above PVA / Ag nanoparticles (525 % in 6 h) were released. Analysis reveals that for 1 wt% Ag, 1.9 ppm of Ag was published in 48 h PVA nanofibers-loaded nanoparticles. PVA / Ag nanofibers (10.47 ± 1.87 mm) displayed a higher inhibition zone on *E-coli*relative to PVA nanofibers (6.00 ± 0 mm) because silver nanoparticles have an anti-bacterial effect. (Augustine et al, 2018)

Urea (U)/Papain (P) loaded PVA nanofibers scaffold for debridement of wound have been investigated by Shoba et al. antibacterial behaviour indicates that pristine nanofibers of PVA have 50 percent activity on bacteria, while papain and urea inclusion stabilise the device against E.coli for longer period. Nanofibers of P / PVA, P-U and PVA

have initial burst release, this behaviour was found attributed to high levels of prolonged release for 24 hours. Surface region and hydrophilic matrix porosity of the surface (Shoba et al, 2014)

Ciprofloxacin antibiotic Polyvinyl Alcohol sodium alginate nanofibers were developed by Kataria et al. for changing patches. Degree of the NaAlg/PVA swelling was higher (190 ± 5.3 % in 12 h) PVA / NaAlg was filled with ciprofloxacin (170 ± 4.3 % at 12 h). Drug release In vitro analysis reveals the PVA nanofibers has a higher rate of release of ciprofloxacin than PVA / PVA/ NaAlg nanofiber composite, the formulation of both releases 99% (Kataria, 2014)

Jannesari et al. have been studying the result of a novel blend containing polyvinyl acetate (PVAc) /PVA composite nanofiber for controlled drugs with ciprofloxacin HCl (CipHCl). The fibre diameter of the full formulations has been decreased by the presence of 10% CipHCl by wt, although the swelling decreases by 10% Enrichment of Cip HCl. (Jannesari, 2011)

For wound healing chitosan /Graphene-based PVA was prepared by Lu et al. The antibacterial analysis reveals that graphene containing PVA / chitosan is resistant to Agrobacterium cells and *E-coli;* the rare occurrence could be because of contact. It was difficult to enter the cell easily transiting electrons from graphene between cell and graphene since cells had a nuclear membrane, but eukaryotic cells, this transitional breakdown of electrons, then of prokaryotic cells in which, because many microbes have prokaryotic cells, graphene can track them in the absence of the nuclear membrane. Proliferation of the Microbe (Lu et al, 2012)

For wound dressing poly vinyl alcohol/nano ZnO/Sodium alginate composite nanofibrous mat has been investigated by Shalumon et al. they are stabilised by 2% glutaraldehyde crosslinking. The analysis of antibacterial substances showed that the increased content of ZnO (0.5-5 %) helps to boost *S-aureus* (15–16 mm) and *E-coli* bacteria inhibition region diameter (14–15 mm). Nanofibers that successfully produce a maximum of 1% ZnO in 96 h, the L929 cells adhere and proliferate (Shalumon et al, 2011)

Drug-loaded PCL based nanofibers:
The Metronidazole for tissue regeneration antibiotic loaded PCL nanofiber scaffold guided was developed by Xue et al. Performance of Drug Encapsulation the matrix is verified (above 80 %) strong dispersion of MNA medicine in the drug release analysis reports. Released with zone of inhibition and initial burst release within 1 week Augmented MNA content increases was that 90 % of MNA cumulatively (Xue et al. 2014)

The embedded PCL nanofibers mat antimicrobial silver nanoparticles (AgNPs) were tested by Hinojos-Márquez et al. for good tolerance to gram-positive and gram-negative bacteria. Increased concentration of Ag (1-100 mM) assists in achievement of fine nanofibers (234 ± 66 nm to 159 ± 79 nm) and on nanofibers (234 ± 66 nm to 159 ± 79 nm) conversely, the concentration of PCL nanofibers in lower AgNPs exhibits sufficient bacterial resistance like S.pyogenes. (Hinojos-Márquez, 2016)

Addition of nanorods (EHNs) of europium hydroxide prepared by Augustine et al. Electrospun Scaffold PCL. The EHN loaded PCL (235 ± 16 MPa) was greater than the break of 0.25 % (235 ± 16 MPa) with mechanical features, including elongation. Of pristine PCL nanofibers (316 ± 14 MPa). It shows that human umbilical vein endothelial cell proliferation (HUVECs) added PCL from 158 ± 16 cells / mm2 to 0.5 wt % EHNs. (24 h) to 284 ± 17 / mm2 cells (120 h) (Augustine et al, 2017)

Augustine et al. have published loaded PCL membrane for rapid fibroblast proliferation and wound healing with electrospun ZnO nanoparticles the analysis of cell density reveals that pure PCL membrane increased cell density from 20 ± 6 cells per mm2 (5 days after implantation) to 212 ± 12 cells per mm2 (5 days after implantation). While, cell density is ten percent. The PCL membrane loaded with ZnO increased (implantation after 5 days of) (implantation after 20 days) Percentage of healing of wounds with PCLL filled with ZnO The membrane (100%) after that was larger than the pure PCL membrane (85%) Twenty-five implantation days (Augustine et al, 2014) the relationship was examined by Preem et al. Between chloramphenicol antibiotic (CAM), exogenous bacteria and polymeric matrix, for infectious wound dressing. About norm fibre radius was higher for PCL / PEO fibres than for PCL / PEO / CAM this was found as a result of drug-drug contact with fibres. The viscosity of the rubber increases and the fibre reduces. About elongation (Preem et al, 2017) PLA /PCL nanofibers were manufactured by Yu et al. For skin tissue regeneration through electrospinning and CaCuSi4O1010 Spin coated nanoparticles Photothermal

influence attributable to CaCuSi4O10 presence. The Cu2+ and SiO44 detach nanoparticles 4-ions promote angiogenesis and the development of the epidermis. The photothermal conversion output of these nanoparticles is also 33.8 %, so it was used Photothermal cancer treatment (Yu et al, 2019)

Yang et al. researched contamination with PCL / gelatin nanofibers embedded with APA-coated Au nanoparticles processed by electrospinning technique for multidrug resistance (MDR) bacteria wound. The review of releases reveals that as-spun % of APA-coated Au nanoparticles in nanofiber are released inside in a saline solution for 14 days.This further illustrates superb biocompatibility and possess high bacterial resistance (Yang et al, 2017)

Chamomile impregnated polyεcaprolactone/polystyrene developed by Motealleh et al the PCL nanofiber impregnated with chamomile the nanofibers were developed for wound dressing has a higher drug release time. PCL/PS (65:35) nanofibers impregnated with chamomile (75 % in 12 h) (% at 12 h) and PS nanofiber impregnated chamomile (26 % at 12 h), due to PS nanofiber (40 %), this was found to exert lower Swelling than Nanofiber PCL / PS (65:35) (275 %), Nanofiber Polycaprolactone (400 %) (Motealleh et al, 2014)

In NVCL The increased MMA content: the captopril drug caused by MAA, e.g. PNVCL-co MAA (1:0.08) nanofibers with 20 percent captopril embedded to be released rapidly. Slower release was observed at 40°C (75 % in 48 h) than twenty percent captopril embedded PNVCL-coMAA nanofibers (90 % in 48 h), similar observed in a ketoprofen drug with the release decreased of the drug regardless of its It was also found that at 40°C (above the lower) hydrophobicity release of drug at critical solution temperature was sluggish even at 20°C fast drug release was observed.

PLA based Drug-loaded nanofibers:

To promote wound healing, Wold et al. manufactured, for nitric oxide (NO) release PLGH. Antibacterial research reveals that 23.3 mg PLGH-cysteamine SNO film and 19.4 mg content are needed for minimise count of bacteria by 96 %. Release of NO in S-nitrosated nanofibers of PLGH-cysteamine close to spin-coated films (0.281 ± 0.016 mmol·g−1) (0.241 mmol·g-1 ± 0.004) (Wold, 2012)

Zhang et al. for drug release prepared impregnated polylacticco-caprolactone captopril for PLCL nanofiber, swell analysis shows (165 percent under 7.4 pH in 50 minutes) decreased the percentage of swelling relative to PLLA (480 % less than 7.4 pH in 50 min) and PLGA (290 % less than 7.4 pH in 50 min) Nanofibers) 7.4 pH. Initial nanofiber PLLA and PLGA burst release (90 percent in 2 hours) was larger than nanofiber PLCL (66 % in 2 hours) and PLCL Nanofiber has a wider drug release rate below 7.4 pH (90 % in 250 h) (Zhang et al, 2012)

Other polymeric material based nanofiber:

Silver nanoparticles were also assessed by GhavamiNejad et al. Polydopaminemethacrylamide-co-methyl methacrylate for adding wound dressing impregnated (MADO) nanofibers. Analysis of Anti-bacterial reveals that MADO-AgNPs contain *E-coli* (165 %), that has *S-aureus* diameter (120 percent) and *P-aeruginosa* (130 percent) improved by a larger proportion. Studies of drug launches show that Initial burst release of MADO-AgNPs (16 μg on day 1) is seen by nanofiber and then sustained release of a drug (25 μg on day 7) in 7 days (GhavamiNejad et al, 2015)

Fayemi et al. studied embedded Polyacrylonitrile nanofibers of Moringa Extract for rapid wound healing. The analysis of wound closure showed that 0.5 g of polyacrylonitrilemoringa embedded extracts on day 7 exhibit 95% wound closure, and the maximum bactericidal effect also observed in 0.5 g with inhibition zone of moringa 12 mm for *S.aureus* and 15 millimetres for *E.coli* (Fayemi , 2018)

Wu et al. prepared thermoplastic-added Ag nanoparticles Nanofibers Polyurethanes (TPUs) for wound dressing. Analysis of Swelling Water absorption of 1 wt percent of AgNO3 electrospun mat suggests Compared to 1 wt%, AgNO3 cast film (517 ± 36 %) was larger compared to 1 wt% (474 % ± 25 %). SEM photos show the microbial AgNO3 exhibits Anti-E-coli activity (Wu et al, 2009) Keratin (K) and silver were studied by Wang et al. Nanofibers of filled polyurethane (PU) nanoparticles (AgNPs) Bactericide for healing wounds. SEM images have confirmed the NIH 3 T3 production of cells on PU / K and PU / K / AgNP was superior to that of the PU mat. The analysis of bactericidal reveals the diameter of zone inhibition *E.Coli* (3.1 mm) was above *S.aureus* (1.9 mm) of Absorption of Exudate The characteristics of nanofibers in PBS were assessed by water absorption, Since the 195.2 ± 7.8 % water absorption was higher than PU, (44.4 ± 4.2%) and PU/K/AgNPs (101.5 ± 5.1%) (Wang et al, 2016)

The Amphotericin B feasibility of (AMB) was explored by Ahmed et al. Polyvinylidene fluoride, poly (methyl methyl) filled with Itraconazole (ITZ), methacrylate), and polyvinylpyridine (PVP) delivery of drug mechanism fibres manufactured by electrospinning and pressure gyration technique. Tests of Morphology reveal that PVP fibers of electrospun drug-loaded have excellent diameter relative to the pressurised technique of gyration, as well as profile of the drug dissolution both suggest Amphotericin B and Itraconazole dissolution is greatly enhanced by drug-loaded PVP fibres. The release of drugs the profile indicates the electrospun PVP fibres display for the initial 15 minutes Rapid release though gyro spun fibres display increased speed after 15 minutes Release of medications (Ahmed et al, 2018)

Different drugs with the drug-loaded uniaxial electrospun nanofibers amounts, products of hydrophilic, have been tremendously studied by researchers. Hydrophobic medicine and parameters of electrospinning the case of matrix entity polymer blend, to electrode width, Polymer material for wound treatment, software for dressing wounds. But the nanofibers are only suitable for bactericidal dressing much of the time.

Hybrid Nanofiber (Uniaxial Nanofiber):
PLLA was hydrophilic, but as the NFZ exerts a hydrophobic nature, 2% NFZ demonstrates hydrophobicity (125.7°), so hydrophobicity can be regulated by the addition of sericin (66 °). Analysis of drug release reveals that a single layer of 0.2% loaded PLLA / sericin exhibits release of burst (98% in 10 minutes), while the single layer of 2% loaded mat dual layer (11.2% at 48 h) (Zhao et al, 2015)

Drug release analysis reveals that PHBV / CNC nanofibers are faster than PHBV nanofibers when initially released combined nanofibers were slower. The release of PHBV was not greater than of PHBV / CNC Nanofibers (37.6% over 540 h) (Cheng et al, 2017)

Coaxial Nanofiber:
Coaxial nanofibers are made using a coaxial electrospinning technique; these nanofibers allow the transfer of specific drugs or biological fibres. Molecule without upsetting the structural stability of the molecule and also preserving it and secure from weather

Polymer nanofiber:
PEO-chitosan nanofibers were analysed for dressing of wound by Pakravan et al. the Scientific Theory specific nanofiber surface area of 16.7 m2 /g was equal to the experimental specific area of the surface (15 ± 1.5 m2 /g) (Pakravan. 2012)

The PEO / Chitosan scaffold for wound treatment was also researched by Zhang et al. The TEM images show that the core and shell layer interfaces are sharp. (Zhang et al, 2009)

Polylactic acid (PLA)-chitosan (CS) nanofiber for dressing of wound was prepared by Nguyen et al. the improvement in the central feed rate (1.0-4.0 µL / min) increased the angle of water interaction (24.1-52.9 °) and reduced the rate of bacterial inhibition (52-22 percent). Mechanical properties, such as CS nanofibers (0.5 MPa) is lesser than PLA nanofibers (3.3 MPa) tensile power (Nguyen et al, 2011)

Biological molecule loaded nanofibers:
FGF2 were reported by Rubert et al. Blue core / shell electrospun nanofibers coated in PEO / PCL. PRISTINE the contact angle for PEO is 20° while the pristine PCL is 118°. Release of drugs the analysis indicates the initial release of the burst (10.6 percent in 1 h) and then preserves it. Release of FGF2 from core / shell nanofibers (52.9% from Day 1 to Day 9) Scaffold (Rubert et al, 2014) the development of fluorescein was attempted by Zhang et al. Laden with isothiocyanate-conjugated serum albumin bovine (fitcBSA) for continuous drug release, the PEG / PCL core / shell nanofiber. Variation in the the fibre diameter is increased by the internal flow rate (0.2–0.6 mL / h) In vitro release and (270-380 nm) tests indicate that PCL / fitcBSA/ Compared to initial burst release (31.2 % in 4 h) (Zhang et al, 2006)

Jiang et al. made lysozyme and individual molecules bioactive of Bovine serum albumin attached PEG / PCL core / shell nanofibers to achieve controlled release. Sustain release was contained in 1.96 % of nanofiber-containing BSA in excess of 5.56 percent Nanofiber-containing BSA (inner feeding rate-2 mL/ h) (95% within 24 days) (Jiang et al, 2005)

One of the key factors that induces a delay in hyperglycemia is this was corrected by stabilising the healing mechanism with hypoxia-inducible factor 1 α (HIF-1 α), so Dimethyloxalylglycine (DMOG)/Col I embedded PCL core / shell nanofibers were analysed by Gao et al. Diabetic Healing Cut. Drug release analysis reveals the DMOG/ Rapid drug release of Col I blend nanofibers (53.3 ± 2.7 % in 12 h) (17 ± 2.1 % in 12 h) than DMOG / Col I core / shell nanofibers. (Gao et al, 2018)

Drug loaded nanofibers:
Tetracycline hydrochloride (TCH)/PLLA core / shell nanofibers were developed by He et al. to help drug delivery. The higher PLLA content (5-10 wt percent) increased the fibre diameter (360-1312 nm) and the drug release profile reveals that 5 percent PLLA nanofibers (55 % within 30 days) have higher drug release than 10 percent PLLA nanofibers (44 % within 30 days) (He et al, 2006)

Sultanova et al. have investigated ampicillin / PCL core/ shell nanofibers to control drug release by changing the shell flow rate. Core nanofiber has 85 % drug release within 4 h (burst release) but 16 % and 7 % drug release within 4 h respectively in Ampicillin / PCL nanofiber (0.5 ml / h) and Ampicillin / PCL nanofiber (0.5 ml / h) (Sultanova et al, 2017)

He et al. identified a metronidazole-containing PCL drug/ Nanofibers for tissue regeneration with zein core/shell. Pristine Zein (146 ° ± 0.8 °) nanofibers have a higher angle of interaction with water than MND-PCL/Zein nanofibers and pristine PCL nanofibers (139 ° ± 1.4 °) (126o ± 1.2o). (He et al, 2017)

Najafi-Taher et al. prepared nanofibers were the glutaraldehyde vapours preserved as prepared nanofibers. Crosslinked-blend nanofibers (33% in 4 hours) had a higher burst release relative to coaxial nanofibers (27% in 4 hours) and even a higher accumulated release of crosslinked coaxial nanofibers (74% in 30 hours) relative to blended nanofibers (63% in 30 hours) (Najafi-Taher et al, 2015)

Worley et al. primed non-dendrimer Polyurethane (PU)/polyurethane with core / shell NO-releasing dendrimer (PU-NO) Nanofibers for dressing up cuts. The higher porosity of the PU nanofibers have lower water absorption than PU-NO nanofibers. Releases of Nanofibers as prepared 0.027-0.072 μmol NO / mg and bactericidal activity demonstrated with S.aureus (Worley et al, 2016)

Hybrid nanofiber:
Li et al. reported solution-doxorubicin hydrochloride (shell) nanofibers based on silk fibroin regenerated nanosphere + curcumin (core)/silk fibroin regenerated for wound healing. The wettability analysis showed that water annealing was treated at 60 ° C RSF nanofibers filled with dual drugs have a higher water touch angle than 45°C conditioned nanofibers and untreated nanofibers. (Li et al, 2017)

In CUR embedded RSF nanospheres, (65 percent in 10 h) relative to percent in 10 nanofibers DOX (30 percent in 10 h) core / shell nanofibers Ranjbar-Mohammadi et al . studied the Gum tragacanth (GT) the core/shell nanofibers of Tetracycline hydrochloride (TCH)/PLGA is used for cleaning wounds. The Wettability Analysis indicates that GT-TCH/ PLGA nanofibers (92°) have a lower angle of contact with water relative to PLGA:GTT Nanofibers 50:50 (42°) and Nanofibers Pristine PLGA (135°) (Ranjbar-Mohammadi et al, 2016)

Tri-axial nanofiber:
Yang et al. analyzed the hollow nanofibers made by tri-axial. A core/middle/sheath layer was used for lecithin-diclofenac sodium (PLDS)/methacrylic acid-methyl methacrylate (MAA-MMA) blend/ethanol acid-methacrylate electrospinning.Protects the middle layer with ethanol Evaporating and evaporating from weather and post-drying variations, drug release analysis indicates continuous release of nanofibers (15% in 3 h) and fragmented release of DS particles (75% in 3 h), this release profile The shell dissolves at 1 pH because of nanofibers, while PLDS dissolves at 7 pH. (Yang et al, 2016)

Nisin-loaded polyvinylpyrrolidone (PVP)/ PCL/ PCL has been reported by Han et al. for prolonged anti-microbial action pristine nanofiber bacterial resistance (8.6% by weight) PCL loaded nisin), PVP / PCL coaxial nanofiber loaded 19 wt percent nisin and 19 wt percent nisin loaded. There are 19 wt percent PVP / PCL / CA tri-axial nanofiber exerts intriaxial nanofibers that extend microbial tolerance to 1 day, 2 days and 6 days, respectively. (Han et al, 2017)

Yu et al. assessed tri-axial fibre ethyl cellulose with differing ketoprofen (KET) Amphetamine concentration for the release of zero-order drugs. Region of the surface of There was a thinner middle layer than the outer and inner layers. Research of opioid release confirms that as prepared tri-axial fibres exhibit 10% sustained release in 2 h and also have a combined release of 90% of the medication in 24 hours. (Yu et al, 2015)

The difference in flow rate has a significant influence on drug release, such as triaxial electrospun fibers of 0.8 mL / h (55 percent KAB in 4 h) reveal rapid KAB release of triaxial electrospun fibers of 1.2 mL / h (26 percent KAB in 4 h), while triaxial electrospun fibers of 0.8 mL / h (98 percent KAU in 4 h) show rapid release of KAU fibers above 1.2 ml/h triaxial el el (85 percent KAUwithin 4 h)(Han at el, 2013)

References:-

1. ELECTROSPINNING NANOFIBERS AS UNIAXIALLY ALIGNED ARRAYS AND LAYER - BY - LAYER STACKED FILMS D. LI ,Y. WANG ,Y. XIA 26 FEBRUARY 2004
2. Electrospun Chitosan Nanofiber Materials as Burn Dressing
3. L. Y. Kossovich, Y. Salkovskiy,I. V. Kirillova 2010
4. K. Zhang, X. Bai, Z. Yuan, X. Cao, X. Jiao, Y. Li, Y. Qin, Y. Wen, X. Zhang, Layered nanofiber sponge with an improved capacity for promoting blood coagulation and wound healing, Biomaterials 204 (2019)
5. M. Ignatova, N. Manolova, N. Markova, I. Rashkov, Electrospun non-woven nanofibrous hybrid mats based on chitosan and PLA for wound-dressing applications, Macromol. Biosci. 9 (2009)
6. A.S. Asran, K. Razghandi, N. Aggarwal, G.H. Michler, T. Groth, Nanofibers from blends of polyvinyl alcohol and polyhydroxy butyrate as potential scaffold material for tissue engineering of skin, Biomacromolecules 11 (2010)
7. A. Aytimur, S. Koçyiıit, I. Uslu, F. Gökmeşe, Preparation and characterization of polyvinyl alcohol based copolymers as wound dressing fibers, Int. J. Polym. Mater. Polym. Biomater. 64 (2015)
8. K.E. Park, H.K. Kang, S.J. Lee, B.-M. Min, W.H. Park, Biomimetic nanofibrous scaffolds: preparation and characterization of PGA/Chitin blend nanofibers, Biomacromolecules 7 (2006)
9. L. Fan, H. Wang, K. Zhang, Z. Cai, C. He, X. Sheng, X. Mo, Vitamin C-reinforcing silk fibroin nanofibrous matrices for skin care application, RSC Adv. 2 (2012)
10. J. Xie, M.R. MacEwan, W.Z. Ray, W. Liu, D.Y. Siewe, Y. Xia, Radially aligned, electrospun nanofibers as dural substitutes for wound closure and tissue regeneration applications, ACS Nano 4 (2010)
11. A. Satish, P.S. Korrapati, Fabrication of a triiodothyronine incorporated nanofibrous biomaterial: its implications on wound healing, RSC Adv. 5 (2015)
12. J. Kang, H.S. Yoo, Nucleic acid-scavenging electrospun nanofibrous meshes for suppressing inflammatory responses, Biomacromolecules 15 (2014)
13. W. Gao, W. Jin, Y. Li, L. Wan, C. Wang, C. Lin, X. Chen, B. Lei, C. Mao, A highly bioactive bone extracellular matrix-biomimetic nanofibrous system with rapid angiogenesis promotes diabetic wound healing, J. Mater. Chem. B 5 (2017)
14. S.J. Liu, Y.C. Kau, C.Y. Chou, J.K. Chen, R.C. Wu, W.L. Yeh, Electrospun PLGA/ collagen nanofibrous membrane as early-stage wound dressing, J. Memb. Sci. 355 (2010)
15. Z.X. Cai, X.M. Mo, K.H. Zhang, L.P. Fan, A.L. Yin, C.L. He, H.S. Wang, Fabrication of chitosan/silk fibroin composite nanofibers for wound-dressing applications, Int J. Mol. Sci. 11 (2010)
16. W. Ma, X. Yang, L. Ma, X. Wang, L. Zhang, G. Yang, C. Han, Z. Gou, Fabrication of bioactive glass-introduced nanofibrous membranes with multifunctions for potential wound dressing, RSC Adv. 4 (2014)
17. X. Dai, J. Liu, H. Zheng, J. Wichmann, U. Hopfner, S. Sudhop, C. Prein, Y. Shen, H.G. Machens, A.F. Schilling, Nano-formulated curcumin accelerates acute wound healing through Dkk-1-mediated fibroblast mobilization and MCP-1-mediated anti-inflammation, e368-e368, NPG Asia Mater. 9 (2017)
18. H. Li, M. Wang, G.R. Williams, J. Wu, X. Sun, Y. Lv, L.M. Zhu, Electrospun gelatin nanofibers loaded with vitamins A and e as antibacterial wound dressing materials, RSC Adv. 6 (2016)
19. H. Chhabra, R. Deshpande, M. Kanitkar, A. Jaiswal, V.P. Kale, J.R. Bellare, A nano zinc oxide doped electrospun scaffold improves wound healing in a rodent model, RSC Adv. 6 (2016)
20. H. Samadian, M. Salehi, S. Farzamfar, A. Vaez, A. Ehterami, H. Sahrapeyma, A. Goodarzi, S. Ghorbani, In vitro and in vivo evaluation of electrospun cellulose acetate/gelatin/hydroxyapatite nanocomposite mats for wound dressing applications, Artif. Cells, Nanomed. Biotechnol. (2018)
21. A.R. Unnithan, G. Gnanasekaran, Y. Sathishkumar, Y.S. Lee, C.S. Kim, Electrospun antibacterial polyurethane-cellulose acetate-zein composite mats for wound dressing, Carbohydr. Polym. 102 (2014)

22. Y. Xi, H. Dong, K. Sun, H. Liu, R. Liu, Y. Qin, Z. Hu, Y. Zhao, F. Nie, S. Wang, Scabinspired cytophilic membrane of anisotropic nanofibers for rapid wound healing, ACS Appl. Mater. Interfaces 5 (2013)
23. N. Charernsriwilaiwat, T. Rojanarata, T. Ngawhirunpat, M. Sukma, P. Opanasopit, Electrospun chitosan-based nanofiber mats loaded with Garcinia mangostana extracts, Int. J. Pharm. 452 (2013)
24. N. Naseri, C. Algan, V. Jacobs, M. John, K. Oksman, A.P. Mathew, Electrospun chitosan-based nanocomposite mats reinforced with chitin nanocrystals for wound dressing, Carbohydr. Polym. 109 (2014)
25. Š. Zupančič, T. Potrč, S. Baumgartner, P. Kocbek, J. Kristl, Formulation and evaluation of chitosan/polyethylene oxide nanofibers loaded with metronidazole for local infections, Eur. J. Pharm. Sci. 95 (2016)
26. M. Sadri, Saede, A. Sorkhi, Preparation and characterization of CS/PEO/cefazolin nanofibers with in vitro and in vivo testing, Nanomed. Res. J. 2 (2017)
27. A.M. Abdelgawad, S.M. Hudson, O.J. Rojas, Antimicrobial wound dressing nanofiber mats from multicomponent (chitosan/silver-NPs/polyvinyl alcohol) systems, Carbohydr. Polym. 100 (2014)
28. N. Charernsriwilaiwat, P. Opanasopit, T. Rojanarata, T. Ngawhirunpat, Lysozymeloaded, electrospun chitosan-based nanofiber mats for wound healing, Int. J. Pharm. 427 (2012)
29. L. Mei, R. Fan, X. Li, Y. Wang, B. Han, Y. Gu, L. Zhou, Y. Zheng, A. Tong, G. Guo, Nanofibers for improving the wound repair process: the combination of a grafted chitosan and an antioxidant agent, Polym. Chem. 8 (2017)
30. M. Sadri, Saede, A. Sorkhi, Preparation and characterization of CS/PEO/cefazolin nanofibers with in vitro and in vivo testing, Nanomed. Res. J. 2 (2017)
31. D. Annur, Z.K. Wang, J. Der Liao, C. Kuo, Plasma-synthesized silver nanoparticles on electrospun chitosan nanofiber surfaces for antibacterial applications, Biomacromolecules 16 (2015)
32. I.H. Ali, I.A. Khalil, I.M. El-Sherbiny, Single-dose electrospun nanoparticles-innanofibers wound dressings with enhanced epithelialization, collagen deposition, and granulation properties, ACS Appl. Mater. Interfaces 8 (2016)
33. E.R. Kenawy, F.I. Abdel-Hay, M.H. El-Newehy, G.E. Wnek, Controlled release of ketoprofen from electrospun poly(vinyl alcohol) nanofibers, Mater. Sci. Eng. A 459 (2007)
34. M. Ranjbar-Mohammadi, S.H. Bahrami, M.T. Joghataei, Fabrication of novel nanofiber scaffolds from gum tragacanth/poly vinyl alcohol for wound dressing application: in vitro evaluation and antibacterial properties, Mater. Sci. Eng. C 33 (2013)
35. S. Jiang, B.C. Ma, J. Reinholz, Q. Li, J. Wang, K.A.I. Zhang, K. Landfester, D. Crespy, Efficient nanofibrous membranes for antibacterial wound dressing and UV protection, ACS Appl. Mater. Interfaces 8 (2016)
36. R. Augustine, A. Hasan, V.K. Yadu Nath, J. Thomas, A. Augustine, N. Kalarikkal, A.E. Al Moustafa, S. Thomas, Electrospun polyvinyl alcohol membranes incorporated with green synthesized silver nanoparticles for wound dressing applications, J. Mater. Sci. Mater. Med. 29 (2018)
37. E. Shoba, R. Lakra, M.S. Kiran, P.S. Korrapati, Design and development of papainurea loaded PVA nanofibers for wound debridement, RSC Adv. 4 (2014)
38. K. Kataria, A. Gupta, G. Rath, R.B. Mathur, S.R. Dhakate, In vivo wound healing performance of drug loaded electrospun composite nanofibers transdermal patch, Int. J. Pharm. 469 (2014)
39. P. Zahedi, I. Rezaeian, S.H. Jafari, In vitro and in vivo evaluations of phenytoin sodium-loaded electrospun PVA, PCL, and their hybrid nanofibrous mats for use as active wound dressings, J. Mater. Sci. 48 (2013).
40. M. Jannesari, J. Varshosaz, M. Morshed, M. Zamani, Composite poly vinyl alcohol/poly vinyl acetate electrospun nanofibrous mats as a novel wound dressing matrix for controlled release of drugs, Int. J. Nanomed. 6 (2011)
41. B. Lu, T. Li, H. Zhao, X. Li, C. Gao, S. Zhang, E. Xie, Graphene-based composite materials beneficial to wound healing, Nanoscale 4 (2012)
42. R. Ahmed, M. Tariq, I. Ali, R. Asghar, P. Noorunnisa Khanam, R. Augustine, A. Hasan, Novel electrospun chitosan/polyvinyl alcohol/zinc oxide nanofibrous mats with antibacterial and antioxidant properties for diabetic wound healing, Int. J. Biol. Macromol. 120 (2018)
43. K.T. Shalumon, K.H. Anulekha, S.V. Nair, S.V. Nair, K.P. Chennazhi, R. Jayakumar, Sodium alginate/poly(vinyl alcohol)/nano ZnO composite nanofibers for antibacterial wound dressings, Int. J. Biol. Macromol. 49 (2011)
44. J. Xue, M. He, Y. Niu, H. Liu, A. Crawford, P. Coates, D. Chen, R. Shi, L. Zhang, Preparation and in vivo efficient anti-infection property of GTR/GBR implant made by metronidazole loaded electrospun polycaprolactone nanofiber membrane, Int. J. Pharm. 475 (2014)

45. J. Lopez-Esparza, L. Francisco Espinosa-Cristobal, A. Donohue-Cornejo, S.Y. Reyes-Lopez, Antimicrobial activity of silver nanoparticles in polycaprolactone nanofibers against gram-positive and gram-negative bacteria, Ind. Eng. Chem. Res. 55 (2016)
46. P. Pal, B. Das, P. Dadhich, A. Achar, S. Dhara, and Carbon nanodot impregnated fluorescent nanofibers for: in vivo monitoring and accelerating full-thickness wound healing, J. Mater. Chem. B 5 (2017)
47. R. Augustine, S.K. Nethi, N. Kalarikkal, S. Thomas, C.R. Patra, Electrospun polycaprolactone (PCL) scaffolds embedded with europium hydroxide nanorods (EHNs) with enhanced vascularization and cell proliferation for tissue engineering applications, J. Mater. Chem. B 5 (2017)
48. R. Augustine, E.A. Dominic, I. Reju, B. Kaimal, N. Kalarikkal, S. Thomas, Electrospun polycaprolactone membranes incorporated with ZnO nanoparticles as skin substitutes with enhanced fibroblast proliferation and wound healing, RSC Adv. 4 (2014)
49. L. Preem, M. Mahmoudzadeh, M. Putrinš, A. Meos, I. Laidmäe, T. Romann, J. Aruväli, R. Härmas, A. Koivuniemi, A. Bunker, T. Tenson, K. Kogermann, Interactions between chloramphenicol, carrier polymers, and bacteria-implications for designing electrospun drug delivery systems countering wound infection, Mol. Pharm. 14 (2017)
50. Q. Yu, Y. Han, T. Tian, Q. Zhou, Z. Yi, J. Chang, C. Wu, Chinese sesame stickinspired nano-fibrous scaffolds for tumor therapy and skin tissue reconstruction, Biomaterials 194 (2019)
51. J. Xue, M. He, Y. Liang, A. Crawford, P. Coates, D. Chen, R. Shi, L. Zhang, Fabrication and evaluation of electrospun PCL-gelatin micro-/nanofiber membranes for anti-infective GTR implants, J. Mater. Chem. B 2 (2014)
52. X. Yang, J. Yang, L. Wang, B. Ran, Y. Jia, L. Zhang, G. Yang, H. Shao, X. Jiang, Pharmaceutical intermediate-modified gold nanoparticles: against multidrug-resistant bacteria and wound-healing application via an electrospun scaffold, ACS Nano 11 (2017)
53. B. Motealleh, P. Zahedi, I. Rezaeian, M. Moghimi, A.H. Abdolghaffari, M.A. Zarandi, Morphology, drug release, antibacterial, cell proliferation, and histology studies of chamomile-loaded wound dressing mats based on electrospun nanofibrous poly ε-caprolactone/polystyrene blends, J. Biomed. Mater. Res. - Part B Appl. Biomater. 102 (2014)
54. L. Liu, S. Bai, H. Yang, S. Li, J. Quan, L. Zhu, H. Nie, Controlled release from thermo-sensitive PNVCL-co-MAA electrospun nanofibers: the effects of hydrophilicity/hydrophobicity of a drug, Mater. Sci. Eng. C 67 (2016)
55. K.A. Wold, V.B. Damodaran, L.A. Suazo, R.A. Bowen, M.M. Reynolds, Fabrication of biodegradable polymeric nanofibers with covalently attached no donors, ACS Appl. Mater. Interfaces 4 (2012)
56. E.R. Kenawy, G.L. Bowlin, K. Mansfield, J. Layman, D.G. Simpson, E.H. Sanders, G.E. Wnek, Release of tetracycline hydrochloride from electrospun poly(ethyleneco-vinylacetate), poly(lactic acid), and a blend, J. Control. Release 81 (2002)
57. H. Zhang, S. Lou, G.R. Williams, C. Branford-White, H. Nie, J. Quan, L.M. Zhu, A systematic study of captopril-loaded polyester fiber mats prepared by electrospinning, Int. J. Pharm. 439 (2012)
58. L.M.D. Loiola, P.R. Cortez Tornello, G.A. Abraham, M.I. Felisberti, Amphiphilic electrospun scaffolds of PLLA-PEO-PPO block copolymers: preparation, characterization and drug-release behaviour, RSC Adv. 7 (2017)
59. H. Li, M. Wang, G.R. Williams, J. Wu, X. Sun, Y. Lv, L.M. Zhu, Electrospun gelatin nanofibers loaded with vitamins A and e as antibacterial wound dressing materials, RSC Adv. 6 (2016)
60. Z.C. Xing, W.P. Chae, J.Y. Baek, M.J. Choi, Y. Jung, I.K. Kang, In vitro assessment of antibacterial activity and cytocompatibility of silver-containing phbv nanofibrous scaffolds for tissue engineering, Biomacromolecules 11 (2010)
61. A. GhavamiNejad, A. Rajan Unnithan, A. Ramachandra Kurup Sasikala, M. Samarikhalaj, R.G. Thomas, Y.Y. Jeong, S. Nasseri, P. Murugesan, D. Wu, C. Hee Park, C.S. Kim, Mussel-inspired electrospun nanofibers functionalized with size-controlled silver nanoparticles for wound dressing application, ACS Appl. Mater. Interfaces 7 (2015)
62. O.E. Fayemi, A.C. Ekennia, L. Katata-Seru, A.P. Ebokaiwe, O.M. Ijomone, D.C. Onwudiwe, E.E. Ebenso, Antimicrobial and wound healing properties of polyacrylonitrile-moringa extract nanofibers, ACS Omega 3 (2018)
63. J. Wu, S. Hou, D. Ren, P.T. Mather, Antimicrobial properties of nanostructured hydrogel webs containing silver, Biomacromolecules 10 (2009)
64. Y. Wang, P. Li, P. Xiang, J. Lu, J. Yuan, J. Shen, Electrospun polyurethane/keratin/AgNP biocomposite mats for biocompatible and antibacterial wound dressings, J. Mater. Chem. B 4 (2016)

65. R. Ahmed, M. Tariq, I. Ali, R. Asghar, P. Noorunnisa Khanam, R. Augustine, A. Hasan, Novel electrospun chitosan/polyvinyl alcohol/zinc oxide nanofibrous mats with antibacterial and antioxidant properties for diabetic wound healing, Int. J. Biol. Macromol. 120 (2018)
66. M.R. Mohammadi, S. Rabbani, S.H. Bahrami, M.T. Joghataei, F. Moayer, Antibacterial performance and in vivo diabetic wound healing of curcumin loaded gum tragacanth/poly ε-caprolactone electrospun nanofibers, Mater. Sci. Eng. C. 69 (2016)
67. R. Zhao, X. Li, B. Sun, Y. Tong, Z. Jiang, C. Wang, Nitrofurazone-loaded electrospun PLLA/sericin-based dual-layer fiber mats for wound dressing applications, RSC Adv. 5 (2015)
68. W.A. Sarhan, H.M.E. Azzazy, I.M. El-Sherbiny, Honey/chitosan nanofiber wound dressing enriched with allium sativum and cleome droserifolia: enhanced antimicrobial and wound healing activity, ACS Appl. Mater. Interfaces 8 (2016)
69. G. Ramanathan, S. Singaravelu, M.D. Raja, N. Nagiah, P. Padmapriya, K. Ruban, K. Kaveri, T.S. Natarajan, U.T. Sivagnanam, P.T. Perumal, Fabrication and characterization of a collagen coated electrospun poly 3-hydroxybutyric acid-gelatin nanofibrous scaffold as a soft bio-mimetic material for skin tissue engineering applications, RSC Adv. 6 (2016)
70. M. Cheng, Z. Qin, S. Hu, S. Dong, Z. Ren, H. Yu, Achieving long-term sustained drug delivery for electrospun biopolyester nanofibrous membranes by introducing cellulose nanocrystals, ACS Biomater. Sci. Eng. 3 (2017)
71. A. Mira, C.R. Mateo, R. Mallavia, A. Falco, Poly(methyl vinyl ether-alt-maleic acid) and ethyl monoester as building polymers for drug-loadable electrospun nanofibers, Sci. Rep. 7 (2017)
72. P. Zhao, H. Jiang, H. Pan, K. Zhu, W. Chen, Biodegradable fibrous scaffolds composed of gelatin coated poly(??-caprolactone) prepared by coaxial electrospinning, J. Biomed. Mater. Res. - Part A 83 (2007)
73. M. Pakravan, M.C. Heuzey, A. Ajji, Core-shell structured PEO-chitosan nanofibers by coaxial electrospinning, Biomacromolecules 13 (2012)
74. J.F. Zhang, D.Z. Yang, F. Xu, Z.P. Zhang, R.X. Yin, J. Nie, Electrospun core-shell structure nanofibers from homogeneous solution of poly(ethylene oxide)/chitosan, Macromolecules 42 (2009)
75. T.T.T. Nguyen, O.H. Chung, J.S. Park, Coaxial electrospun polylactic acid/chitosan (core/shell) composite nanofibers and their antibacterial activity, Carbohydr. Polym. 86 (2011)
76. M. Rubert, J. Dehli, Y.F. Li, M.B. Taskin, R. Xu, F. Besenbacher, M. Chen, Electrospun PCL/PEO coaxial fibers for basic fibroblast growth factor delivery, J. Mater. Chem. B 2 (2014)
77.] Y.Z. Zhang, X. Wang, Y. Feng, J. Li, C.T. Lim, S. Ramakrishna, Coaxial electrospinning of (fluorescein isothiocyanate-conjugated bovine serum albumin)-encapsulated poly ε-caprolactone nanofibers for sustained release, Biomacromolecules 7 (2006)
78. H. Jiang, Y. Hu, Y. Li, P. Zhao, K. Zhu, W. Chen, A facile technique to prepare biodegradable coaxial electrospun nanofibers for controlled release of bioactive agents, J. Control. Release 108 (2005)
79. W. Gao, L. Sun, X. Fu, Z. Lin, W. Xie, W. Zhang, F. Zhao, X. Chen, Enhanced diabetic wound healing by electrospun core-sheath fibers loaded with dimethyloxalylglycine, J. Mater. Chem. B 6 (2018)
80. X. Ren, Y. Han, J. Wang, Y. Jiang, Z. Yi, H. Xu, Q. Ke, An aligned porous electrospun fibrous membrane with controlled drug delivery – an efficient strategy to accelerate diabetic wound healing with improved angiogenesis, Acta Biomater. 70 (2018)
81. C.L. He, Z.M. Huang, X.J. Han, L. Liu, H.S. Zhang, L.S. Chen, Coaxial electrospun poly L-lactic acid ultrafine fibers for sustained drug delivery, J. Macromol. Sci. Part B Phys. 45 B (2006)
82. R. Qi, R. Guo, M. Shen, X. Cao, L. Zhang, J. Xu, J. Yu, X. Shi, Electrospun poly lactic-co-glycolic acid/halloysite nanotube composite nanofibers for drug encapsulation and sustained release, J. Mater. Chem. 20 (2010)
83. G. Kabay, A.E. Meydan, G. Kaleli Can, C. Demirci, M. Mutlu, Controlled release of a hydrophilic drug from electrospun amyloid-like protein blend nanofibers, Mater. Sci. Eng. C 81 (2017)
84. M. He, H. Jiang, R. Wang, Y. Xie, C. Zhao, Fabrication of metronidazole loaded poly ε-caprolactone/zein core/shell nanofiber membranes via coaxial electrospinning for guided tissue regeneration, J. Colloid Interface Sci. 490 (2017)
85. R. Najafi-Taher, M.A. Derakhshan, R. Faridi-Majidi, A. Amani, Preparation of an ascorbic acid/PVA-chitosan electrospun mat: a core/shell transdermal delivery system, RSC Adv. 5 (2015)
86. Š. Zupančič, S. Sinha-Ray, S. Sinha-Ray, J. Kristl, A.L. Yarin, Controlled release of ciprofloxacin from core-shell nanofibers with monolithic or blended core, Mol. Pharm. 13 (2016)
87. L. Zhu, X. Liu, L. Du, Y. Jin, Preparation of asiaticoside-loaded coaxially electrospinning nanofibers and their effect on deep partial-thickness burn injury, Biomed. Pharmacother. 83 (2016)

88. R. Li, Z. Cheng, R. Wen, X. Zhao, X. Yu, L. Sun, Y. Zhang, Z. Han, Y. Yuan, L. Kang, Novel SA@Ca2+/RCSPs core-shell structure nanofibers by electrospinning for wound dressings, RSC Adv. 8 (2018)
89. B.V. Worley, R.J. Soto, P.C. Kinsley, M.H. Schoenfisch, Active release of nitric oxide-releasing dendrimers from electrospun polyurethane fibers, ACS Biomater. Sci. Eng. 2 (2016)
90. H. Li, J. Zhu, S. Chen, L. Jia, Y. Ma, Fabrication of aqueous-based dual drug loaded silk fibroin electrospun nanofibers embedded with curcumin-loaded RSF nanospheres for drugs controlled release, RSC Adv. 7 (2017)
91. M. Ranjbar-Mohammadi, M. Zamani, M.P. Prabhakaran, S.H. Bahrami, S. Ramakrishna, Electrospinning of PLGA/gum tragacanth nanofibers containing tetracycline hydrochloride for periodontal regeneration, Mater. Sci. Eng. C 58 (2016)
92. C. Yang, D.G. Yu, D. Pan, X.K. Liu, X. Wang, S.W.A. Bligh, G.R. Williams, Electrospun pH-sensitive core-shell polymer nanocomposites fabricated using a triaxial process, Acta Biomater. 35 (2016)
93. W. Liu, C. Ni, D.B. Chase, J.F. Rabolt, Preparation of multilayer biodegradable nanofibers by triaxial electrospinning, ACS Macro Lett. 2 (2013)
94. D. Han, S. Sherman, S. Filocamo, A.J. Steckl, Long-term antimicrobial effect of nisin released from electrospun triaxial fiber membranes, Acta Biomater. 53 (2017)
95. D.G. Yu, X.Y. Li, X. Wang, J.H. Yang, S.W.A. Bligh, G.R. Williams, Nanofibers fabricated using triaxial electrospinning as zero order drug delivery systems, ACS Appl. Mater. Interfaces 7 (2015)
96. D. Han, A.J. Steckl, Triaxial electrospun nanofiber membranes for controlled dual release of functional molecules, ACS Appl. Mater. Interfaces 5 (2013).