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Review –Electrospun Nanofibers In Biomedical Field

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Abstract: *Recently, nanotechnology as novel interdisciplinary sciences has been introduced among all fields and gets numerous attentions, due to its unique applications. The electro spinning technique provides non-wovens to the order of few nanometres with large surface areas, ease of functionalisation for various purposes and superior mechanical properties. Also, the possibility of large scale productions combined with the simplicity of the process makes this technique very attractive for many different applications. Electrospinning is a versatile technique that has gained popularity for various biomedical applications in recent years. Electro spun materials have the benefits of unique properties for instance; high surface area to volume ratio, enhanced cellular interactions, and protein absorption to facilitate binding sites for cell receptors. Electrospinning is being used for fabricating nanofibers for various biomedical wound healing, scaffolds, filtration and protective material, electrical and optical applications, sensors etc.*
Keywords*: Electrospinning, Biomedical applications.*

I. Introduction

Electrospinning process Electrospinning is a highly versatile spinning process used for fiber formation which utilizes high electric field applied to the droplet of a solution or melt purging out from the tip of a capillary. It requires a DC voltage source in the range of several tens of kVs in order to produce electrostatic forces. The process mainly based on the principle that strong electrical repulsive forces generated by this voltage source overcome the weaker forces of surface tension in the liquid droplet. The electrostatic forces affecting the liquid cause the shape of the droplet to change from rounded meniscus to the Taylor cone, a phenomenon observed due to the electrostatic repulsions between similar charges in the liquid [1]. At this critical point, the applied electric field eventually becomes more prominent and overcomes the surface tension of the liquid leading to a jet of the solution ejected from the tip of the Taylor cone. As the jet travels through the air, the flow changes from ohmic to convective because of the charges migrating to the surface of the fiber and an unstable whipping of the jet occurs in the space between the tip and the collector. This leads to evaporation of the solvent, leaving the solid fiber behind which will result to a continuous fiber formation with diameters ranging from tens of nanometers to several micrometers. Due to the possibility of unpleasant or even harmful emissions of some polymers or solvent vapors during the spinning, the process should be carried out under properly ventilated chamber [2].

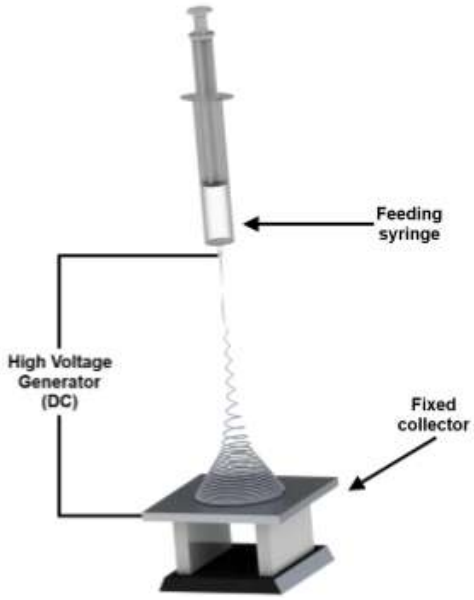

Figure (1) Advances in Electrospinning of Nanofibers and Biomedical Applications

BIOMEDICAL APPLICATION

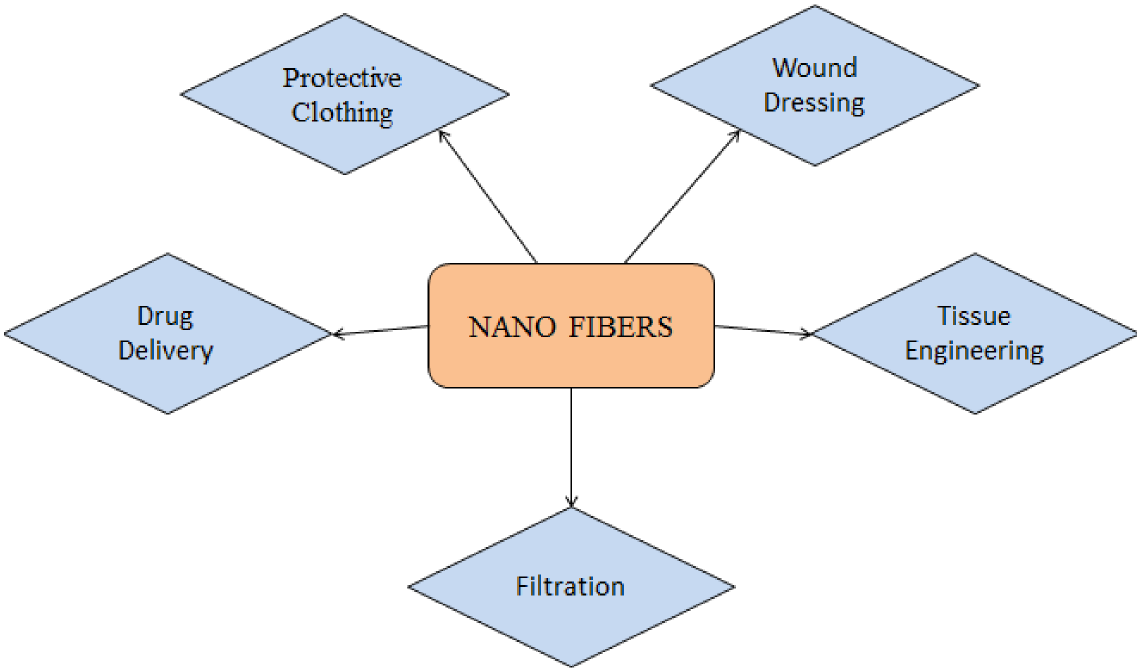

Figure (2) Applications of electrospun nanofibers in the biomedical field

Drug Delivery Methods

One of the main areas of research in biomedical application is drug delivery where the electrospun fibers help to encapsulate the therapeutic agent in the fibers. In addition, electrospun fibers maintain the integrity and bioactivity of the drug molecules due to the mild processing parameters. Localized inoculation of medicines in wound treatment using electrospun fibers as delivery vehicles can significantly reduce the systemic absorption of the drug and prevent/reduce any side effects from the drugs [3]. In addition, the efficacy of the drug would also improve due to localization of the treatment. The release of the drug is then dependent on the degradation of the polymer fibers and thus can be properly controlled. The core shell electrospun fibers have usually been used in drug delivery applications. This is due to the fiber's ability to encapsulate the drug molecules until they are needed in the hollow core. These fibers protect the drug and also prevent other molecules such as enzymes and growth factors from denaturing during processing. In this manner the therapeutic agents remain unaltered and encapsulated until needed at the site of action [4].

Tissue engineering

Tissue engineering is an interdisciplinary field requiring the knowledge of medicine, biology, engineering and material science fields. With the use of a combination of cells, materials, therapeutic agents and other biochemicals, the field provides regeneration of tissues which have been destroyed by diseases, injuries or congenital defects [5]. The most important problem encountered during the development of artificial tissues is the requirements needed to be met in order to support the cells which are provided by extracellular matrix (ECM) in natural tissue. The fibrous component of ECM is made up of protein fibers such as collagens, elastin, keratin, laminins, fibronectin and vitronectin [6]. These ECM fibers provide structural support and mechanical integrity to tissues as well as locations for cell adhesion and regulation of cell functions such as proliferation, shape, migration, and differentiation. Therefore, ECM fibers are maybe the most important component needed to be simulated in artificial tissue regeneration [7].

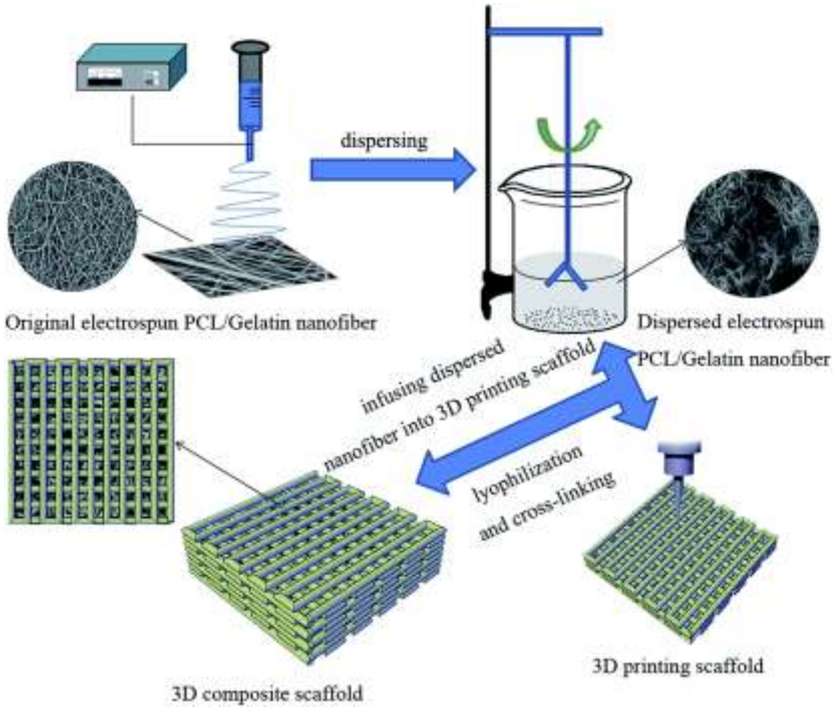

Figure (3) Fabrication and characterization of electrospinning/3D printing bone tissue engineering scaffold

Nanofibers in Protective Clothing (PC) Applications

Water vapour transport properties of ENMs were found to be comparable to textile materials and hence they can be applied in protective clothing applications. Although increased filtration efficiency for aerosol was observed for ENMs, relatively higher pressure drop was reported. Reactive organic materials and nanoparticles have been incorporated into nanofibers by mixing with polymer solutions followed by simple electrospinning and tested for the decontamination of chemical warfare agents. The decontamination efficiency of such ENMs was found to be much higher than conventional activated charcoal. Simple mixing of nanoparticles into polymer solution led to the formation of nanoparticles aggregates and thereby catalytic activity was reduced. In order to overcome this problem, electrospraying technique was utilized to spray nanoparticles and was combined with electrospinning technique, whereby nanoparticles were made available on the nanofiber surfaces by Sundarrajan et al. However, the nanoparticles on such nanofiber surfaces are not stable. Sundarrajan et al overcame this problem by electrospinning the polymers with functional groups such as poly(ethylene imine) and cellulose [8].

Filtration Performance of nanofibers

In the conventional filters, according to filtration theory, non-slip flow is the dominant mechanism. However, when the nanofibrous layer is coated on the conventional filter, the slip flow mechanism becomes dominant due to the smaller fiber size ability to disturb the air flow. As can be seen from depth filtration is taking place on the conventional filter media (dust loading), whereas surface loading of dust particles is taking place on the nanofiber coated on conventional filte [9, 10].

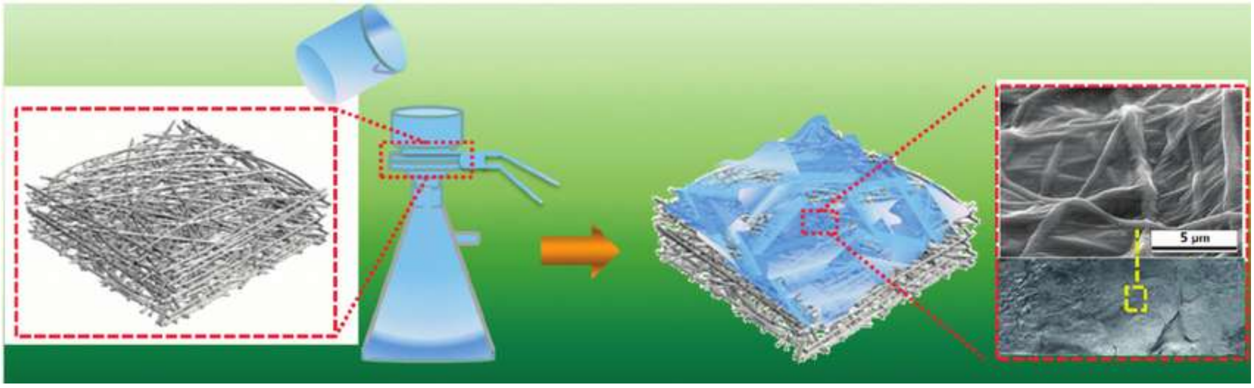

Figure (4) Synergistic effects of a novel free-standing reduced graphene oxide film and surface coating fibronectin on morphology, adhesion and proliferation of mesenchymal stem cells†

Wound Dressing

Wound dressing mats, aside from tissue engineering scaffolds, are protective covers used to promote healing and/or to prevent further harming of a wound. For this purpose, a certain porous structure is required since it is both crucial to maintain a level of humidity and sustenance at the wound site and to be impervious against exogenous pathogens [10,11]. Especially, the effect of humidity, as firstly described by winter is the key to a successful healing since a dry environment will cause dehydration of the collagen matrix where the cells die and form a scab that obstructs keratinocytes from penetrating the viable tissue [12] The required porous structure can be achieved in a fibrous morphology by manipulation of the pore size and distribution which is possible with the versatility of the electrospinning process. For example, Gu et al. investigated electrospinning of gelatin and gelatin/poly(L-lactide) blend mats for wound dressing [13,14].

Figure (5) Electrospinning of soy protein fibers and their compatibility with synthetic polymers

II. Conclusion

In conclusion, the electrospinning process has been recognized as a useful technique of creating scaffolds for the applications in tissue engineering, drug delivery, wound dressing and filtration. In the future it is important for researchers to focus on obtaining a better fundamental understanding of the process and its parameters in order to use this as a tool in developing better biomedical applications

References

[1]. Hilal Turkoglu Sasmazel and Ozan Ozkan, "Advance in Electrospinning of Nanofibers and their Biomedical Applications", Current Tissue Engineering, Vol. 2, No. 2, 2013.

[2]. P. V.Londhe, S.S.Chavan, P.N.Deshmukh, "Investigation of Electro spun Nanofibers: A Parametric Study for Diameter of Nanofiber", 2012.

[3]. Nishath Khan, "Applications of electrospun nanofibers in the biomedical field", Studies by Undergraduate Researchers at Guelph Vol. 5, No. 2, , 63-73, 2012.

[4]. Jian Fang, Xungai Wang and Tong Lin, "Functional Applications of Electrospun Nanofibers, Intech, Vol.6, 1030-1035.2010.

[5]. Md. Mahabub Hasan, A.K.M. Mashud Alam, "Application of electrospinning techniques for the production of tissue engineering scaffolds: A Review", European Scientific Journal May vol.10, No.15 1857 – 7881, 2014.

[6]. Yinxian Yu, Sha Hua, Mengkai Yang, Zeze Fu, Songsong Teng, Kerun Niu, Qinghua Zhao and Chengqing Yi, "Fabrication and characterization of electrospinning/3D printing bone tissue engineering scaffold", Issue 112, Page 110460 to 111631,2016.

[7]. A. Gholipour Kanani, S. Hajir Bahrami, "Reviews on Electrospun Nanofibers Scaffold and Biomedical Applications", Trends Biomater. Artif Organs, vol 24(2),93-115,2010.

[8]. Subramanian Sundarrajana, Kwong Luck Tana, Soon Huat Lima, Seeram Ramakrishna, "Electrospun Nanofibers for Air Filtration Applications", Science Direct, Procedia Engineering 75 159 – 163, 2014.

[9]. Venugopal and S. Ramakrishna, "Applications of Polymer Nanofibers in Biomedicine and Biotechnology", Applied Biochemistry and Biotechnology Vol. 125, 2005.

[10]. Asiti shankar , Abdel-fattah M. seyam and Sam M. Hudson, "Electrospinning of soy protein fibers and their compatibility with synthetic polymers", Journal of textile and apparel technology and management, volume 8, issue 1, 2013.

[11]. Shih-Feng Chou, Simi Gunaseelan, Mhd Hussam Hijazi Kiellani, "A Review of Injectable and Implantable Biomaterials for Treatment and Repair of Soft Tissues in Wound Healing", Journal of Nanotechnology Volume 15 2017.

[12]. Martina Abrigo, Sally L. McArthur, Peter Kingshott, "Electrospun Nanofibers as Dressings for Chronic Wound Care: Advances, Challenges, and Future Prospects", Macromol. Biosci., 14, 772–792 , 2014.

[13]. L. Maleknia and Z. Rezazadeh Majdi, "Electrospinning of Gelatin Nanofiber for Biomedical Application", Oriental journal of chemistry, Vol. 30, No. (4), Pg. 2043-2048, 2014.

[14]. Seema Agarwal, Joachim H. Wendorff, Andreas Greiner, "Use of electrospinning technique for biomedical applications", Polymer 49 5603–5621, 2008.

[15]. Lin Jin, ab Zhiping Zeng, Shreyas Kuddannaya, Dan Yue, Jingnan Bao, "Synergistic effects of a novel free-standing reduced graphene oxide film and surface coating fibronectin on morphology, adhesion and proliferation of mesenchymal stem cells", Chem. B, 3, 4338, 2015.