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Public Health 2020: Electrospinning fibres for the controlled delivery of antibiotics

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We are studying the controlled release of antibiotics from multi-layered electrospun matrices.

The purpose of this study is to investigate the design and application of multilayered electrospun micro-nanofibres as controllable drug-delivery devices, an important avenue in modern medicines design.

Many formulations of electrospun poly-caprolactone (PCL) and poly(ethylene-co-vinyl acetate (PEVA) have been designed, prepared as micro-nanofibre layers, and assayed for the controlled release of the clinically useful antibiotic tetracycline (Tet) HCl with potential applications in wound healing and especially in complicated skin and skin-structure infections. Tet HCl was also chosen as a model drug possessing a good UV chromophore and capable of fluorescence together with limited stability.

Tet HCl was successfully incorporated (essentially quantitatively at 3% w/w) and provided controlled release from multi-layered electrospun matrices. The Tet HCl release test was carried out by a total immersion method on 2×2 cm square electrospun fibrous mats in Tris or PBS heated to 37ºC. The formulation PCL/PEVA/PCL with Tet HCl in each layer gave a large initial (burst) release followed by a sustained release. Adding a third layer to the two layered formulations led to release being sustained from 6 days to more than 15 days. There was no detectable loss of Tet chemical stability (as shown by UV and NMR) or bioactivity (as shown by a modified Kirby-Bauer disc assay). Using Tet HCl-sensitive bacteria, Staphylococcus aureus (ATCC 25,923), the Tet HCl loaded three layer matrix formulations still showed significant antibacterial effects on days 4 and 5.

Electro spinning provides good encapsulation efficiency of Tet HCl in PCL/PEVA/PCL polymers in micro-nanofibre layers which display sustained antibiotic release and may find applications in drug releasing wound dressings.

Electrospinning is an old technology for the manufacture of continuous nanofibers with a relatively simple configuration. However, in recent years it attracted much attention because of its potential in biomedical and other nanotechnical applications. Its inherent high surface-volume ratio, ease of operation and cost-effectiveness are all attractive features for its biomedical application. Electrospinning for drug loading into hydrophilic fibers is especially important to increase the dissolution and for instance biodisponibility, of poorly water-soluble drugs. Immediate dissolution formulations for buccal absorption of drug are produced with this technique for fast drug absorption and to avoid first pass metabolism, or degradation in gastric fluids. Systems for local delivery of antineoplastics, antimicrobials, etc. can also be developed by electrospinning. With the development of electrospinning techniques, such as coaxial electrospinning, and the availability of a rich variety of materials (including natural, synthetic and semisynthetic polymers), several drugs have been electrospun into ultrafine fibers with controllable diameters and morphologies. Advanced electrospinning arrangements allow the production of delivery systems for hydrophilic drugs including macromolecules such as proteins and DNA.

This paper summarizes the modification of the electrospinning system configurations and the effect of the process parameters on the fibers, their application in drug delivery, including carrier materials, loaded drugs and their release kinetics, and illustrates their application for local chemotherapy. To date, most studies on the release of antibacterial agents, drugs (psychoactive, antineoplasic, etc.), are carried out in vitro. In vivo, in-depth systemic studies are necessary before any clinical marketing is contemplated, especially those on the kinetics and dynamics of drug release in vivo; the effects of drug dosage and release kinetics on therapeutic efficacy and the biodistribution of the liberated drugs. Complete studies are required on the toxic effect, as well as distribution and elimination process, of the polymeric carriers. Many pharmaceutical drugs have been loaded into nanofibers, but these studies are limited in just the loading and characterization of nanofibers. It is observed that the lack of the correct dosage is a common issue in most articles. It can be concluded, that this disadvantage is the stronger weakness of electrospinning: it is difficult to load a desired concentration into nanofibers with the end purpose of applied in clinical studies in humans.

This review proposes to continue the investigation to optimize the incorporation of interesting drugs into nanofibers, but further clinical studies, considering patient acceptance of the administration form. Scaling to mass productions of drug loaded electrospun mats is also an issue that has to be considered.

Finally, it can be said, that electrospinning had demonstrated been effective in a great diversity of biomedical application and studies will continue on its different uses, because its versatility, cost-effectivity, easy to use and easy to fabricate in any research facilities, even with low economic support.

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