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# Novel Method for Nanofibre Yarn Production Using Two Differently Charged Nozzles

**Abstract**
*In this study a new method of yarn production from electrospun nanofibres is discussed. This method is an innovation in electrospinning, using two differently charged nozzles and a collector travelling through the air to form yarn continuously. In this project PAN electrospun nanofibres were used to produce twisted yarn with a linear density of 2.1 tex at laboratory scale. The tensile properties of these yarns were then investigated. With this method it is possible to produce yarns with different polymers and linear densities.*

**Key words:** *nanofibre yarn, tensile properties, charged nozzle, linear density, electrospun.*

## Introduction

Electrospinning has been known for almost 70 years as a simple and effective technique for producing continuous ultra fine polymeric fibers with diameters from several to hundreds of nanometers. It is based on the use of electrostatical forces to drive a jet of polymer solution to form nanofibres. Electrospun nanofibres from a variety of polymers have been employed in filters, composites, tissue engineering scaffolds, protective clothing, electronics, catalysis, ceramic fibers, wound dressing, drug delivery materials and many other applications [1]. The principles of electrospinnig are simple and include four main parts: a metallic capillary as a needle which is connected to a high voltage source; a pump which controls the output flow of the polymer solution; and a collector grounded or charged to a negative voltage. In this technique only a small amount of polymer solution is needed [2]. Also, various methods have been used to obtain aligned electrospun nanofibres such as spinning onto a rotating drum [3], spinning onto the sharp edge of a thin rotating wheel [4], using a metal frame as the collector [5], a collector based pair of split electrodes [6]. There have been many attempts to align electrospun nanofibres. Moreover, a great deal of attention has been paid to produce yarns from these nanofibres, which has led to the introduction of various techniques.. One of these methods involves using multi field electrospinning apparatus with vertically oriented rings connected in series and charged at the same polymer jet voltage coming from a syringe needle. In this method, the travelling path of nanofibres was limited to a cone shape just before collecting onto a collector, which is achieved by applying an electrical field to these rings to prevent spun nanofibres from spreading. Consequently, electrospun nanofibres are collected on the wooden frame and form a yarn. As the wooden frame width is 1 inch, it is possible to produce yarns of only1 inch length [7]. Another method is based on the use of an oscillating metal grounded frame of high frequency as a collector. The bundle of electrospun nanofibres which is collected on this frame has a high degree of alignment of nanofibres within; but a drawback of this method is that only relatively short tows of aligned fibers can be obtained, and there has been no report detailing the mechanical properties of these yarns [8]. The use of two grounded rings as collectors which collect and align electrospun nanofibres is reported. In other techniques aligned fibers are twisted around one another by rotating one of the rings and forming a yarn. Although such twisted yarn has the advantage of a high degree of fibrealignment within it, it is very vulnerable as it has a diameter of about 4 micrometers, indicating poor stability [9]. The technique of spinning polymer onto a water reservoir collector is another method of yarn production from electrospun nanofibres and was referred to in an abstract presented at a conference in 2001 in which yarn of PAN electrospun nanofibres was obtained on the surface of water [10]: electrospun nanofibres came into contact with the surface of the water while they were travelling toward a grounded plate placed under the water. The initial non-woven web of nanofibres formed on the surface of the water was then drawn and pulled out to form a continuous yarn, which was done with the aid of a take-up roller rotating at constant speed [11]. Using the latter method showed that PLC yarn formed from PLC electrospun nanofibres had a lower strength than yarns formed by other techniques [12]. Twisting PAN electrospun nanofibres using a rotating drum as an electrical twister was reported by Fennessey *et al*, which led to the formation of a bundle of aligned PAN nanofibres with dimensions of 2 × 32 cm. The maximum strength and modulus of yarns obtained by this meth-

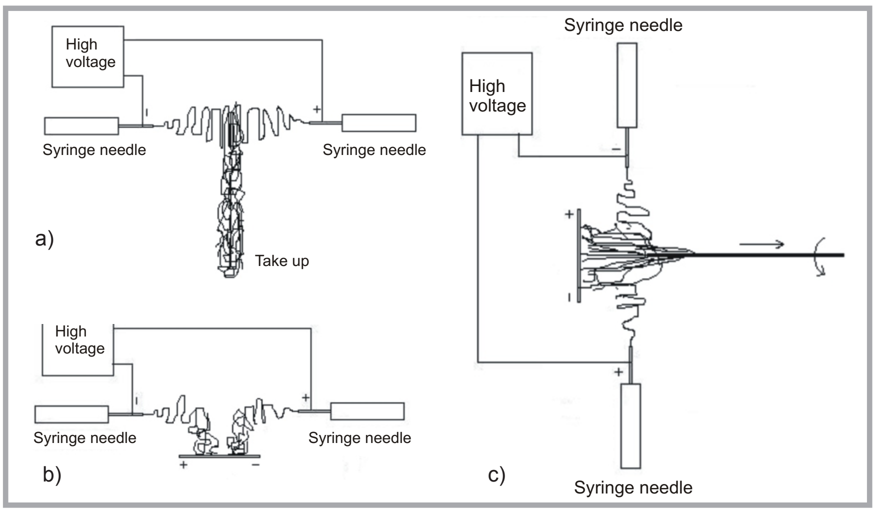


***Figure 1.*** *Schematic of the mechanism of: a) strand formation (Type A), b) yarn formation (Type B), c) yarn formation (Type C).*