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論　文　内　容　の　要　旨

The growing application of nanofibers in various fields led the nanofibers research intense in terms of exploring multifunctional properties. Nanofiber technical application, a few patents and papers on nanofibers apparel have been appeared recently. All nanofibers apparel so far reported have demonstrated functional properties but lack the aesthetic properties. Providing aesthetic appealing nanofibers with functional properties, we conducted series of experiments and developed nanofibers for apparel application. This thesis reports the aesthetic and functional properties of nanofibers. The aesthetic properties cover by investigating dyeability of nanofibers with various dye class and functional properties covers by developing nanofibers substrate for biosensor and nanofiber tubes for nerve guide.

Fashion and casual apparel of cellulose based have widely been used by a consumer due to its outstanding properties of breathability, air permeability, hygroscopicity, no static electricity, biodegradability and show interesting physical properties such as a low density together with high mechanical characteristics. The cellulosic apparels are marketed in the form of white, dyed or printed according the end-user's requirement. We investigated aesthetic properties by producing colored cationic-cellulose nanofibers for the very first time for the potential application of apparel use. The cellulose acetate nanofibers were electrospun followed by deacetylation and cationization to produce functional cationic-cellulose nanofibers and then dyed with anionic reactive dyes. The spectrophotometric measurement of dyed samples was carried out to determine color coordinates and color yield values. The cationic-cellulose nanofibers showed enhanced color yield and dye fixation without addition of an electrolyte in comparison to cellulose nanofibers. The cationization of cellulose nanofibers significantly enhanced the color yield values of around 76% at dye concentrations of 5%. Excellent color fastness results demonstrate that these new colored and breathable materials can potentially be considered as future apparel for casual or fashion.

In another study, webs of cellulose acetate nanofiber were electrospun and dyed with a high energy level CI Disperse Red 167:1 dye and a low energy level CI Disperse Blue 56 dye using the continuous pad–dry–bake method. Results revealed that the high energy level dye produced better color yield than the lower energy level dye. The dyed cellulose acetate nanofibers produced acceptable colorimetric values, color yield and color fastness. Young's modulus of dyed nanofibers increased by threefold in comparison to the undyed cellulose acetate nanofibers. Scanning electron microscopy images showed good morphology with the smooth surface of the dyed cellulose acetate nanofibers.

The study of functional and dyeing properties of the electrospun nanofibers has recently gained substantial interest. However, the dyeing of nanofibers still in transition phase and faces problem of lower color yield. Owing to the higher surface area of cellulose nanofibers, the color yield obtained is nearly four to five times lower than the conventional cotton fiber. The present work reports on dyeing of cellulose nanofibers with CI reactive black 5 dye via a simple and dual padding method to improve color yield and dye fixation. The color yields were determined by K/S values and color coordinates using spectrophotometer and the results were compered between single and dual padding methods. The dyed cellulose nanofibers were characterized by FTIR, WAXD and FE-SEM. X-ray diffraction studies revealed that the dyed cellulose nanofibers having Cellulose II form and show a better crystallinity than the undyed cellulose nanofibers.

Cellulose Acetate (CA) nanofibers have unique absorption properties and therefore they have been considered a suitable candidate to be used as substrate for biosensor. CA nanofibers webs deserve a special attention because of their very good water retention properties. CA nanofibers based biosensor in certain application come into contact with various liquids and requires high degree of wicking rate to transport liquid to its destination. Cellulose acetate (CA)/ poly vinyl alcohol (PVA) blended nanofibers were prepared via co-electrospinning using double nozzle for jetting cellulose acetate and poly vinyl alcohol independently. The CA/PVA blend nanofibers webs were deacetylated in aqueous alkaline solution to convert CA in to regenerated cellulose and to remove PVA nanofibers from the raw web. The resultant nanofibers webs were characterized by wicking rate, water contact angle, SEM and FTIR analysis. The results revealed that by varying concentration of PVA solution enhances the wicking rate. Such a nanofibers web may be used in biosensor strip and other medical applications where the high wicking rates are desired.

Recently attempts have been made to develop nanofibers tubes suitable for nerve regeneration made of biodegradable nanofibers. We electrospun the PCL-PLLA nanofiber tubular using different blend ratios of PCL-PLLA. The electrospun nanofibers were continuously deposited over high speed rotating mandrel to fabricate nanofibers tubes having inner diameter of 2 mm and the wall thickness of 55-65 μm. The diameters of nanofibers were between 715-860 nm. Scanning Electron Microscope (SEM) showed better structural stability and formability than the neat PLLA nanofibers. Fourier transform infrared spectroscopy (FTIR) study revealed that the PCL-PLLA blend nanofiber exhibit characteristic peaks of both PCL and PLLA and was composition dependent. Raman and X-ray diffraction studies showed that the increasing PCL ratio in the PCL-PLLA blend increased crystallinity of PCL-PLLA blends. Differential Scanning Calorimetry (DSC) revealed recrystallization peaks in PCL-PLLA blends ratio of 1:2 and 1:1. Based on characterization, the electrospun PCL-PLLA nanofibers tubes is considered to be a better candidate for further in-vivo or in-vitro investigation, and resolve biocompatibility issues in tissue engineering.