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Preparation and Characterization of NPK Nutrient Loaded Electrospun Cellulose Acetate Nanofiber Mat to be used as a Slow-release Fertilizer

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Abstract

A major unsolved issue with chemical fertilizers is the low nutrient use efficiency. It has been reported that an excessive amount of up to 70% of the nitrogen applied to plants with traditional fertilizers is lost to the surrounding. Hence, the drastic pollution effects of chemical fertilizer usage. Slow-release fertilizers aim to reduce such losses via slow and sustained release of nutrients to the plant. In this study, we report the successful fabrication and characterization of a novel and biodegradable cellulose acetate (CA) electrospun nanofiber (NF) mat loaded with nitrogen, phosphorus and potassium plant nutrients of urea, hydroxyapatite nanoparticles (HANPs) and MOP respectively to be used as a slow-release fertilizer (SRF). It was envisaged that the unique properties of the electrospun NFs could overcome the shortcomings of traditional slow-release fertilizers (SRFs). The fabrication of the NFs was done with 8.5% w/v CA polymer dissolved in a 6 mL solvent system of acetone to dimethylformamide in a 2:1 volume ratio along with the addition of the aforementioned nutrients at 10% of the polymer weight. Electrospinning parameters were set after parameter optimization. The high-voltage supply was set at 16 kV, the spinneret to collector distance was 13cm and the flow rate was 1.5 ml/h. The solutions were electrospun only when the relative humidity was approximately between 65 to 70%. The HANPs incorporated were synthesized by the wet chemical precipitation method. The successful synthesis of the HANPs was confirmed via Fourier transform infrared (FTIR) spectroscopy and powder X-ray diffraction (PXRD) analysis. The successful loading of the nutrients onto the electrospun NF mat was evident from FTIR, Raman and EDX analysis. Furthermore, the scanning electron microscopy images of the nutrient loaded NFs depicted a reduced average diameter with respect to those of the neat NF mat. The total nitrogen percentage of the nutrient loaded NF mat was determined to be 2.60% from Kjeldahl analysis. The initial nutrient release studies in water depicted a biphasic release model for orthophosphate and potassium nutrients while only a burst release profile was observed for nitrogen. It can be concluded that the electrospun NF mats display a potential application with regards to SRFs. However, several modifications to the NF mat fabrication such as the usage of coaxial electrospinning will have to be made in order to better optimize the nutrient loading and enhance its slow-release properties.

***Keywords**:* Electrospinning, Nanofiber mat, Slow-release, Hydroxyapatite nanoparticles