# Melt Electrospinning: As a Method for Producing Photo-converting Nanocomposite Materials

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Melt electrospinning involves the heating of a polymer to above its melting point and extruding it through a die into a strong electric field (~1 kV/cm), to produce micro/nano fibers (see figure 1). The elevated temperatures involved in the melt electrospinning process are ideal for thermodynamically driving a chemical reaction in the polymer melt with greatly slowed reaction kinetics.
We take advantage of this unique ability of melt electrospinning to produce lead halide organic-inorganic perovskite (OIP) crystallites embedded throughout polymer fibers. Films composed of OIPs are gaining notoriety as high efficiency photo-converters in photovoltaic devices. However OIP crystallites are highly sensitive to water exposure, leading to hydrolyzation[1] and large degradation in photo-conversion efficiency.

We have successfully synthesized OIP crystallites in a poly(propylene) (12,000mw, Isotactic) melt at ~200 °C and resultant structures were characterized using x-ray diffraction (XRD) and energy dispersive spectroscopy (EDS). The XRD and EDS analysis were done to verify that OIPs were indeed being formed in the polymer melt and to assess the feasibility of this synthesis method. The diffractograms and spectra indicate that the synthesis of the OIP was successful.

The protection of the OIPs by the polymer matrix is further enhanced by increasing the crystallinity of the polymer. We study the electrostatic elongation process taking place during melt electrospinning that will orient the polymer chains in a preferential direction increasing polymer crystallinity.[2] The crystallinity of the polymer should be further increased by carrying out this elongation above the glass transition temperature of the polymer in the melt as shown with differential scanning calorimetry (DSC).[3]

Polymer/OIP composite fibers are melt spun and further characterized using XRD, EDS, and DSC to understand and optimize the process parameters effect on the reaction kinetics and polymer crystallinity of produced fibers. In addition scanning electron microscopy is used to study the morphology and distribution of the OIP crystallites in the fibers to determine how these fibers can be used in current photovoltaic device architecture and in novel device architecture in the future.

1. G. Niu, X. Guo, L. Wang, Review of recent progress in chemical stability of perovskite solar cells. *J Mater Chem A* (3) 2015
2. O. Ero-Phillips, M. Jenkins, A. Stamboulis, Tailoring Crystallinty of Electrospun Plla Fibres by Control of Electrospinning Parameters. *Polymers (4)*, 2012
3. A.P. Gray, Polymer Crystallinity Determinations by DSC, *Thermochimica Acta (1),*1970


Figure 1. Melt electrospun poly(propylene) fibers, with needle-to-collection-plate separation of 3 cm and 8 kV acceleration voltage.

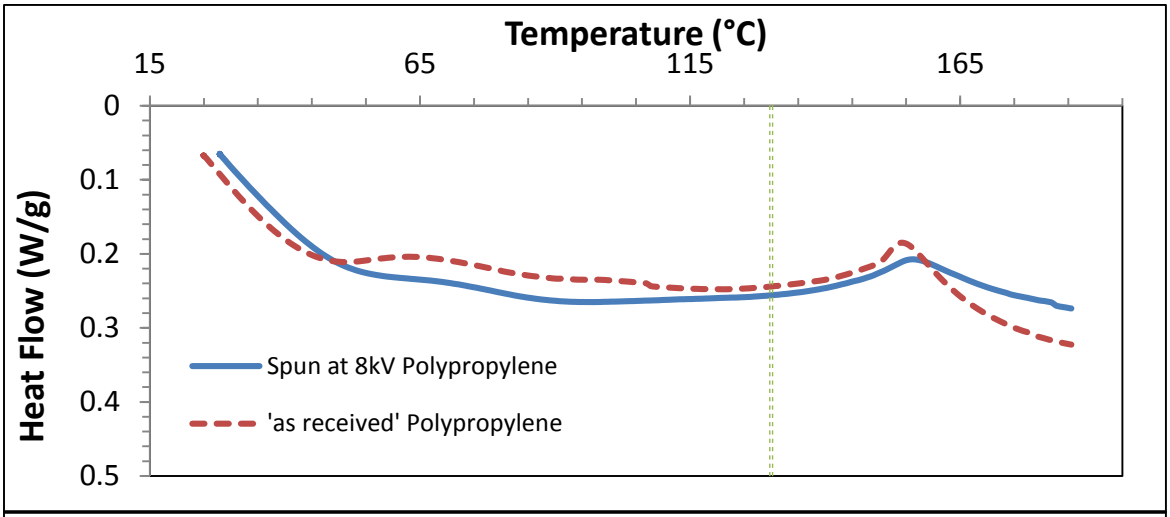


Figure 2. Differential scanning calorimeter scans of a polypropylene samples, 'as received' and electrospun at 8 kV. Scanning parameters were 10 °C/min heating, 5 °C/min cooling, set to run from ambient to 190 °C (Exothermic up). Initial experiments indicate small increases in crystallinity as a result of the melt electrospinning process.

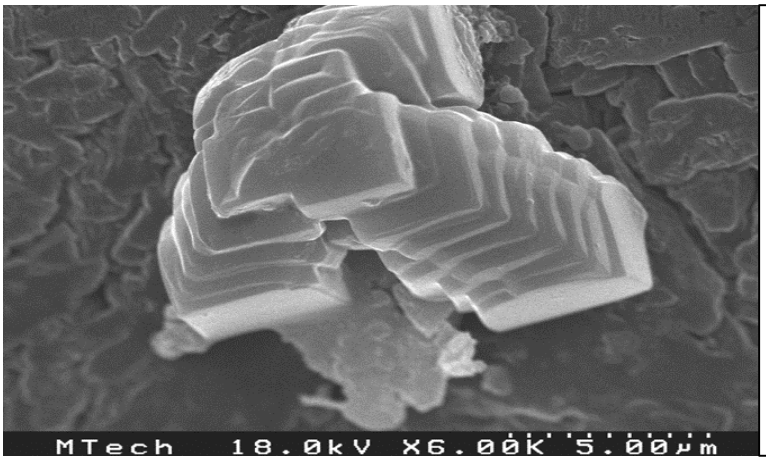


Figure 3.
Electron Micrograph of residual a precursor salt in a poly(propylene) matrix. Melt electrospinning conditions must be optimized to reduce the overall amount of precursor salts in fabricated fibers.