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Disentangled solid state and metastable polymer melt; a solvent free route to high-modulus high-strength tapes and films of UHMWPE[1]

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Ultra High Molecular Weight Polyethylene (UHMWPE) having average molar mass greater than a million g/mol is an engineering polymer. Due to its light-weight, high abrasion resistance and biocompatibility it is used for demanding applications such as body armour, prostheses etc. At present, because of its high melt viscosity to achieve the uniaxial/biaxial properties in the form of fibers/films the polymer is processed via solution route where nearly 95wt% of the solvent is used to process 5wt% of the polymer. In past several attempts have been made to process the polymer without using any solvent. However, compared to the solvent processing route the achieved mechanical properties were rather poor. Here we show that by controlled synthesis it is feasible to obtain UHMWPE that could be processed free of solvent to make uniaxial tapes and biaxial films, having unprecedented mechanical properties, exceeding that of the solution spun fibers. We address some of the fundamental aspects of chemistry, physics, rheology and processing for the development of desired morphological features to achieve the ultimate mechanical properties in tapes and films. The paper will also address the metastable melt state obtained on melting of the disentangled crystals and its implication on rheology in linear and nonlinear viscoelastic region. Solid state NMR studies will be applied to establish disentangled state in solid state to the polymerisation conditions. References: Macromolecules 2011, 44(14), 5558-5568; Nature Materials 2005, 4, 635-641; Phys Rev Lett 2006, 96(21), 218303-218205.

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