Enhancing the Recyclability of Poly(ethylene terephthalate) (PET) for High-Value Applications: Novel Processing by Solid-State Shear Pulverization

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One of the grand challenges associated with the field of "green polymers" is to enhance the effective recyclability for high-value applications of synthetic polymers made from non-renewable resources. Here we apply a novel, industrially scalable process method called solid-state shear pulverization (SSSP) to poly(ethylene terephthalate) (PET) to overcome a stumbling block in such high-value recycling of PET. The SSSP apparatus is a modified twin-screw melt extruder in which the barrel is cooled rather than heated. Process variables are identical to those of twin-screw extrusion (feed rate, temperature, screw design, and screw speed), and the powder or particulate output can be directly melt processed into final products using conventional melt process methods. When SSSP is applied to PET, the product exhibits both a tunable increase in melt viscosity (demonstrated factor of 1.2 to 2.0) and a major enhancement in crystallizability. This increase in melt viscosity originates from mechanochemistry during SSSP leading to lightly branched PET and addresses a long-standing problem regarding the high-value recycling of PET, i.e., melt processing PET at ~550 K into high-value products results in a molecular weight reduction caused by hydrolysis reactions, thus making the viscosity too low for effective use of recycled PET in high-value applications. Additionally, the enhanced crystallizability of the the PET subjected to SSSP indicates that any need for cold crystallization of the blow-molded PET product can be reduced or potentially eliminated, providing some savings in process time and energy.