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Coextrusion of multilayer piezoelectric tape

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Materials with piezoelectric properties are defined as materials that produce an electrical potential when subjected to mechanical stress (sensor function) or, in the opposite sense, produce mechanical work when subjected to an electrical field (actuator function).
Poly(vinylidene fluoride), PVDF, is a polymer with a high piezoelectric coefficient, and thus is often used in the above mentioned applications. The PVDF α phase is the most stable, and is readily obtained when cooling the polymer from the melt at moderate cooling rates. However, it can be converted to the β phase, the polymorph with the highest piezoelectric activity, when the material is stretched above a certain stretch ratio at a specific range of temperatures. After the material's crystallite dipolar moments are reoriented (poled) by application of a strong electric field, the polymer exhibits the highest piezoelectric activity.
The main objective of this study was the development of the processing tools required to produce multilayer piezoelectric tape. The tape is composed of a middle layer of PVDF and two layers of a commercial electrically conductive polymer, which serve as electrodes. Two different compounds were compared for the electrodes: one based on composites of PP/Carbon Black composites and on PP/Carbon Nanotubes. In order to meet the proposed objectives it was necessary to develop a tape coextrusion die, which was done with the aid of numerical modeling tools, aiming to obtain a uniform flow distribution along the tape width. The adopted constructive solution for the extrusion die presents a modular concept, thus allowing a flexible arrangement for the tape production, varying the number of layers from one to three.
Processing conditions and the minimization of adhesion difficulties between the raw materials have been studied. Adhesion problems were observed between the PVDF and the conductive layers for both PP-based materials used as electrodes.
Studies on the optimization of the coextruded tape processing conditions were performed, covering the most relevant process parameters, particularly the extrusion and drawing temperature and ratio. PP/CB layers suffered strong curling after cooling and revealed to be excessively stiff, to be used in the intended applications. On the other hand, PP/CNT allows producing coextruded tape with good quality, with the exception of the delamination (adhesion) problem.
The tests performed allowed to conclude that the best results in terms of tape quality and process stability were obtained drawing with the heater temperature below 160°C and a drawing ratio of 2.

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