Effect of layer thickness on polymer morphology and physical properties of fluoropolymer films prepared by multilayer coextrusion

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Fluoropolymers have excellent weather, heat and chemical resistance. These contribute towards a long product life, reducing industrial waste and conserving resources. The long product life and the higher material costs necessitate imparting additional functionality, such as high mechanical strength, to the film. Typically, materials with the desired properties are combined to form multilayers. However, fabricating multilayers by combing fluoropolymers with nonfluorinated resins is not preferable as this results in the loss of some of the unique advantages of fluoropolymers, such as weather resistance. Therefore, it is preferable to combine different fluoropolymers. Due to their high fluorine content, these polymers are typically soft and improving the mechanical properties of the resins remains a challenge. Instead of focusing on the improving the resins, we have approached this problem by fabricating multilayers. By progressively reducing the layer thickness and by appropriate post-processing of the fabricated multilayers, we anticipate that the crystal structure and the polymer morphology can be affected to yield improvements in the desired properties.

In this work, we have combined ethylene tetrafluoroethylene (ETFE), which possesses an adequate balance of physical properties, and fluoroinated ethylene propylene (FEP), which can act as an excellent water barrier. By keeping the total film thickness a constant and using a layer multipicator (see Fig. 1) to coextrude films with 3, 9, 33, 129 and 513 layers, we fabricated multilayers with different layer thicknesses. Planar elongation was used to further reduce the layer thickness. For these multilayers, we investigated the relationship between the mechanical properties and the polymer morphology. Using the results of the tensile testing of the multilayers, the dependence of the energy to break on the number of layers is plotted in Fig. 2. While the unstretched films exhibited little change upon increasing the number of layers, the multilayers subject to planar elongation indicated a clear increase in the energy to break. Small angle X-ray scattering (SAXS) results, shown in Fig. 3, suggest that this increase is accompanied by a change in the nanoscale structure. We are currently further exploring the relationship between the mechanical properties and the structure at different size scales.

![Fig.1 Schematic of the multiplying die.](Image)

![Fig.2 Variation of the energy to break with the number of layers in the film.](Image)

![Fig.3 2D SAXS patterns of ETFE, FEP and ETFE/FEP multilayers 1) as cast 2) subject to planar elongation (MD × TD=3 × 1).](Image)