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Effect of Starch and Plasticizer Types and Fiber Content on Properties of Polylactic Acid/Thermoplastic Starch Blend

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Abstract : Polylactic acid (PLA) is the most commercially available bio-based and biodegradable plastic at present. PLA has been used in plastic related industries including single-used containers, disposable and environmentally friendly packaging owing to its renewability, compostability, biodegradability, and safety. Although PLA demonstrates reasonably good optical, physical, mechanical, and barrier properties comparable to the existing petroleum-based plastics, its brittleness and mold shrinkage as well as its price are the points to be concerned for the production of rigid and semi-rigid packaging. Blending PLA with other bio-based polymers including thermoplastic starch (TPS) is an alternative not only to achieve a complete bio-based plastic, but also to reduce the brittleness, shrinkage during molding and production cost of the PLA-based products. TPS is a material produced mainly from starch which is cheap, renewable, biodegradable, compostable, and non-toxic. It is commonly prepared by a plasticization of starch under applying heat and shear force. Although glycerol has been reported as one of the most plasticizers used for preparing TPS, its migration caused the surface stickiness of the TPS products. In some cases, mixed plasticizers or natural fibers have been applied to impede the retrogradation of starch or reduce the migration of glycerol. The introduction of fibers into TPS-based materials could reinforce the polymer matrix as well. Therefore, the objective of the present research is to study the effect of starch type (i.e. native starch and phosphate starch), plasticizer type (i.e. glycerol and xylitol with a weight ratio of glycerol to xylitol of 100:0, 75:25, 50:50, 25:75, and 0:100), and fiber content (i.e. in the range of 1-25 % wt) on properties of PLA/TPS blend and composite. PLA/TPS blends and composites were prepared using a twin-screw extruder and then converted into dumbbell-shaped specimens using an injection molding machine. The PLA/TPS blends prepared by using phosphate starch showed higher tensile strength and stiffness than the blends prepared by using the native one. In contrast, the blends from native starch exhibited higher extensibility and heat distortion temperature (HDT) than those from the modified starch. Increasing xylitol content resulted in enhanced tensile strength, stiffness, and water resistance, but decreased extensibility and HDT of the PLA/TPS blend. Tensile properties and hydrophobicity of the blend could be improved by incorporating silane treated-jute fibers.

Keywords : polylactic acid, thermoplastic starch, Jute fiber, composite, blend
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