WOOD-FILLED LLDPE COMPOSITES WITH IMPROVED BIOCIDE PROPERTIES

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Introduction

The effects of the silica containing immobilized nanocopper (SiO_2-Cu) as well as maleated linear low-density polyethylene (MLLDPE) on the phase behavior, microstructure and mechanical properties of wood-filled linear low-density polyethylene composites (LLDPE/W) were studied using scanning electron microscopy (SEM), differential scanning calorimetry (DSC), thermogravimetry (TGA) and dynamic-mechanical analysis (DMTA). Furthermore, the ability of SiO_2-Cu to give bactericidal properties was also investigated for the first time in such nanocomposites.

Experimental

Materials

The linear low-density polyethylene (LLDPE) was supplied by Dow Chemicals (Dowlex4056G). The soft wood fiber (Lignocel C 120) with particle size 70-150 μm was provided by J. Rettenmaier GmbH. Maleated linear low-density polyethylene containing 0.68 wt.% of grafted maleic anhydride was prepared by melt blending according to the procedure published elsewhere [1] and used as a compatibilizer at the concentration of 5 wt.%. Spherical silica containing immobilized nanocopper synthesized according to the developed sol-gel process [2, 3] was used as a nanofiller.

Preparation and methods

Prior to preparation of samples, wood fiber was dried at 65 ± 2 °C for 24 h. Then, LLDPE, wood fiber, MLLDPE and SiO_2-Cu were melt mixed using a Berstorff ZE-25x33D twin screw co-rotating extruder (D = 25 mm, L/D = 33) according to the process published elsewhere [4]. Samples for structural and mechanical tests were prepared by injection molding using Arburg 420M injection machine, type Allrounder 100-250.

Escherichia coli strain ATCC 8739, *Staphylococcus aureus* strain ATCC 6538 and *Salmonella typhimurium* strain ATCC 14028 were used as test

organisms to check bactericidal properties. The exact initial concentration of bacteria was determined using microscopy method. Vitality of bacteria onto polymers was determined using ATP method. The HY-LiTE® (Merck) system based on bioluminescent method was applied to measure the ATP content on polymer surface.

RESULTS AND DISCUSSION

SEM observations showed that the addition of silica in the presence of MLLDPE improves adhesion between the LLDPE and wood fiber. DMTA measurements confirmed these observations, showing an enhancement of the storage modulus in the presence of MLLDPE and SiO_2-Cu. Moreover, higher silica content resulted in higher storage modulus, proving that the material became stiffer. Through DSC runs it was found that the MLLDPE and SiO_2-Cu increased crystallization temperature of wood-filled LLDPE. The thermal stability of the composites containing SiO_2-Cu was better in comparison with pure and wood-filled LLDPE. The gradual enhancement in tensile and flexural strengths of the wood-filled composites containing MLLDPE was observed. The addition of silica nanoparticles to the wood-filled LLDPE composites increased tensile and flexural moduli, pointing to a synergistic effect arising from the presence of the reinforced LLDPE phase, containing high amounts of the finely dispersed wood fiber. Wood-filled LLDPE composites modified with SiO_2-Cu were found to be active against *Escherichia coli*, *Staphylococcus aureus* and *Salmonella typhimurium* whereas unmodified composite did not show this efficacy. Thus wood-filled LLDPE composites containing SiO_2-Cu are effective bactericidal materials.

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References

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