Effect of shear rate on orientation of cellulosic nanofibers and nanocrystals in poly(butylene adipate-co-terephthalate) based composites

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Résumé

Raising awareness of the environmental problems induced by the extensive use of plastics has led to further investigations on biodegradable polymers due to their ability to undergo natural decomposition process (1)(2) . However, these materials do not achieve the same mechanical properties as conventional ones, which makes their possible applications very limited. Therefore, current studies focus on adding fillers to biodegradable polymers to develop composites with much better properties. Poly(butylene adipate-co-terephthalate) with or without thermoplastic starch was used as matrix in composites reinforced with 5 and 10%-wt of either microfibrillated cellulose (MFC) or cellulose nano-crystals (CNCs). In this study, the effect of a controlled shear rate on the orientation of the filler was investigated. To this end, composites prepared by melt mixing and then compressed were taken as a reference state of low orientation. On the contrary, to orient the fillers, extrusion through a slit die with a determined shear rate was carried out. Results of tensile tests, microscopic observations, atomic force microscopy and dynamic mechanical analysis in the melt showed that orientation of fillers in the flow axis was possible for shear rates higher than 13 s-1. The orientated samples presented enhanced mechanical properties in the elastic domain as opposed to unoriented samples. In general, orientation of fillers leads to uniaxial stiffness at lower filler content with much better ductility. However, this was observed only on samples for which the percolation of the filler was not obtained in the unoriented state. In the latter case, orientation proved to be detrimental to the elastic mechanical properties, indicating a rupture in the formed network.

Key words: polymer, bio-composite, cellulose, orientation, dispersion

References

(1) Y. Ikada et H. Tsuji, " Biodegradable polyesters for medical and ecological applications ", *Macromol. Rapid Commun.*, vol. 21, no 3, p. 117-132, 2000, doi: https://doi.org/10.1002/(SICI)1521-3927(20000201)21:3< 117::AID-MARC117> 3.0.CO;2-X.

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(2) W. Amass, A. Amass, et B. Tighe, " A review of biodegradable polymers: uses, current developments in the synthesis and characterization of biodegradable polyesters, blends of biodegradable polymers and recent advances in biodegradation studies ", *Polym. Int.*, vol. 47, no 2, p. 89-144, 1998, doi: https://doi.org/10.1002/(SICI)1097-0126(1998100)47:2< 89::AID-PI86> 3.0.CO;2-F.