Abstract

Influence of filler size and melt processing routes on the mechanical/thermal properties of cellulose reinforced EVOH and NYLON composites

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Cellulose is the most abundant bio-polymer on earth and can be extracted from different sources (e.g. wood pulp, cotton, etc.) [1, 2]. Using mechanical and chemical processes, cellulose can be disintegrated into micro- and nano-size particles. Two types of cellulose are microcrystalline cellulose (MCC) and cellulose nanocrystals (CNCs). While the fabrication of MCC is less costly, the advantages of CNCs include large surface areas due to their nano size [2, 3, 4]. As reported in [5], solution and in-situ polymerization can be used to produce cellulose composites with improved properties. In order to enable an energy and cost efficient processing of cellose composites in industry scalabe melt processing methods (e.g. compounding, compression moulding and injection moulding) are investigated in this study. Polyamide 6 (NYLON (6)) and ethylene vinyl alcohol (EVOH) are polymers commercially used in industry. Like cellulose, these materials have a high amount of reactive chemical groups, i.e. hydroxyl (OH-) and amine (NH-) groups. This allows the formation of hydrogen bonds between the molecule chains which, in turn, impact the mechanical and thermal properties [6, 7].

EVOH and NYLON were combined with MCC and CNCs, respectively, to produce composites. EVOH and NYLON were ground using a freezer mill to reduce the particle size to micrometer size. This was done in order to investigate whether an improved interaction between the matrix and the filler material could be achieved. The powder form materials were dry mixed and subsequently compounded using a co-rotating twin screw extruder. The melt blending was performed according to a Design of Experiments (DoE). The one-half fraction of a 2^3 design was investigated in order to study the influence of different processing parameters (filler weight content, screw speed, screw design) on the structure-property relationship, as depicted in Figure 1.

The resulting composites were further processed either in a platen press via compression moulding or via injection moulding and specimens were manufactured. Testing of the specimens included the determination of tensile, flexural and impact properties.

In order to investigate the thermal properties differential scanning calorimetry (DSC) and dynamic mechanical thermal analysis (DMTA) were used. The results obtained from compression moulded and injection moulded specimens were compared.

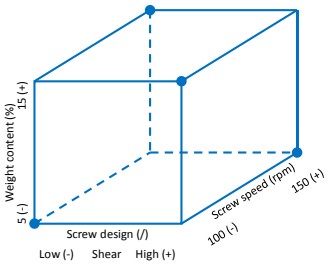

Figure 1: Different parameter settings of a 2^3 Design of Experiments depicted as corners of a cube.

The particle size distribution measurement revealed that similar particle sizes of EVOH and NYLON to MCC could be achieved, see Figure 2. The dispersion morphology was further investigated using scanning electron microscopy (SEM).

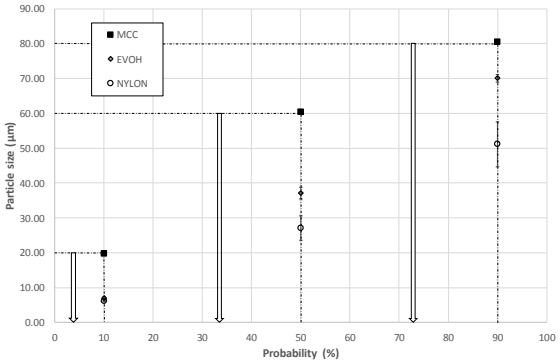

Figure 2: Particle size distribution (cumulative) of MCC, EVOH and NYLON at 10 %, 50 % and 90 %.

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