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論　文　内　容　要　旨

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学位論文題目	DEVELOPMENT AND CHARACTERIZATION OF HIGH STRENGTH CELLULOSIC NANOFIBER AND POLYVINYL ALCOHOL (PVA) COMPOSITE MATERIALS (高強度セルロースナノ繊維/ポリビニールアルコール複合材料の開発およびパフォーマンスの評価)		

内容要旨

In this study, the mechanical properties of MFC, BC and their composites with PVA were studied to understand the effect of heat treatment on the mechanical properties of PVA and the composites fabricated with these two different types of cellulose nanofiber, which are MFC and BC with PVA polymer as matrix. Different weight ratios of MFC were incorporated to study the effect on the properties of the composites. The MFC content which yields the highest mechanical properties was determined and the effect of heat treatment on the mechanical properties of the MFC/PVA composites was evaluated. Two types of PVA with different degrees of hydrolysis were used to study the mechanical properties of the composites. The morphology of the composite was analyzed by scanning electron microscopy (SEM) to observe the MFC dispersion in PVA at different MFC weight ratios. Thermal analysis was done by thermogravimetric analysis (TGA); meanwhile other characterizations such as X-ray diffraction (XRD) analysis and FT-IR analysis were conducted to study the crystallinity and molecular structure changes of the specimens due to the heat treatment.

Chapter 1 describes the introduction on the topic of green composites and the main materials which comprise this type of composites. The development and various studies which have been conducted previously by various researchers were also listed out in order to grasp the latest technology and findings regarding this topic.

Chapter 2 explains about preliminary works which were done to investigate the mechanical properties of MFC-reinforced PVA composites. The neat PVA films, MFC sheets, and their nanocomposites containing MFC weight ratios of 10, 15, 30, 40, 50 and 80 wt% were fabricated. Heat treatment by hot pressing at 180°C was conducted on the samples to study its effect to the mechanical properties and the results were compared with the non heat-treated samples. Morphology of the composites was studied by scanning electron microscopy (SEM), the thermal degradation properties of PVA films and MFC was studied by thermogravimetric analysis (TGA) and the mechanical properties were evaluated by means of tensile tests. Results from this preliminary work will be referred for further experimentation work in this study.

Chapter 3 is the study based on the preliminary data and results, where we further investigate the properties of MFC/PVA composites using MFC at 40 to 80 wt% content, and two different heat treatment methods were studied, which consisted of the hot press method and the oven heat method. The results were compared and characterization was conducted by X-ray diffraction analysis and FT-IR analysis to understand the effect of different heat treatment methods on the mechanical and physical properties of the composite materials. Morphology of the samples surfaces and fracture surfaces were examined by SEM observations.

Chapter 4 presents further investigation which was made on composites using different heat treatment processes of bacterial cellulose (BC) to yield the highest mechanical properties and the samples were characterized to understand the effect of the different manufacturing methods on the molecular structure, the thermal behavior and the chemical composition of the composites. The mechanical properties and the characterization results were studied and discussed in detail.

From this study, we could conclude that:

1. The mechanical properties, mainly tensile strength and Young's modulus of two types of PVA have different results due to the dependency on the degree of hydrolysis. It was observed that PVA with higher degree of hydrolysis yields higher strength due to the stronger hydrogen bonds and higher resistance to water.

2. The mechanical properties of both MFC and BC nanofibers and their PVA composite show higher results by the hot pressing methods, where it has significantly increased the Young's modulus and gave a higher tensile strength on almost all specimens. This is based on the fact that the heat treatment eliminates water molecules in between the PVA molecular planes and so decreasing the distance between them, creating stronger intracrystalline bonds.

3. The MFC fiber content in MFC/PVA composites show that fiber content at 40 to 65 wt% has better reinforcing effect compared to lower contents of 10 to 30 wt% and higher contents of above 80 wt%.

This is due to the reinforcing effect of the hydrogen bonds in the MFC fibers that increases the mechanical properties of the composites. A suitable amount of reinforcing material will enable good interaction between both materials, however too low or too much reinforcement materials will result in lower interaction due to insufficient reinforcing capability or on the other extreme, insufficient room for proper bonding. We managed to prove that higher MFC content of 40 wt% with heat treatment yields high mechanical properties not reported elsewhere, to the best of our knowledge.

4. The morphology and the microstructure of MFC and BC sheets and their composites show uniformly dispersed fibers across the specimen since ample mixing time was considered during the mixing process, and the PVA managed to be properly absorbed into the sheets as we conducted the sheet soaking in vacuum condition with ample time for resin impregnation.