ABSTRACTS (MASTER THESIS)

Reinforcement effect of surface chemically modified cellulose nanofibers in natural rubber

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Introduction

As a new material featuring light weight, high strength, and low thermal expansion, cellulose nanofibers (CNF, width: 15 nm – 20 nm) are expected to use as nano-fillers for resins, elastomers, and so on. However, CNF has a poor affinity for hydrophobic polymers since CNF has a lot of hydroxyl groups. To attain high reinforcement effects of CNF as a filler, chemical treatments of CNF are inevitable. In this study, we investigated mechanical reinforcement of natural rubber (NR) by chemically modified CNF.

Experiments

CNF was prepared from bleached softwood pulp by using a grinder. Then, chemically modified CNF was obtained by the reaction with pyridine and acid chloride. Saturated fatty acid and unsaturated fatty acid were incorporated into CNF surface. Control CNF was mixed with natural rubber latex in water, whilst chemically modified CNF was mixed with natural rubber solution in toluene. After drying, sulfur cross-linking reaction (vulcanization) was performed. Then, tensile tests, scanning electron microscope observation of fractured surface, thermal analysis and so on were performed.

Results and discussion

In this report, we mainly explained the reinforcement effects about stearoyl CNF (stCNF), which has saturated side chain groups, and oleoyl CNF (oleCNF), which has unsaturated side chain groups, with equal carbon number (C18). Incorporation of stearoyl CNF 5 wt% increased Young's modulus of natural rubber from 1.7 MPa to 18.6 MPa, and reduced thermal expansion of natural rubber from 226.1 ppm/K to 36.3 ppm/K. These results are attributable to the improvement of dispersibility and affinity of CNF in natural rubber by chemical modification. Moreover, oleoyl CNF 5 wt% increased Young's modulus of natural rubber to 27.7 MPa, and reduced thermal expansion to 18.6 ppm/K. These significant reinforcement effects can be explained not only by the improvement of dispersibility and affinity of CNF but also the formation of the sulfur cross-linkage between natural rubber and CNFs.

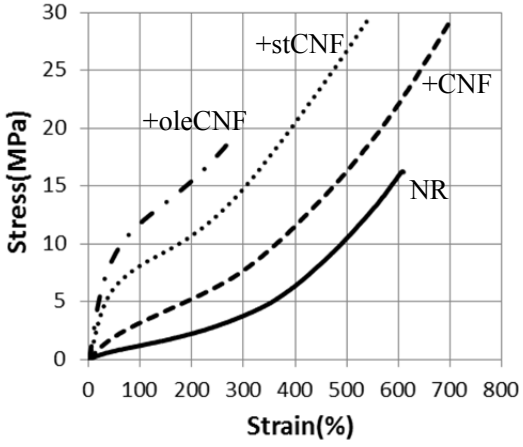

Fig.1 Stress-Strain Curves of natural rubber and CNF nanocomposites (CNF content: 5 wt%)

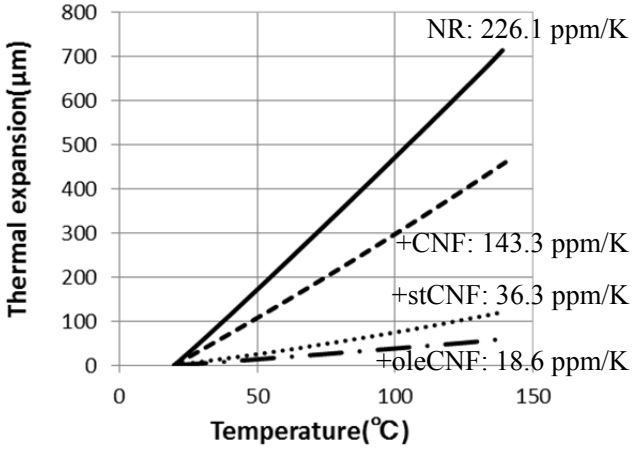

Fig.2 Thermal expansion of natural rubber and CNF nanocomposites (CNF content: 5 wt%)