Microfibrillated Cellulose Suspension and Its Electrorheology

Kisuk Choi 1, Jae Do Nam 1, Seung Hyuk Kwon 2, Hyoung Jin Choi 2*, Md Sakinul Islam 3 and Nhol Kao 3

1 Department of Polymer Science and Engineering, Sungkyunkwan University, Suwon 16419, Korea; kisuk929@skku.edu (K.C.); jdam@skku.edu (J.D.N.)
2 Department of Polymer Science and Engineering, Inha University, Incheon 22212, Korea; focalis@naver.com
3 School of Engineering, Chemical and Environmental Engineering, RMIT University, Melbourne, Victoria 3000, Australia; s3390737@student.rmit.edu.au (M.S.I.); nhok.kao@rmit.edu.au (N.K.)
* Correspondence: hjchoi@inha.ac.kr

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Abstract: Microfibrillated cellulose (MFC) particles were synthesized by a low-pressure alkaline delignification process, and their shape and chemical structure were investigated by SEM and Fourier transformation infrared spectroscopy, respectively. As a novel electrorheological (ER) material, the MFC particulate sample was suspended in insulating oil to fabricate an ER fluid. Its rheological properties—steady shear stress, shear viscosity, yield stress, and dynamic moduli—under electric field strength were characterized by a rotational rheometer. The MFC-based ER fluid demonstrated typical ER characteristics, in which the shear stresses followed the Cho–Choi–Jhon model well under electric field strength. In addition, the solid-like behavior of the ER fluid was investigated with the Schwarzl equation. The elevated value of both dynamic and elastic yield stresses at applied electric field strengths was well described using a power law model ($\sim E^{1.5}$). The reversible and quick response of the ER fluid was also illustrated through the on–off test.

Keywords: microfibrillated cellulose; rice husk; electrorheological fluids; suspension

1. Introduction

Smart bio-based fibers and polymers, originated from biomass feedstock and renewable agriculture, have attracted a huge amount of attention recently due to their abundant source and ascending concern of the environmental issue of petroleum-based polymers [1]. Among these, cellulose is one of the most ample polymers, with its annual production being about $1.5 \times 10^{12}$ tons [2]. Many studies have proven that natural fibers or cellulosic fibers could become an alternative mineral/inorganic reinforcing fiber in composites [3–6]. Whilst natural fibers consist of many benefits—such as low density, biodegradability, abundance, and renewability—pristine lignocellulosic fillers are constrained in industrial usage because of their insufficient mechanical properties, even though they possess good specific mechanical properties at low density [3].

In general, among various cellulosic fibers, the microfibrillated cellulose (MFC) is the one fabricated by the delamination of cellulose fibers using a high-pressure homogenizer [7,8]. The mechanical shear force induced by a high-pressure homogenizer propagates to fibrillation of the cellulosic fibers, resulting in microfibrils with the diameter of 10–100 nm and a web-like form. The fabrication of MFC does not require acid hydrolysis, which would be the next step required for converting microfibrils to cellulose nanowhiskers or cellulose nanofibrils. This process is not only time consuming and expensive, due to the filtration, but it also requires a dialysis process to remove the remaining acid. Other processes include the use of a grinder or a microfluidizer for mechanical fibrillation [9]. For instance,