Development of Functional Poly(vinyl alcohol) Materials Prepared without Organic Solvent

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Poly(vinyl alcohol) (PVA) is a synthetic polymer with hydroxyl groups. It is used in various fields due to its chemical resistance, biodegradability, and biocompatibility. It is well known that PVA exhibits excellent mechanical properties due to strong intermolecular hydrogen bonds. Another important characteristic of PVA is that it is water soluble, which is unusual for a synthetic resin. Since it is water soluble, there is no need to use organic solvents or other solvents when processing. However, there are currently many challenges to processing using only water as a solvent, and dimethyl sulfoxide (DMSO) and other solvents are often used. In addition, hydrogen bonding in PVA prevents a high degree of molecular orientation, which inhibits the improvement of mechanical properties of PVA fibers and other materials. PVA has several problems: its melting and decomposition points are close to each other, it has almost no thermoplasticity, and it cannot be molded and processed by heat. Previous studies have reported that the addition of lithium salts is an effective way to reduce hydrogen bonds in PVA and slow the crystallization rate. However, few specific studies have been conducted to determine the extent to which these effects are effective in processing PVA.

The present focused on the effect of lithium salt addition on the ductility of PVA fibers and on the mechanical properties, crystal structure, and thermoplasticity of PVA prepared by hot pressing with lithium salt addition. The stretchability of PVA fiber spun by adding lithium iodide (LiI) to PVA was greatly improved and showed high mechanical properties. This is because stretching in a state where hydrogen bonds are reduced by LiI reduces orientation defects during stretching and increases the drawing ratio. The highly stretched fibers have high molecular orientation and exhibit superior mechanical strength compared to fibers without LiI addition. High-strength PVA fibers can be used as reinforcing fibers in fiber reinforced plastics (FRP) and will play an important role in the fiber industry in the future. Lithium salts reduce the crystallinity and melting point of PVA, which may provide thermoplasticity. The physical properties of PVA prepared by adding lithium salt (lithium halide) and hot pressing showed a lower melting point, lower crystallinity and lower mechanical strength compared to No salt PVA. This effect was higher in the order LiCl > LiBr > LiI. The thermoplasticity was confirmed by the decrease in crystallinity and melting point. There was little difference in the mechanical strength of PVA before and after thermoforming. In other words, lithium salt can improve the processability of PVA.

Syndiotactic PVA (sPVA) was difficult to handle because it hardly dissolves in water or organic solvents. However, sPVA-H could be adjusted by using a hot press. Compared to atactic PVA hydrogel (aPVA-H), sPVA-H exhibited higher mechanical strength and crystallinity at lower water content. This is attributed to the high stereo-regularity of sPVA and its easy crystallization.

Keywords: Poly(vinyl alcohol), Lithium salts, Hydrogen bond, Crystallization, Thermoplasticity, Tacticity