Factors Affecting on the biodegradation of cellulose fibers

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1. Introduction

When textiles are buried in soil, soil resident microorganisms take part in degradation of textile material, which is called biodegradation, and the biodegradability is often used as a standard for the environment-friendliness of textile products. It was shown in the previous studies that the biodegradabilities of cellulose fibers were closely correlated to the moisture regain of the fibers, which reflects the hydrophilicity and internal structure of the fibers. In this study, the biodegradabilities of cellulose fibers were measured by various test methods and then the degradation behaviors based on each test method were compared. Moreover, the effects of environmental conditions were determined.

2. Experimentation

The biodegradability of cellulose fibers were evaluated by employing a soil burial test, an activated sewage sludge test and an enzyme hydrolysis. In order to examine the effect of environmental conditions, moisture regain of burial test soil and amounts of inoculums remaining in activated sewage sludge test were varied.

3. Results

3.1. Biodegradability measurement by activated sludge test

Generally, rayon showed higher biodegradability because of its lower crystallinity and greater hydrophilicity than other samples. And acetate showed the lowest biodegradability regardless of its low crystallinity, and this could be explained by the fact that quite a few hydroxyl groups in acetate molecules were replaced by less-hydrophilic acetyl groups. In respect of the effect of environmental conditions (amount of inoculums), more sludge inoculums led to higher biodegradability except in the case of cotton. That is, the biodegradability of regenerated fibers increased with the amount of microbes. And the amount of microbes had a different influence on the biodegradability of cotton.

3.2. Biodegradability measured by soil burial test

Figure 1-(A) shows the biodegradability of cellulose fibers in the soil of moisture regain less than 20% and (B) shows the results in the soils of moisture regain greater than 50%. Comparing (A) with (B), there was little effect of variation of moisture regain of burial test soil. Of particular interest from the result of cotton is that even if the induction period where biodegradation barely occurred during the initial stage were rather long. Then a few days later, however, biodegradation started to occur. From this phenomenon, we infer that the natural fiber specimens which have high crystallinity would take some time to become prepared for biodegradation.(Fig. 1)

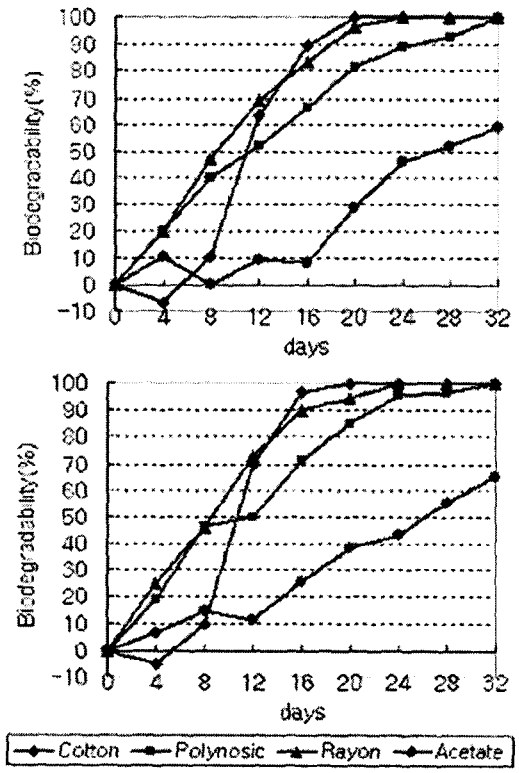

Fig. 1. Biodegradability from Soil burial test. (A): moisture regain of soil was under 20% (B) moisture regain of soil was over 50% (experimental period: Apr. 17th ~ May 19th).

3.3. Enzymatic hydrolysis

Enzymatic biodegradability that is presented as weight loss by enzymatic hydrolysis was the greatest in rayon, which was followed by cotton > polynosic rayon > acetate in decreasing order. It was previously shown that the rate of enzymatic hydrolysis was dependent on the accessibility of the enzyme to the surface of the cellulosic structure. In this result, Rayon has relatively more non-crystalline cellulose than other specimens, and that would be the reason of the highest degradability. Acetate however, in spite of the lowest crystallinity, showed the lowest enzymatic hydrolysis rate.