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Dynamical Property and Molding Processability of the Dehydrated Heat-Treated Egg White Gel

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Elastic stiffness of dehydrated heat-treated egg white gel (DHTEWG) was measured in a temperature range from 303 to 443K. In the measurement, it is found that DHTEWG shows an elastic anomaly around 323K (T_g), which resembles that in the glass transition of non-crystalline polymers. It is also found that, above T_g, DHTEWG (fragile in room temperature) becomes elastic remarkably and easy to deform. These results indicate the possibility of a new biodegradable product made from bio-related material, which are interesting not only from the standpoint of a investigation of fundamental properties but also from that of probing new materials.

Key words: elastic stiffness, egg-white gel, dehydrated gel, glass transition, processability, amorphous

1. INTRODUCTION

Gel shows peculiar properties, such as the volume phase transition,[1] by change in the interaction of the two components; polymer network and solvent. Therefore, it is very interesting how the gel behaves when the solvent disappears. Takushi *et al.* found that dehydrated heat-treated egg white gel (dehydrated boiled egg white; abbreviated as DHTEWG hereafter) becomes transparent and fragile.[2] Besides, the broad halo ring in the X-ray diffraction photograph,[3] an endothermic peak in the temperature-increasing DTA measurements[4] and a Boson peak in low frequency region of Raman spectrum[5] have been observed. In spite that the fusion and quick-quench process which is usually performed to obtain glasses is not applied to make DHTEWG, it has characteristics of a glass as mention above. Although the egg white gel was obtained by increasing temperature, the heat process in making gel is not essential because the egg white gel can be also made by other processes such as high pressure.[6] In these circumstances, the next question is follows, that is, whether DHTEWG shows the glass transition or not. Though we have some indications of the glass transition as mentioned above, detailed studies are yet to be made. Therefore, in the present study, we carried out the measurement of elastic stiffness of DHTEWG with elevating temperature, which is one of the most popular examinations of the glass transition of organic polymers.[7] We also demonstrated molding processability by heating and bending the sheet of DHTEWG. The results of the present study contribute not only to fundamental gel science but also to the probing of new materials, because DHTEWG shows possibility of a new biodegradable material.

2. EXPERIMENT AND RESULTS

The heat-treated egg white gel was prepared by boiling egg white for 15min at 371K. Then, we obtained DHTEWG by dehydrating the gel in a refrigerator (temperature;278K, humidity; 60%). The sample for measuring the elastic stiffness was prepared by cutting DHTEWG into a sheet (length=30.0~40.0mm, width=7.0mm, thickness=1.5mm). In order to measure the dynamic elastic stiffness, we utilized a commercial apparatus (Seiko Denshi Model DMS110) in the three-point bending mode at a constant frequency (1 Hz). The measurements were performed with increasing temperature (8K /min, temperature range from 303 to 443K). In order to prevent crack by loss of internal moisture, the specimen was covered with very thin silicone grease layer (we confirmed that the grease did not affect the measurement at all). The specimen being free from crack was verified before and after the measurement.

Figure 1 shows the change in the elastic stiffness of DHTEWG with increasing temperature. In this process,

the elastic stiffness decreased remarkably around 323K (T_g), which corresponds to the temperature around which the endothermic peak is observed in the temperature-increasing DTA measurements.[4] Besides, the observed elastic feature is quite similar to that in the glass transition of non-crystalline polymers.[7] The result in the present study has clearly shown the occurrence of the glass transition in DHTEWG with increasing temperature.

3. DISCUSSIONS

DHTEWG has been expected as a new biodegradable material since the discovery of the glass-like state of the egg white.[2] However, its fragile property has hindered the development because of the difficulty of processing. DHTEWG being flexible above T_g has made clear the possibility of a mold processing above the temperature. In order to demonstrate the easy mold process, we bent a DHTEWG sheet at 363K which is above T_g. Figure 2 shows the DHTEWG sheet (length=35.0mm, width=6.5mm, thickness=1.5mm) which was easily bent in an acute angle. The result shown above indicates that the DHTEWG can be used as a biodegradable, processable, and non-petrochemical origin material, though there are some problems such as the moisture absorbing and Maillard reaction. It is desired that the other materials similar to DHTEWG having more excellent properties are probed without delay.

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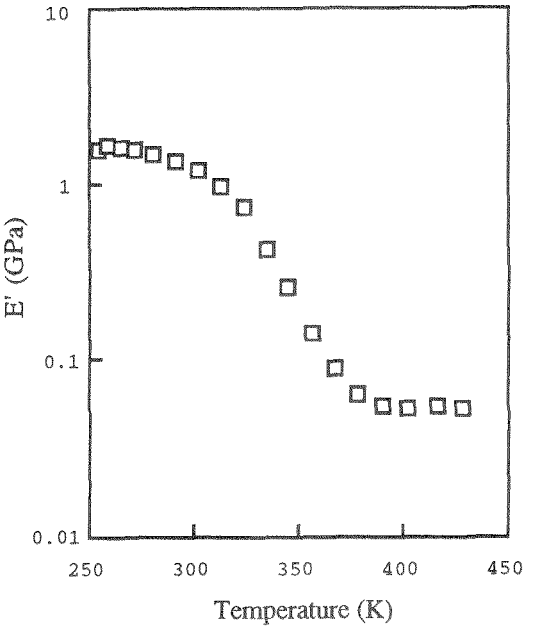

Figure 1 The change in the elastic stiffness of dehydrated heat-treated egg white gel (DHTEWG) with elevating temperature. The measuring frequency is 1Hz.

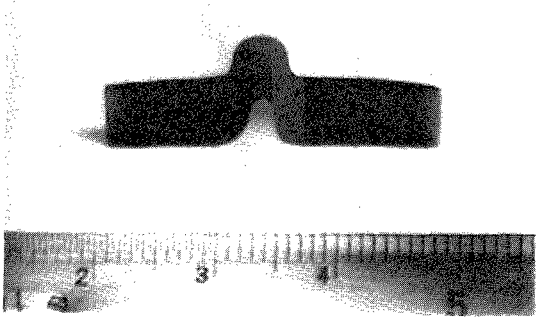

Figure 2 The photograph of a DHTEWG sheet bent at 363K which is above the glass transition temperature. The DHTEWG sheet could be easily bent in an acute angle, which demonstrates an easy mold process.

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