Biodegradability evaluation of biodegradable plastics by FTIR (2)

Introduction

Biodegradable plastics have been developed as materials that can reduce the burden on the global environment. The products that meet the criteria of biodegradability and the criteria for environmental compatibility are marked with "GreenPla" (Figure 1) and the use of the name is permitted[*1]. For the commercially available garbage bags marked with "GreenPla" mark, we reported the results of evaluating the biodegradation process in soil by FTIR at 030-AT-0251. In this report, in addition to field tests in the soil reported earlier, changes in biodegradable plastics due to outdoor exposure and heating were evaluated by FTIR.

<keywords>
Biodegradable plastics, GleenPla, FTIR, ATR

Fig. 1 GreenPla mark

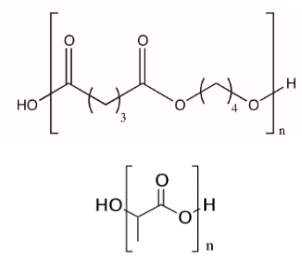

Fig. 2 Structures of polybutylene succinate (top) and polylactic acid (bottom)

Experimental

(1) Sample

Biodegradable plastic	Garbage bag labeled "Green Pla" (BS-PL copolymer: polybutylene succinate - polylactic acid copolymer)
General plastic	Polyethylene (PE) garbage bag

(2) Field test condition

Soil burial condition	Films cut out to 3 x 6 cm was buried in a place about 5 cm deep in the soil at the burial place.
Outdoor exposure condition	Films cut out to 3 x 6 cm was placed at a height of about 100 cm from the ground surface under sunlight outdoors.
Heating condition	Films cut out to 3 x 6 cm was placed in an incubator* set at 70ºC (*Incubator "breeze" and SS type controller, Isuzu Seisakusho)

(3) Measurement condition

Instruments:	FT/IR-4600	Resolution:	4 cm^{-1}
Detector:	DLATGS	Accumulation:	64 times
Measurement Method:	ATR		
Accessory:	ATR PRO ONE (Diamond prism)		

Fig.3 FT/IR-4600 + ATR PRO ONE

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Results and discussions

(1) Change of IR spectra

Figures 4-6 show the sequential IR spectra of soil burial test, outdoor exposure test and heating test results for each functional group. In PE, no remarkable change in spectrum was observed in any of the field tests.

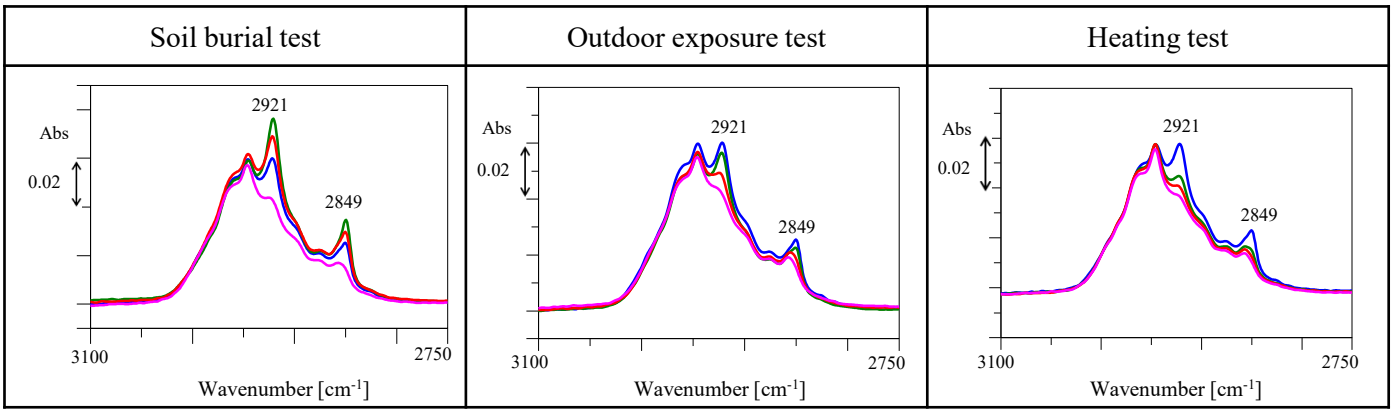

Fig. 4 Sequential change of ATR-IR spectrum of -CH stretching vibration (offset)

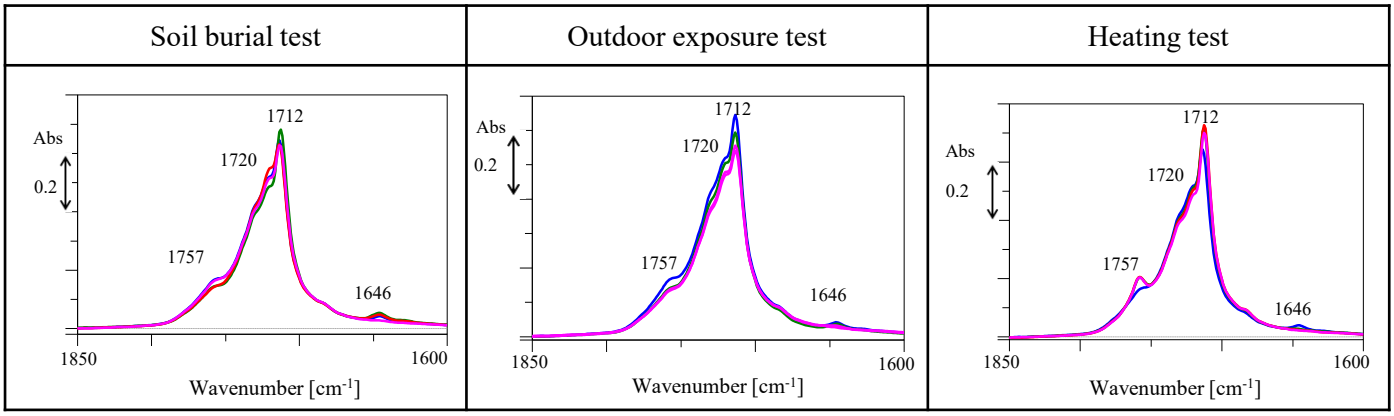

Fig. 5 Sequential change of ATR-IR spectrum of -CO stretching vibration (offset)

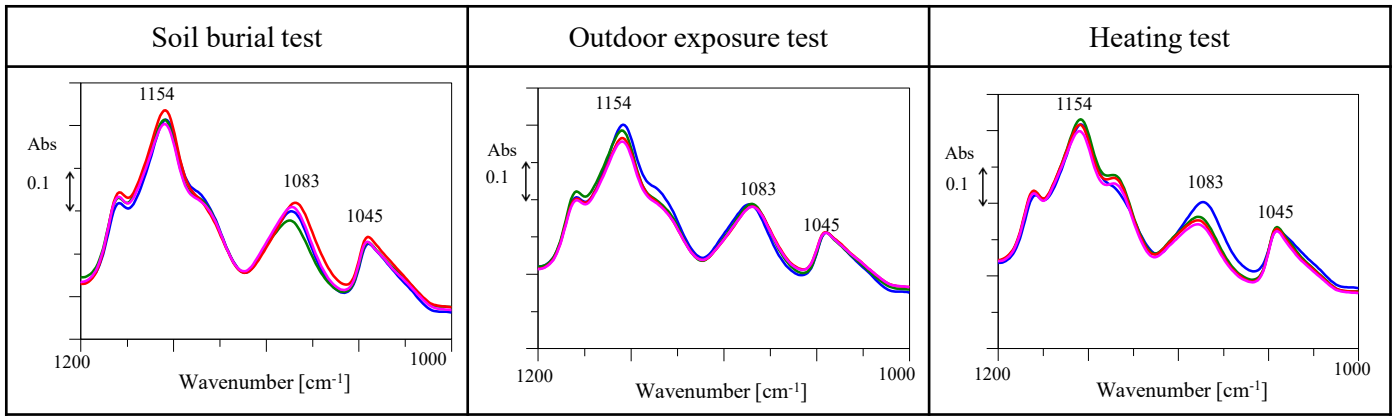

Fig. 6 Sequential change of ATR-IR spectrum of -C(=O)O- stretching vibration (offset)

0 day — 2 weeks — 4 weeks — 8 weeks

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From the results of the IR spectrum by decomposition in the soil and photodegradation by UV and decomposition by heating, it was clearly observed that the difference in the decomposition behavior, such as the change in the alkyl terminal group of the polymer chain and the appearance of a new carbonyl group due to the decrease in molecular weight[*2], were caused by the difference in the progress of cleavage of the ester group and the progress of dehydration.

Conclusion

Under the natural environment there are various deteriorating factors for plastics, each of which is thought to be acting in a complex way, it is difficult to grasp the mechanism of deterioration in detail. However, by evaluating the biodegradability of biodegradable plastics using FTIR, it was possible to evaluate the degradation behavior due to the difference in degradation factors.

References

*1 JBPA (Japan BioPlastics Association) http://www.jbpaweb.net/index.htm (As of August 2017)
*2 Michael Niaounakis, Biopolymers Reuse, Recycling, and Disposal, *Elsevier Science*, 2013.

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