Decomposing plastic by Microorganisms

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In Japan, burning plastics is the common way to dispose of the material.This means it requires vast energy and consumes much resources. Also, it accelerates global warming. If this situation continues, our life will have a severely affected future. Are there any other ways to dispose of it? We thought that microorganisms can be used for the new way to dispose of plastic. We focused on the ester bond that camelia have on their leaves, and tried to decompose plastics using microorganisms that live in the soil under a camellia tree. The result shows that camellia leaves are affected by microorganisms,we observed the cross section of the plastic and found that plastic had been decomposed. If the method to decompose plastic by microorganisms can be made more efficient, it may become a big step to a decarbonized society that doesn't rely on fossil fuels.

1 Background

At present,in Japan,the way of burning garbages account for about 80%.This rate is the highest in the world,that's how much Japan use a large energy.So,my country has advanced technology that gather heat which be used by the way.However,the way that depend on fossil fuels which will be running out will reach the limite.

From this,we think are there the new way which deal with plastic,we come up with the way use microorganisms.That's because there is the result which microorganisms exist in soils which pine is glowing decomposed polyethylene which similar structure of pine laeve surface.As a prospect, the structure of the cuticular layer covering the surface of Camellia camellia leaves (fig.1) was described as having ester bonds, which is a unique structure of polyester.

Camellia leaves, or rather the leaves of plants, are always decomposed after they fall to the ground through some kind of soil action.

This means that the cuticular layer which has ester bonds, or polyester as it is called, is decomposed.
We thought that polyester could be decomposed by microorganisms living in the soil where camellia trees grow (called camellia soil).

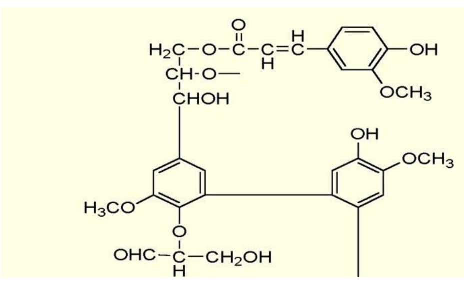


fig.1 A structure of camellia cuticle

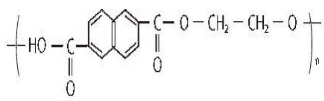
The goal of this research is to develop a low energy, don't depend on fossil fuel, microorganisms decomposed to polyester which is the most used plastic in our life.
The polyesters used in the study are polyethylene terephthalate (PET), which is used to make PET bottles, and polyethylene naphthalate (PEN), which is used to make cover films for smartphones (fig. 2).

The flow of the research is as follows. First, camellia soil was collected from Tsurugaya Central Park, small animals such as Armadillidium vulagare were removed, and half of the soil was sterilized using an autoclave (called sterilized soil).

The soil was divided into petri dishes and plastic pieces (PET, PEN) were placed on top,we observe it for 4 months,we measure the mass.(Experiment 1)

However, this mass change was so small , we wondered whether the leaves were decomposed only by microorganisms, so we observed the decomposition of leaves using camellia leaves and camellia soil with microorganisms for 2 months. (Experiment 2)

From these results, we experimented using Armadillidium vulgare to investigate how camellia leaves are decomposed in the soil(Experiment 3,)Finally, the plastic pieces used in Experiment 1 were observed with an electronic microscope. (Observe)



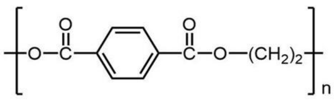


fig.2 A structure of Polyethylene Telephthalate (PET) ,Polyethylene Naphthalate (PEN)

In view of the above, and in order to clear up any doubts that may have arisen during the research, the objectives of this research are twofold. (1) To clarify whether polyester (PET, PEN) can be decomposed by microorganisms. (2) To clarify how camellia leaves are decomposed in the soil.

2 How to evaluate

At farst,we collected camellia soil from Tsurugaya Central Park ,and removed small creatures such as insects with a sieve.We sterilized half of the soil in an autoclave.

3 Result and Discussion

(1) Experiment1

We put four pieces of PET and PEN (4cm×4cm) clean with an ultrasonic cleaner into a petri dish filled with camellia soil and sterilized soil (Soil moisture content–30%). Then,we measured the mass of the piece of plastic.We each prepared one with the scratches and one without.We did not prepare a petri dish with sterilized soil and scratched plastic.Those petri dishes were placed in an incubator(30℃).We compared the mass every month with the beginning.We measured to the fourth decimal place and continued for four months.We prepared four identical petri dishes ,and measured the mass of one of them every month.

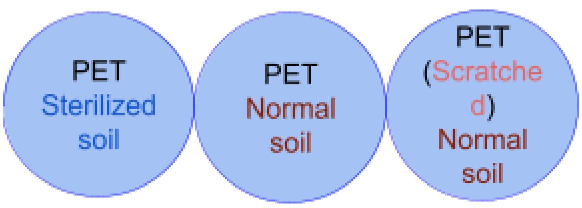


fig.3 Schematic of the petri dish used in the experiment

The result are shown below (fig.4).Some samples decreased in mass ,while others increased in mass. We did an experiment on scratched plastic for a reason. We consider that increasing surface area makes it easier for microorganisms to decompose plastic.However,there are not big differences.Mass of plastic in sterilised soil decreased.It may be some complex reason,but we consider that our low experimental accuracy caused it.Therefore,we concluded that microorganisms were not involved in the change of mass of plastic.

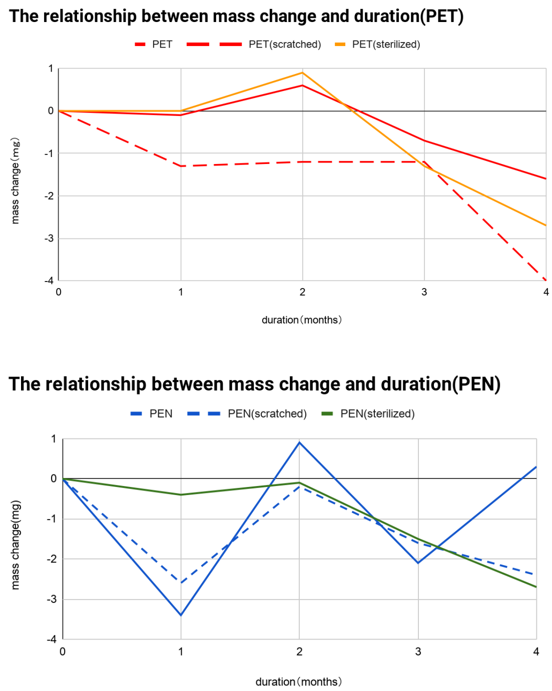


fig.4 The relationship between mass of plastic used in experiment 1 and duration.

Line showing change mass of plastic in sterilised soil made a different color than that in camellia soil.
(PET:Orange,PEN:Green)

(2) Experiment2

Considering experment1,if it had no effect on plastic,it may not be correct that camellia leaves are decomposed by microorganisms. Thus, we observed whatever microorganisms decompose the leaves.

We put two leaves of each into camellia soil and sterilised soil,and observed for two months.

The result is shown in the picture.It was merely a dead leaf.There were no other changes in appearance.In other words,camellia leaves were not decomposed at all.

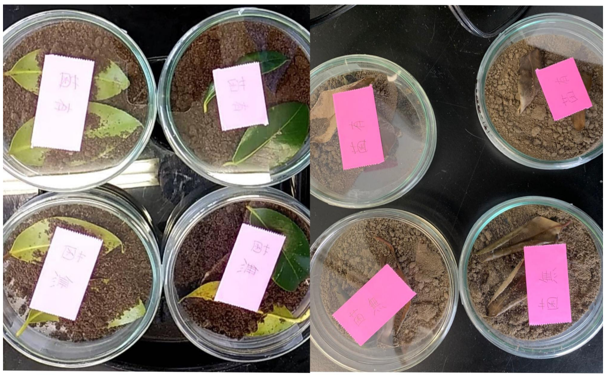


fig.5 Pictures of petri dish with camellia leaves in camellia soil and that in sterilised soil .

Each of above two : Camellia soil

Each of bellow two : Sterilised soil

Left picture : Before the experiment

Right picture : After the experiment

We found that not onry effect of microorganisms but also other factors are involved.

(3)Experiment3

Another factor in the process of decomposition considered in Experiment 2 was considered to be a small animal in the soil, and the representative pill bug was placed in the dead camellia leaves used in (2) for 2 weeks. Observation was made.

fig.6 The picture of samples used in experiment2 after Armadillidium vulagare were put in, and left for 2 week(Above two pictures: camellia soil, bellow two pictures: stelirized soil)

In camellia soil, leaves are decomposed byArmadillidium vulagare,but no leaves are decomposed in sterilized soil.

The following can be seen from the results of (2) and (3).

① Camellia leaves are decomposed under the condition that both microorganisms and pill bugs are present.(There is a good possibility that small animals other than Armadillidium vulagare will also be decomposed, but this is not described because it could not be done in this experiment.)

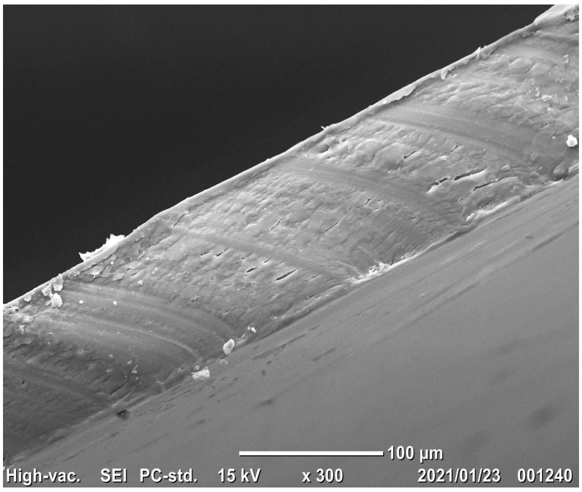
②The leaves are not decomposed only by lacking either microorganisms or Armadillidium vulagare.

③Microorganisms have some effect on camellia or Armadillidium vulagare.

According to ③,You might think that logic is jumping too far,but in experiment 3,Considering that the leaves were decomposed only in the camellia soil where the microorganisms were present under the condition that the Armadillidium vulagare was added, the microorganisms acted on the surface of the camellia leaves,or it may be thought that it assists the decomposition by small animals.If the microorganisms affect the surface of the camellia, it can be expected from experiment 2 that it is a small effect that is not visible.Therefore, we thought that this action was to decompose the cuticle layer of camellia. Then, the microorganism breaks down the ester bond of the cuticle layer.From this, it is possible that the microorganisms had some effect on the plastic. Moreover, if the effect is small, it can be explained that it did not appear in the mass change of the plastic in experiment 1.

(4) Observation

If the consideration of (3) is correct, some influence should be seen on the plastic used in experiment 1.Therefore, the cross section of the PEN (4 months later) used in experiment 1 was observed using an electron microscope.



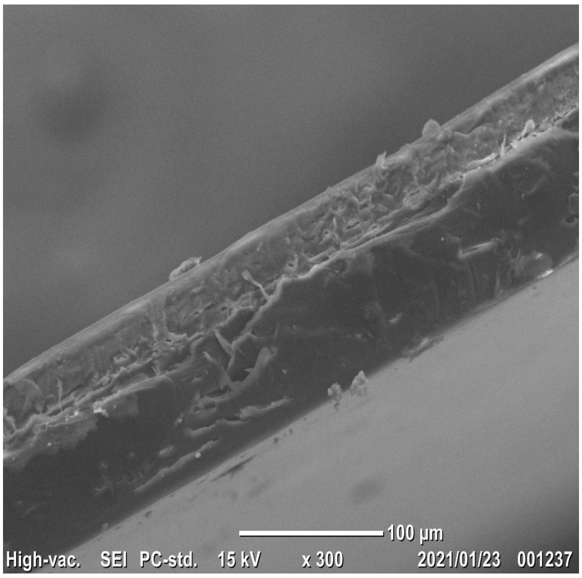


fig.7 The cross section of the PEN (Above:PEN that is not used in the experiment Below:PEN that is used in experiment 1, after 4 months)

As can be seen from the picture(fig.7), the cross section of the PEN not used in the experiment was cut by a cutting machine and is neat and clean,The cross section of the PEN after the experiment shows not artificial gouges. From this, it can be seen that the microorganisms dissolve and decompose the surface of PEN.

4 Conclusion

Our reserch revealed the following two things.

(1)PEN is decomposed by microorganisms that live in the soil under the camellia tree.

(2) Camellia leaves are decomposed only in the presence of both microorganisms and Armadillidium vulagare (Larleille), and not in the absence of either.

5 Future work

Not having enough time, we couldn't observe the cross section of PET in our research. In addition, although we revealed that plastic can be decomposed by microorganisms, this is far from a practical application if it is not visible in mass or apperrence. Also, the name of microorganisms and the enzyme, we'll take these things as a future work.

Reference

Miyagi Sendai Daisan Senior High School,「Decomposing Plastic」

Toshiaki Matsura.2009「Experiments and Observation to Examine Preference of leaves in an Isopod,Armadillidium vulagare(Larleille)」 https://www.kyokyo-u.ac.jp/cee/17-9.pdf