# NYLON RECOVERY FROM CARPET WASTES THROUGH THE PYROLYSIS UNDER THE PRESENCE OF ZnO AND THE MILLING BY A METALLIC ROLLING MACHINE

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## Abstract

*A recycling process of carpet wastes has been studied whose recycling is not extensively carried out because of their complex combination of materials. A representative type of carpet is arranged in three layers: nylon fibers, adhesives, and backing materials made of poly(vinyl chloride). We have employed the pyrolysis under the presence of zinc oxide. Nylon fibers could be effectively recovered by the consequent milling treatment from the brittle backing materials. The influence of process parameters, such as pyrolysis temperature and reaction time, on the separation efficiency is discussed.*

***Keywords:*** *Carpet, Plastic Recycling, Pyrolysis, Milling*

## 1. Introduction

Carpet tile is commonly used in office buildings. In the United States alone, approximately 1.5 million tons of carpet fibers are produced annually [1]. Of this amount, approximately 65% is composed of nylon 6 and naylon 66. The European annual production of carpet is approximately 1.5million tons [1]. As a result, an enormous amount of polymers waste is discharged, most of which is in landfills. Pyrolysis treatment is one of the attractive methods, because it enables feedstock recycling of synthetic polymers with simultaneous volume reduction of wastes. Recently, thermal decomposition of various kinds of carpets has been investigated [2]. Difficulties of the carpet waste treatment arise from the complex combination of the materials. A typical carpet is arranged in three layers. The materials of the top layer consist of nylon fibers, typically nylon 66. The second layer is base fabric and adhesive. The materials of the bottom layer are backing materials that are mainly made of resin of poly(vinyl chloride), PVC, because it is cheap, commodity polymer, showing good mechanical property, as well as flame retardancy. Thus, the pyrolysis of waste carpet results in the emission of chlorinated compounds, such as hydrogen chloride and chlorinated organic compounds, which requires the careful emission control. In our previous works, we showed that degradation temperature of PVC was lowered and chlorine was fixed as zinc chloride in pyrolysis of PVC under the presence of ZnO [3]. It is, therefore, expected that the pyrolysis of waste carpets under the presence of ZnO leads to the fixation of chlorine. The decomposed brittle carbonaceous compounds from PVC are to be removed from the nylon layer by appropriate mechanical methods. In the present study, we have carried out pyrolysis of waste carpet in the presence of ZnO, and examined the roll-milling treatment to separate the nylon from the PVC backing material.

## 2. Materials and Methods

The carpet waste, supplied from Showa Seni. Co., was used in the present study. A sample size was 10mm × 50mm × 5mm with weight of 1.0g. The powder of ZnO reagent, Kanto Chem. Co., Ltd., was used. It is difficult to degrade only PVC because the degradation temperature of nylon, 265°C, is very close to that of PVC, 280 °C. Thus, we constructed a pyrolysis equipment which consists of hot plate that enables uni-directional heating of backing materials. Pyrolysis set up is schematically shown in fig.1. The dome-shaped reactor consists of an electric heater (its heated area is 180mm in diameter), a nickel plate (120mm × 120mm × 2.0mm), and a copper cover. The nickel plate on which zinc oxide powder was put, was heated from the bottom side. Pyrolysis was conducted under helium atmosphere. A sample carpet waste was dropped onto the powder layer of ZnO.

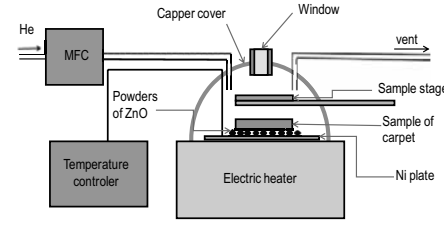


Fig.1 Pyrolysis reactor

After the reaction, the sample was taken out of the reactor and milled by a metalic rolling machine. After that, the sample containing nylon fibers and powder of backing material was separated by a screen with the mesh of 1mm.

## 3. Results and Discussion

Fig. 2 shows the photograph of nylon fibers separated by a screen. Nylon fibers were well separated from backing material.

Fig. 3 shows the relationship between the degree of separation and reaction time in pyrolysis at 270°C. The degree of separation is defined as follows:

$$\frac{w_2}{w_1} \times 100\%, \quad (1)$$

Where $w_1$ is the total weight before the pyrolysis, and $w_2$ is the weight of nylon fibers after separation by a screen. It is apparent that nylon fibers are recovered most efficiently at 30min. Presumably, backing materials are not decomposed enough when reaction time is shorter than 30min. On the other hand, a part of nylon fibers is melted and adhere to backing materials when reaction time is longer than 30min.

Fig. 4 shows the relationship between the degree of separation and reaction temperature. The reaction time was 30min. It is obvious that nylon fibers are recovered most efficiently at 265°C. The melting point of nylon 66 is 265°C, so that the pyrolysis at the melting point is especially effective for the recovery of nylon 66. Near the melting point, nylon fibers are still solid, while backing materials are enough decomposed, under the presence of ZnO, at the temperature slightly lower than the "degradation" temperature of pure PVC.

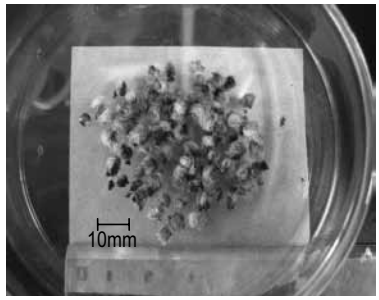


Fig2. Nylon fibers separated by a screen at pyrolysis temperature of 265°C and reaction time of 30min. Small amount of black material, probably carbonaceous backing material, remains on the nylon fibers.

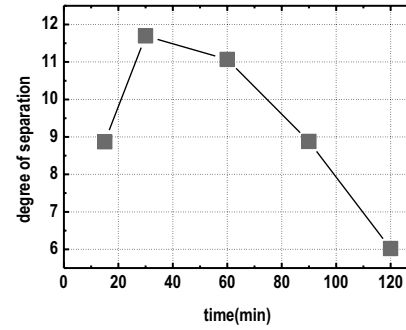


Fig 3. Relationship between the reaction time and the degree of separation at reaction temperature of 270°C.

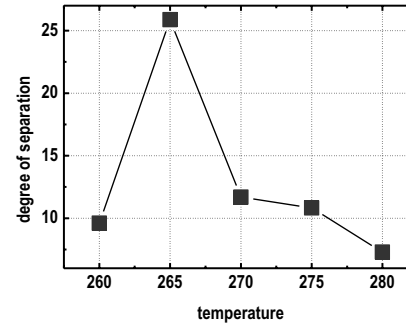


Fig 4. Relationship between the reaction temperature and the degree of separation when reaction time was 30 min.

## 4. Conclusions

Nylon fibers were efficiently recovered by the proposed method combining pyrolysis with milling. It was found that the reaction temperature and time considerably affect the degree of separation. Under the examined conditions, nylon fibers can be effectively recovered at 265°C and reaction time of 30min. Further study on the optimization of the process should be carried out.

## References

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