

# Improvement of adhesion, water-absorption and painting properties of polypropylene and ultra-high molecular weight polyethylene

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## 1. INTRODUCTION

As polyolefins such as polypropylene (PP) and polyethylene (PE) give high tensile strength and high resistance to chemical reagents, they are used in manufacture of strings, tubes, bags, and containers, etc. In addition, ultra-high molecular weight PE (UHMPE) attracts a lot of attention these days because of its very high strength and high wear resistance. However, these materials have no hydrophilic properties and cannot be bonded to other materials by using adhesives. The chemical improvement of these materials has been carried out by the following methods; polymer blending, corona discharge treatment, ozone treatment, plasma treatment, electron-beam irradiation, UV irradiation, chemical treatments with sulfuric acid, hydrofluoric acid and other chemical reagents, graft polymerization, and polymer coating, etc. But, these techniques cannot give effective and durable improvement of polyolefins. The purpose of the present research is to find effective and durable methods to improve the surface property of these materials.

## 2. EXPERIMENTAL

### Materials

Non-woven or woven fabrics, plate or films of PP, PE, UHMPE, polyester (PET) and poly(ether sulfone) (PES), etc. were used.

### Activation step

The energy techniques such as UV irradiation, plasma treatment, high-voltage electric discharge treatment, and corona discharge treatment or chemical reactions were carried out to activate polymer materials.

### Treatment with monomer and other reagents

Activated polymer materials were treated with a mixture of monomers and other reagents in the presence of initiators.

### IR spectroscopy

IR spectra of PP fabrics or films were recorded by the ATR method using a Shimadzu FTIR 8500.

## 3. RESULTS AND DISCUSSION

### Improved properties

Polymer materials are considered to be oxidized in the activation step. Figure 1 gives the IR spectra of PP non-woven fabrics untreated or treated by the activation process.

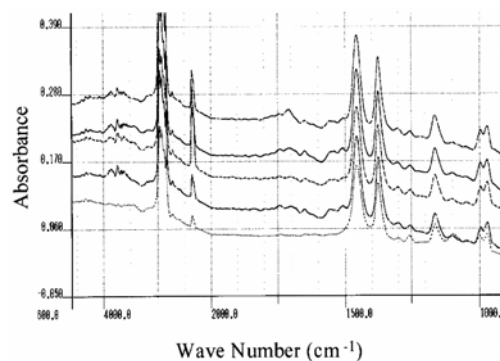


Fig.1 IR spectra of PP fabrics; from the bottom to top, untreated and treated PP (treatment time: 0, 15, 30, 45 and 60 min.)

Some of main chains of PP should be oxidized in the activation step. When PP fabrics made of fine fibers were treated, the tensile strength of the fabrics was decreased with treatment time. Figure 2 gives the relation between the tensile strength of PP non-woven fabrics and treatment time of the activation step.

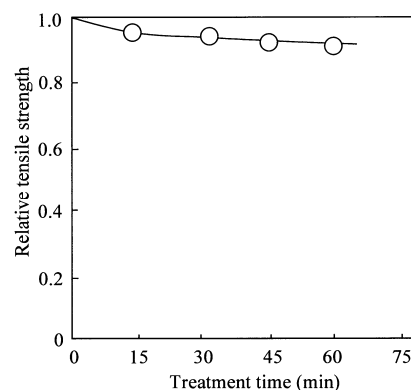


Fig.2 Relation between tensile strength of PP fabrics (fiber diameter: 12.5  $\mu\text{m}$ ) and treatment time

It is preferable that the activation step is performed for a short time. Activated PP or PE materials were reacted with a mixture of monomers and reagents by heating or UV irradiation. Obtained materials were improved as follows.

### 1) Water absorption property

Figure 3 gives PP fabrics soaked in water. The treated PP absorbed water of over ten times of weight of original PP.

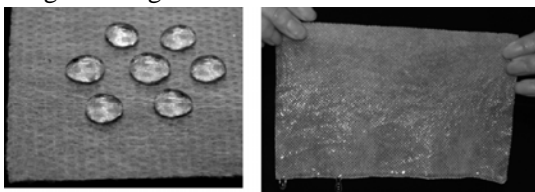


Fig.3 PP non-woven fabrics soaked in water; left: untreated PP and right :treated pp.

### 2) Adhesion property

Treated PP and PE materials gave good adhesion properties to paper, wood, aluminum and acrylic resin, etc. using usual glue or adhesives (polyvinyl pyrolidone, polycyano acrylate, etc.), although these original (untreated) materials gave no adhesion properties. Figures 4, 5 and 6 give the photographs of the adhesion of improved UHMPE plate to paper, iron, wood, aluminum, acrylic resin plates, respectively.



Fig.4 Adhesion of UHMPE plate to paper (left) and iron plate (right)

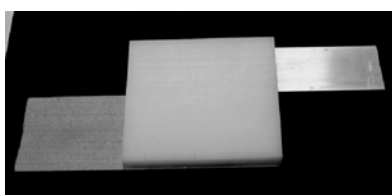


Fig.5 Adhesion of UHMPE plate to wood plate (left) and aluminum plate (right)

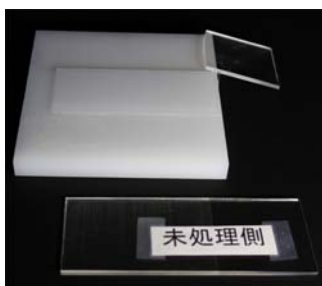


Fig.6 Adhesion of UHMPE plate to poly methyl methacrylate resin plate

### 3) Painting property

Treated PP materials gave a good painting property with usual acrylic paint and nitrocellulose paint.<sup>[1]</sup> Figure 7 gives the result of the cross-cut test (JIS K5400) on untreated or treated PP plates coated with acrylic paint (Nippe spray lacker, Nippe Home Products, Co. Ltd.). The treated PP gave 100/100 value.

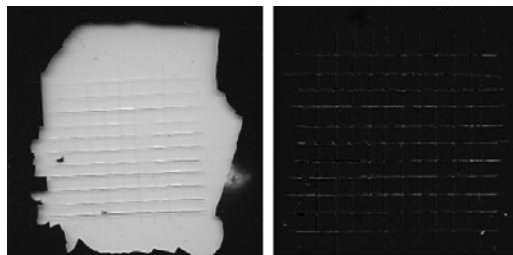


Fig.7 Painted PP plates used in the cross-cut test; left: untreated PP and right :treated pp.

### Mechanism

Hydroperoxy groups (-O-OH) are considered to be formed in the activation step.<sup>[2,3]</sup> As hydroperoxy groups are not stable in air, they are considered to be changed to the other structures containing carbonyl groups. The activated polymer materials were reacted with monomers or other reactants, RX. The reaction is speculated as below.

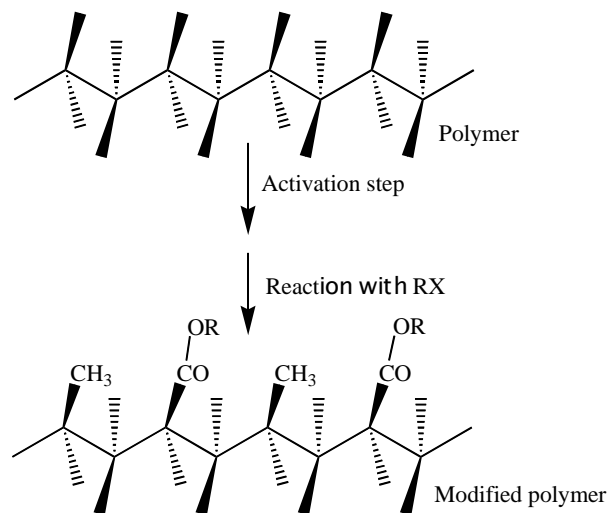


Fig. 6 Scheme

## 4. REFERENCES

- [1] H. Kanazawa, US Patent 6830782B2US, Japanese Patents 3729130, 4229421, Korean Patent 10-0752245, etc.
- [2] I. Enomoto, et. al., *Sen-i Gakkai Preprint*, 2008 p.300 (2008).
- [3] T. Matsui, A. Yamaoka, and Y. Yamaguchi, *Nippon Kagaku Kaishi*, 732 (1992).