Surface Treatment of Thin Polymer Sheet by Using Microplasma

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INTRODUCTION

This study introduces the surface treatment of polymer sheet developed for medical use by using microplasma. The thickness of the sheet is less than 100nm. The sheet is fabricated for the medical use, and the adhesive force is important when is applied on wounds. Microplasma treatment was used in order to improve the adhesive force which is related to the hydrophilic property of the sheet.

(1)Microplasma Electrodes

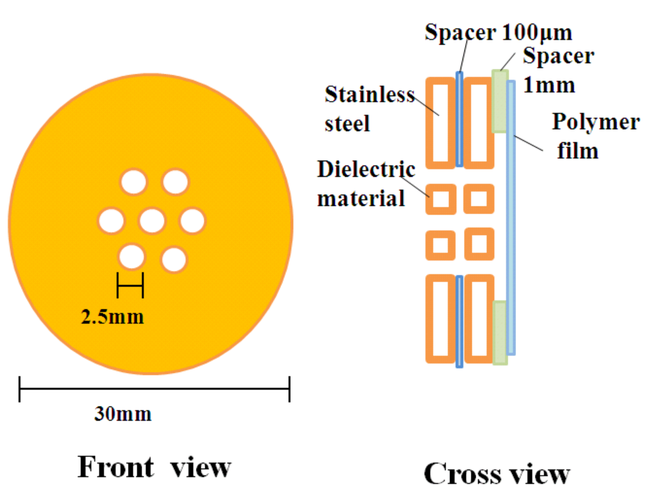

Fig. 1 Microplasma electrodes.

A pair of metal plates covered with dielectric layer were used as a electrodes (Fig. 1).
A spacer with a hexagonal hole with 7mm side was inserted between electrodes in order to increase a gas flow and to secure the desired gap length.

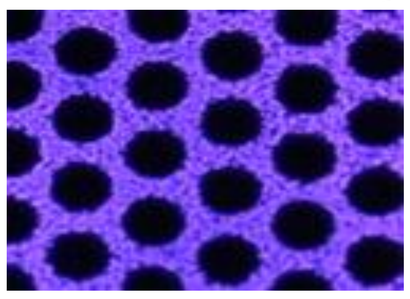

Fig. 2 The image of microplasma electrodes during discharge at a discharge voltage of 1 kV.

(2) Experimental Setup

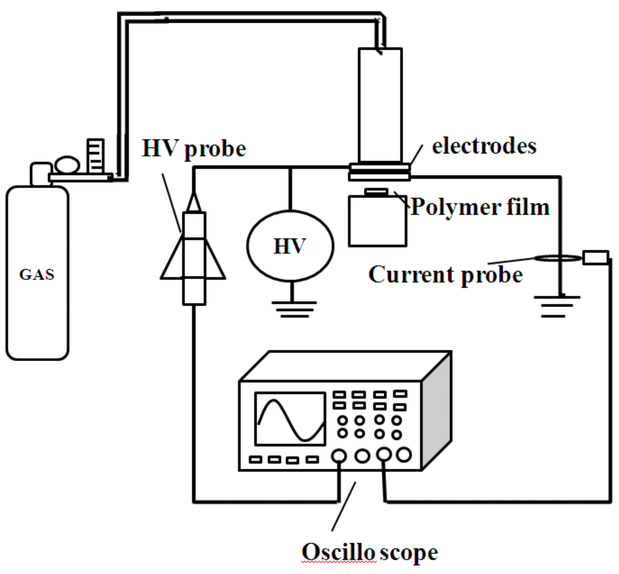

Fig. 3 An experimental setup for surface treatment of polymer sheet.

A neon transformer was used as an AC high voltage power supply. Carrier gas was flowed into the reactor in which were enclosed microplasma electrodes. The radicals and ions generated by microplasma collided with the surface of polymer film (Fig. 3).
Discharge voltage and discharge current were measured by a digital oscilloscope. Treated polymer film surface modifications were estimated by using XPS and a contact angle meter.

Table 1 An experimental condition of Surface treatment.

Gas flow late [L/min]	5
Process gas	Ar,N2,Air
Distance of between electrodes and polymer sheet [mm]	1

RESULTS

(1)Electric Characteristics

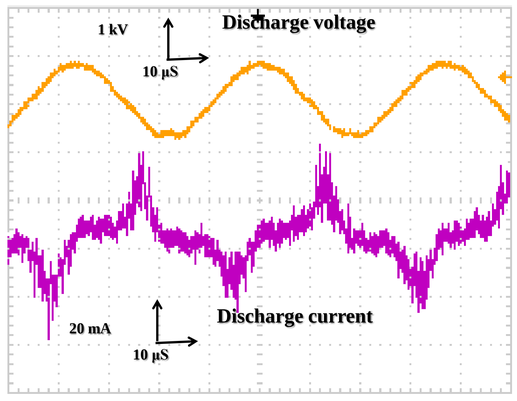

Fig. 4 Discharge voltage and current discharge waveform.

Spike currents generated due to the streamers appeared at the slope of discharge voltage as shown in Fig. 4. Microplasma reactor can generate atmospheric plasma at about 1 kV, since its discharge gap was narrow (about100 μm).

(2) Emission Spectroscopy

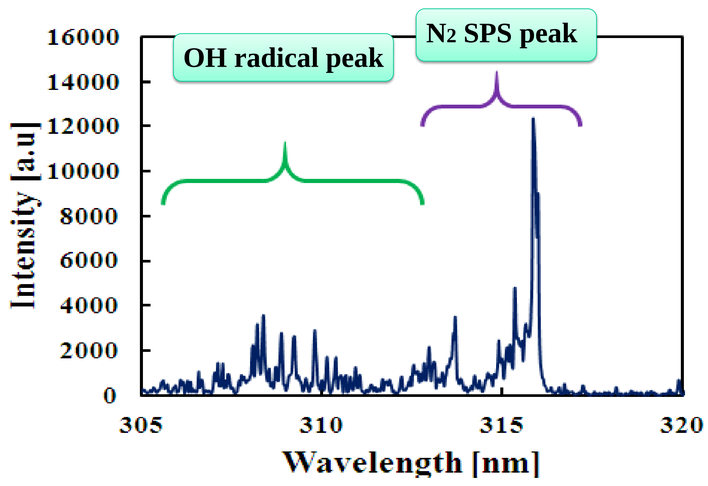

Fig. 5 Emission spectroscopy (Process gas: 1% N2 in Ar).

OH radical, peaks were observed. These active species cut surface bonds and contributed to make new surface bonds.

(3) Relation of Treatment Time and Contact Angle

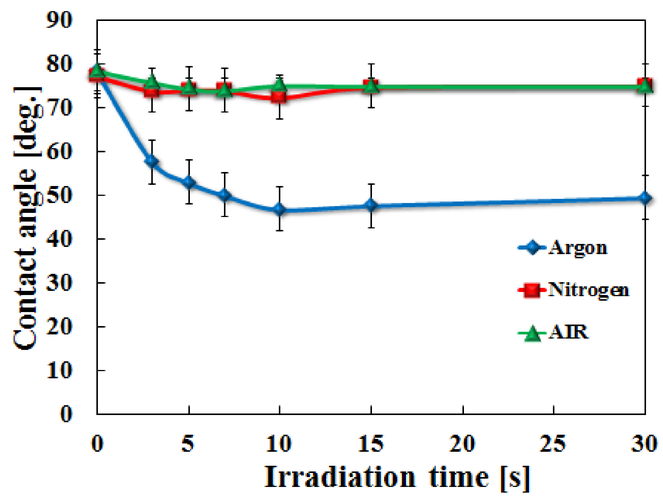

Fig. 6 Treatment time versus contact angle.

Table 2 Applied voltage for surface treatment

Process gas	Applied voltage [kV]
Ar	0.9
N2	1.3
Air	1.4

Contact angle was reduced to 30° in 10 seconds using Ar as shown in Fig. 6. Air and N2 microplasma did not affected so much as using Ar. These condition are shown in Table 2.

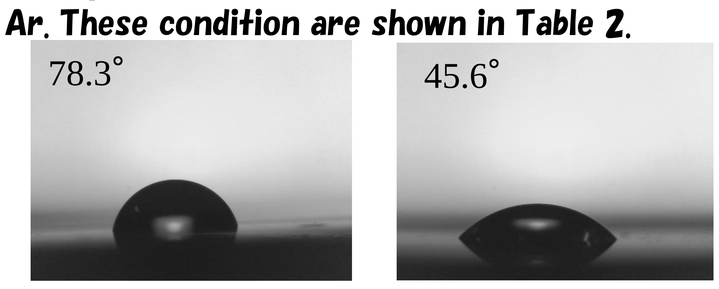

Fig. 7 Image of water droplet on the polymer film.

The water droplet on the surface of treated polymer film changed to a more elongated shape without plasma treatment as shown in Fig. 7.

(4) Durability of Plasma Effect

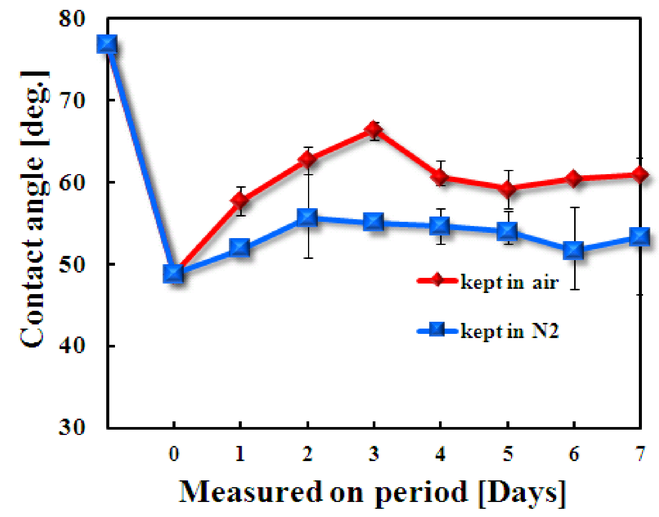

Fig. 8 Durability of plasma effect.

A polymer sheet, which was treated by Ar plasma (applied voltage 880 V, treatment time 30 s) was kept in both air and N_2 atmosphere between 0-7days. The contact angle did not return to initial value even after 7 days (Fig. 8). An increase of contact angle was observed for both air. Contact angle remained at a lower value for N_2 than in the air.

(5) Surface Analysis by XPS

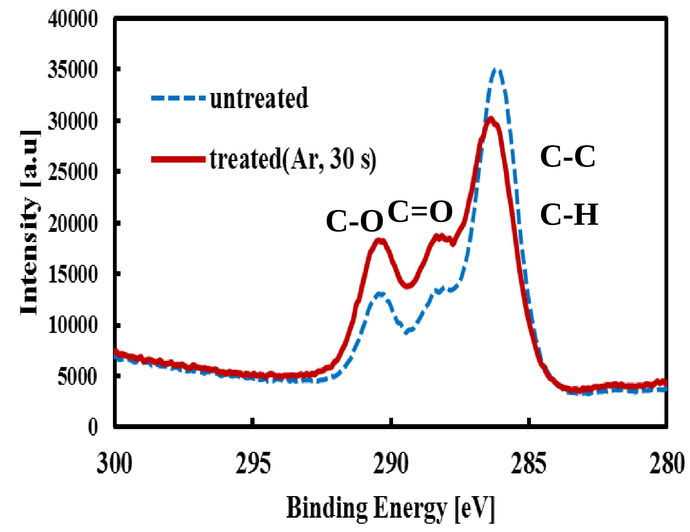

Fig. 9 XPS spectra of the C1s component.

The C-C,C-H bond decreased and C-O, C=O bonds decreased compared with untreated polymer films (Fig. 9). Microplasma treatment cut C-C, C-H bonds and made C=O, C-O bonds. The C-O, C=O bonds have the hydrophilic property. The C-C, C-H bonds has hydrophobic property.

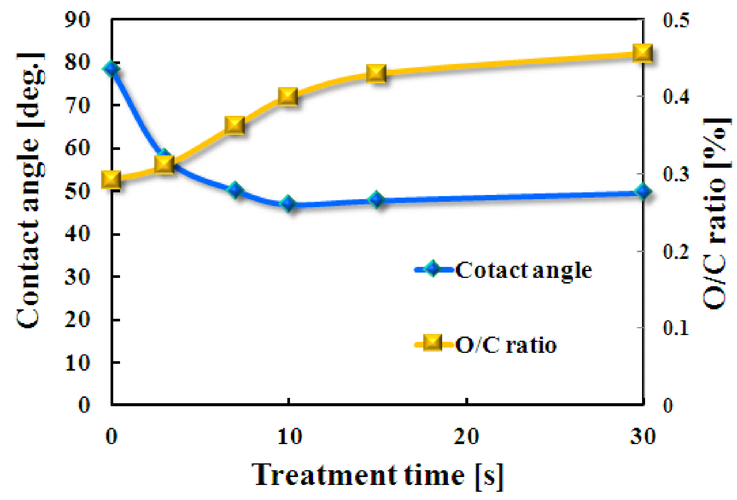

Fig. 10 O/C ratio of surface analysis by XPS.

Increase of C/O ratio corresponding contact angle degreased was observed as shown in Fig. 10.

CONCLUSIONS

Microplasma treatment for polymer film was carried out.

1. The minimum contact angle was about 45° with Ar plasma treatment.
2. A longer lasting effect of microplasma treatment was observed after keeping the treated polymer in N2 than air.
3. Hydrophilic group increased and the hydrophobic group decreased after plasma treatment.