Geosynthetics, J. Kuwano & J. Koseki (eds)

Evaluation of strength and hydraulic properties of plasma treated nonwoven geotextiles

Bouazza, A.
Department of Civil Engineering, Monash University, Melbourne, Australia
Jeon, H-Y.
Division of Nano-Systems Engineering, Inha University, Incheon, Korea

Keywords: nonwoven geotextiles, plasma treatment, permeability, tensile strength

ABSTRACT: The surface of nonwoven geotextiles was modified by plasma treatment to improve their hydraulic and strength performance. Plasma treatment was applied to poly vinyl alcohol (PVA) needle-punched geotextiles, polypropylene (PP) needle-punched geotextiles and polyester (PET) spun-bonded geotextiles. The nonwoven geotextiles tensile strength and permeability were measured before and after plasma treatment to compare the change in their properties. The present experimental results show that the tensile strength of the nonwoven geotextiles increased after plasma treatment. It is also shown that plasma treatment had a limited effect on the permeability properties of the PVA nonwoven geotextiles whereas a drop in permeability was observed on PP and PET nonwoven geotextiles.

1 INTRODUCTION

Polyester (PET) and polypropylene (PP) nonwoven geotextiles are used extensively in geotechnical and geo-environmental applications as protection, reinforcement, separation, filtration and drainage materials.

In general, most nonwoven geotextiles are simply composed of fiber entanglements and special modification is usually needed to improve their performances. Especially, their surface since it is strongly related to the separation and hydraulic performances.

Plasma treatment is generally used to improve the surface property of polymeric materials and their water repellency property. However, at this point in time, there are no examples of plasma treatment application to nonwoven geotextiles for use in geotechnical and geo-environmental applications.

Polyester (PET), polypropylene (PP) and poly vinyl alcohol (PVA) nonwoven geotextiles were selected for use in the present study. Their surface structure was modified by plasma treatment, under different condition, to improve their strength and hydraulic properties. Tensile strength and permeability of the different nonwoven geotextiles were compared before and after plasma treatment to investigate any changes in their properties

2 MATERIALS AND EXPERIMENTAL PROCEDURE

2.1 *Materials*

PVA nonwoven geotextiles with mass unit per area of 500 and 800 g/m^2, respectively, PP geotextiles and PET geotextiles with a mass unit per area of 370 and 200 g/m^2, respectively, were selected in the present investigation to undergo plasma treatment. Table 1 shows some of their specifications.

2.2 *Plasma treatment*

Plasma treatment was carried with a CD 400 PC (Euro Plasma Belgium) plasma treatment apparatus. The operation condition was as follow: base pressure-30 mTorr, pump-down time-120 min., and critical

Table 1. Specifications of nonwoven geotextiles.

Geotextiles	Polymer	Type of yarn	Manufacturing method	Weight (g/m^2)
PVA-NW-3	PVA	Staple	Needle-Punching	500
PVA-NW-4	PVA	Staple	Needle-Punching	800
PP-NW-1	PP	Staple	Needle-Punching	370
PET-NW	PET	Filament	Needle-Punching after Spun-Bonding	200

temperature-254°C, pump pressure-140 mtorr, extra pump down time-1 sec., work pressure-999 mTorr. Hydrophobic plasma treatment was applied to all specimens; C_2F_6 gas was applied for this purpose. The treatment conditions are shown in Table 2.

Table 2. Parameters of plasma treatment

Lot No.	Electric Power (Watt)	Gas flow (sccm)	Treatment Time (min)
1	0	0	0
2	100		1
3	100	40	5
4	100		10
5	100		1
6	100	60	5
7	100		10
8	200		1
9	200	40	5
10	200		10
11	200		1
12	200	60	5
13	200		10
14	300		1
15	300	40	5
16	300		10
17	300		1
18	300	60	5
19	300		10

2.3 *Evaluation of properties*

The different properties of the nonwoven geotextiles were evaluated following the ASTM testing protocols. Tensile strength and permeability were evaluated, before and after plasma treatment, in accordance with ASTM D 4595 and ASTM D 4491, respectively.

3 RESULTS AND DISCUSSION

3.1 *Tensile properties*

Figures 1 to 4 show the variation of nonwoven geotextiles tensile strength, before and after plasma treatment, against plasma treatment time, energy used in the treatment process and gas flow rate. It can be see from Figures 1 and 2 that PVA-NW-3 and PVA-NW-4 show an increase in the tensile strength with an increase in plasma treatment time and energy. For both type of geotextiles, the larger tensile strength was obtained for a gas flow rate of 40 sccm.

Figure 3 indicates that the increase in tensile strength of PP-NW-1, although noticeable, is not constant. It tends to fluctuate over the range of energy and treatment time investigated. Similarly to PVA-NW-3 and PVA-NW-4, it was found that the larger tensile strength of PP-NW-1 was obtained at a gas flow rate of 40 sccm.

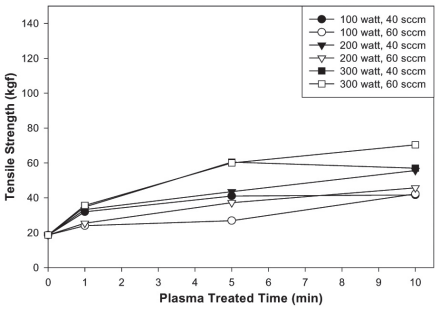

Figure 1. Tensile strength of PVA-NW-3: Plasma treated time vs. tensile strength.

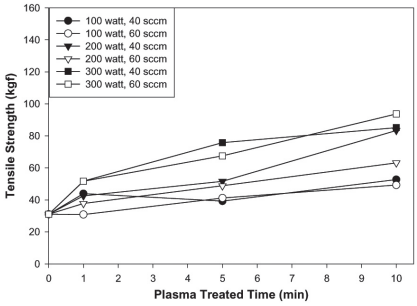

Figure 2. Tensile strength of PVA-NW-4: Plasma treated time vs. tensile strength.

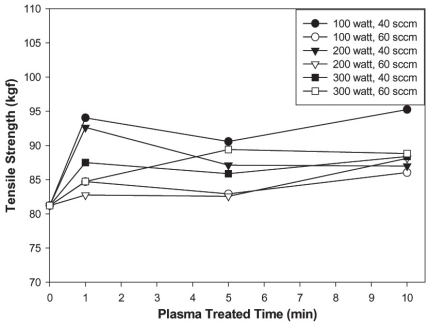

Figure 3. Tensile strength of PP-NW-1: Plasma treated time vs. tensile strength.

No clear trend was observed in Figure 4 in the variation of tensile strength of PET-NW versus the treatment time, energy used and gas flow rates. However, the results indicate that the tensile strength tend to increase after plasma treatment. This increase is probably due to the increase in fiber bonding effect by plasma treatment.

3.2 *Permeability*

Figures 5 to 8 show the variation of permeability, before and after plasma treatment, versus plasma treatment duration. Energy and gas flow rates

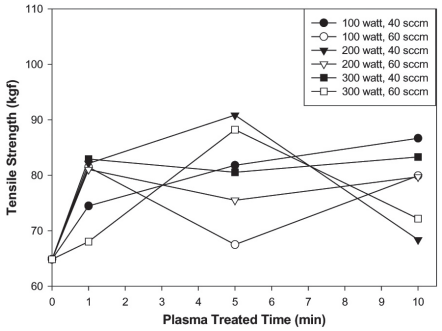

Figure 4. Tensile strength of PET-NW: Plasma treated time us. tensile strength.

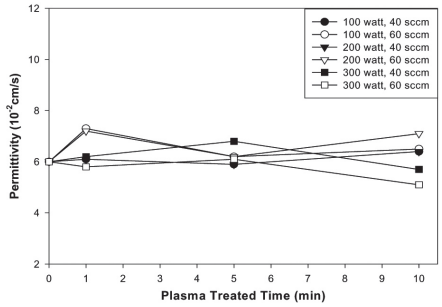

Figure 5. Permeability of PVA-NW-3: Plasma treated time vs. permeability.

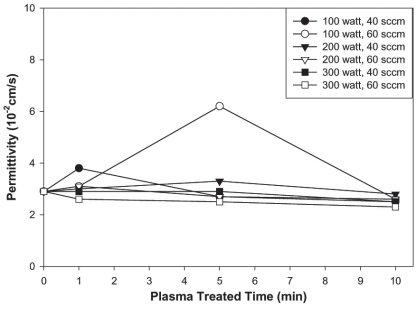

Figure 6. Permeability of PVA-NW-4: Plasma treated time vs. permeability.

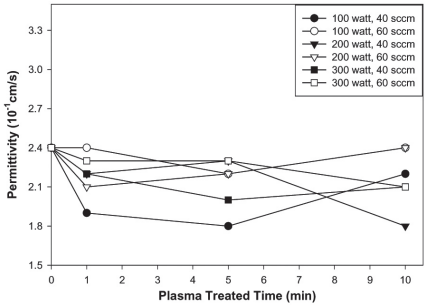

Figure 7. Permeability of PP-NW-1: Plasma treated time vs. permeability.

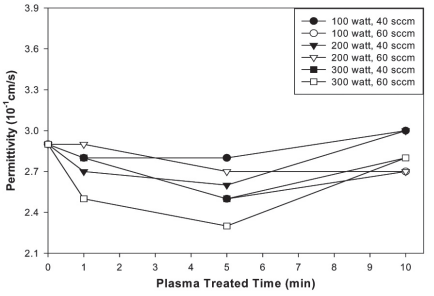

Figure 8. Permeability of PET-NW: Plasma treated time vs. permeability.

parameters are also included in the comparison process.

No major changes in permeability can be seen in Figures 5 and 6 for PVA-NW-3 and PVA-NW-4 except for one measurement, which seems to be an outlier. The minimal change observed is probably due to the already hydrophobic nature of these materials, indicating that the plasma treatment was not very efficient for these types of geotextiles.

The permeability of PP-NW-1 and PET-NW seem to decrease slightly after plasma treatment indicating probably that their hydrophobicity was increased by the treatment undergone on their surface.

4 CONCLUSIONS

The salient conclusions that can be drawn from this investigation are:

(1) Plasma treated nonwoven geotextiles utilised in the present investigation showed an increase in their tensile strength. This is probably due to the effect of treatment on the fibres bonding.
(2) Plasma treatment had a limited effect on PVA nonwoven geotextiles permeability due probably to their already hydrophobic nature. PP-NW and PET showed a slight decrease in their permeability indicating that plasma treatment has probably increased their hydrophobicity.

REFERENCES

ASTM D 4491-92. (2004). "Standard Test Methods for Water Permeability of Geotextiles by Permittivity", ASTM standards on geosynthetics, pp 23-27.

ASTM D 4595-86. (2004). "Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method", ASTM standards on geosynthetics, pp. 38-48.