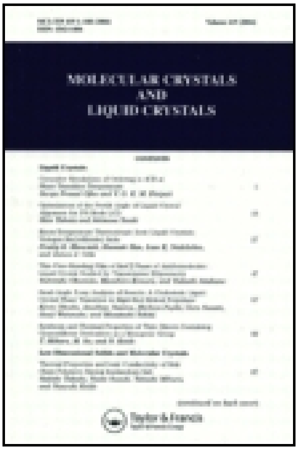
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Tensile properties were measured to compare the performance change of nonwoven geotextiles before and after plasma treatment. Friction tests were executed between the interface of geomembranes and nonwoven geotextiles, which use to the liner systems for the representative waste landfill in order to estimate of the friction properties. For hydrophobic treatment, C_2F_6 gas wasused and the electric power, the plasma treated time, and the gas flow rate were 100, 200, and 300 watt, 1, 5, and 10 min, and 40 and 60 sccm, respectively. From the experimental results, tensile strength of nonwoven geotextiles increased after plasma treatment. Peak shear stress and the residual shear stress of nonwoven geotextiles were examined and frictional coefficients and angle were increased.

Keywords: frictional coefficients; nonwoven geotextiles; plasma treatment; tensile strength

INTRODUCTION

In general, most of nonwoven geotextiles are simply composed of fiber entanglements and the special modification should be needed to improve the performances. Especially, the surface of nonwoven geotextiles would be strongly related to the separation and hydraulic performances for application this material to the soil structure [1–3]. Furthermore, these performances would affect to the structural safety and long-term serviceability after the installation of nonwoven geotextiles in the soil structure [4–5].

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Plasma treatment is generally used to improve the surface property of polymeric materials and the water repellent property could be improved by this treatment. But there is no application example of the plasma application of nonwoven geotextiles to the geotechnical and environmental fields. The separation and hydraulic performances of nonwoven geotextiles could be improved if the frictional property between soil and nonwoven geotextiles is advanced by plasma treatment.

In this study, we modified the surface structure of nonwoven geotextiles by plasma treatment with different condition. The long-term performance of nonwoven geotextiles could be determined and analyzed from the experimental results before and after plasma treatment.

EXPERIMENTAL

Preparation of Samples

PVA nonwoven geotextiles of 800 g/m^2 and PET geotextiles of 780 g/m^2 were used to plasma treatment and compare the property change. 2.0 mm thickness HDPE geomembrane of smooth type that is widely used to waste landfill construction in Korea was also used to compare the frictional properties of nonwoven geotextiles.

Table 1 shows the specifications of nonwoven geotextiles and HDPE geomembrane to be used in this study.

Plasma Treatment

CD 400 PC (EURO PLASMA BELGIUM) was used as plasma treatment apparatus and operation condition was as following: base pressure-30 m Torr, pumpdown time-120 min., and critical temperature-255°C, pump pressure-140 mtorr, extra pumpdown time-1 sec., and work pressure-999 mTorr. Hydrophobic plasma treatment was applied to all specimens and the C_2F_6 gas was applied with 100, 200, 300 watt and 1, 5, 10 min. for 40, 60-sccm-gas flow.

TABLE 1 Specifications of Nonwoven Geotextiles

Geotextiles	Polymer	Type of yarn	Manufacturing method	Weight (g/m^2)
PVA-NW	PVA	Staple	Needle-Punching	800
PET-NW	PET	Filament	Needle-Punching after Spun-Bonding	780

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

Table 2 shows the parameters of plasma treatment for nonwoven geotextiles.

Evaluation of Properties

Tensile strength of nonwoven geotextiles before and after plasma treatment was evaluated in accordance with ASTM D 751 by AGS-500D (SHIMADZU) universal tensile testing machine. For frictional test, the small size direct shear test equipment to be designed by Ming-Han Li and Robert B. Gilbert etc. was used to examine the shear strength between interfaces. Geotextile specimens were bonded the lower shear box and 60 mm circle type HDPE geomembrane was attached the upper box. For this test, normal stress was 690 kPa and shear rate was 0.66 mm/min.

RESULTS AND DISCUSSION

Surface Change of Geotextiles by Plasma Treatment

Figures 1 and 2 shows the SEM photographs of plasma treated fibers of geotextiles. In here, it was seen that some part of the fiber surface

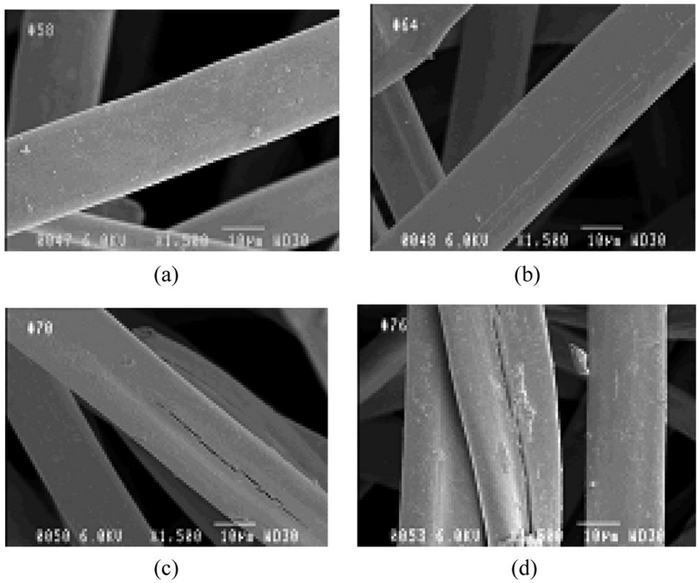


FIGURE 1 SEM photograph of PVA-NW: (a) before treatment, (b) 100 watt 60 sccm, 10 min, (c) 200 watt, sccm, 10 min, (d) 300 watt, 60 sccm, 10 min.

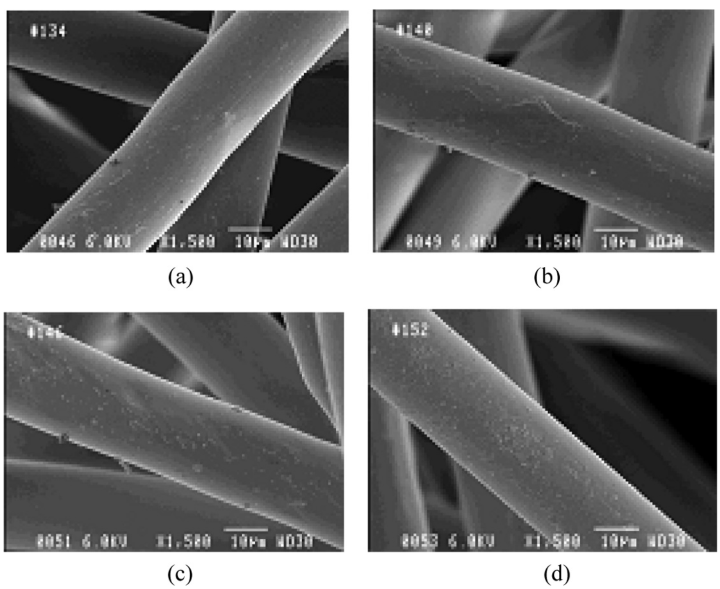


FIGURE 2 SEM photograph of PET-NW: (a) before treatment, (b) 100 watt, 60 sccm, 10 min, (c) 200 watt, 60 sccm, 10 min, (d) 300 watt, 60 sccm, 10 min.

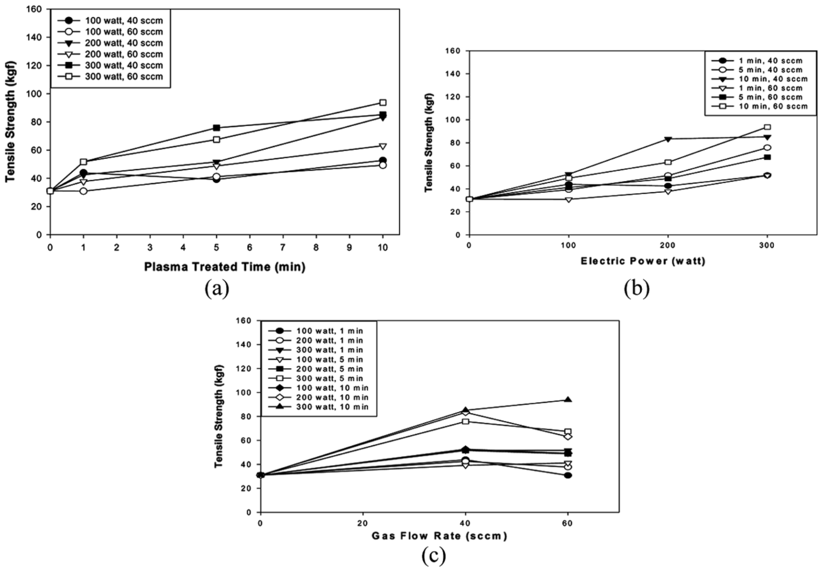


FIGURE 3 Tensile strength of PVA-NW: (a) Plasma treated time vs. tensile strength, (b) Electric power vs. tensile strength, (c) Gas flow rate vs. tensile strength.

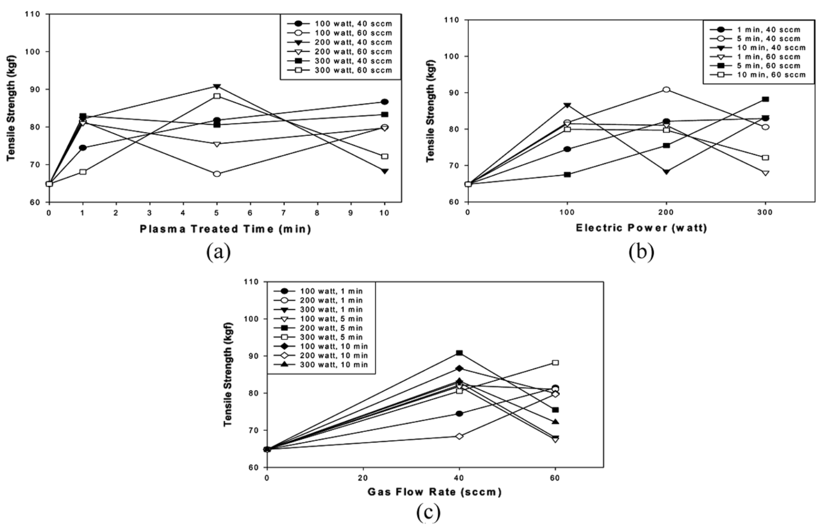
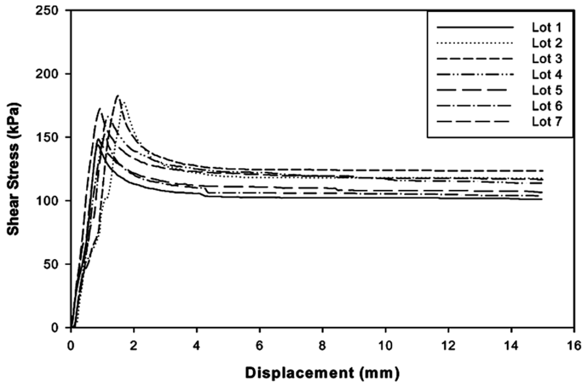
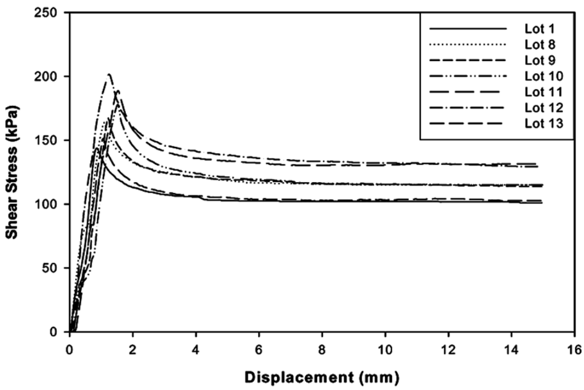


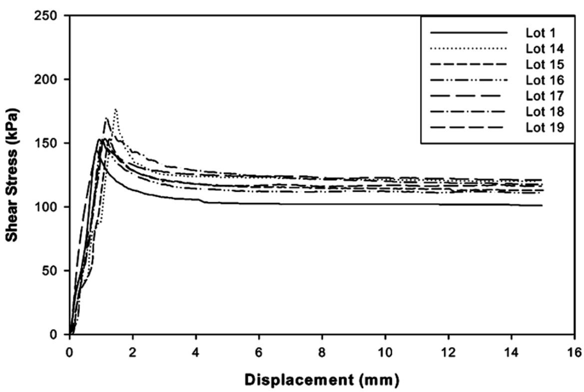
FIGURE 4 Tensile strength of PET-NW: (a) Plasma treated time vs. tensile strength, (b) Electric power vs. tensile strength, (c) Gas flow rate vs. tensile strength.



(a)



(b)



(c)

FIGURE 5 Shear stress versus displacement of PVA-NW.

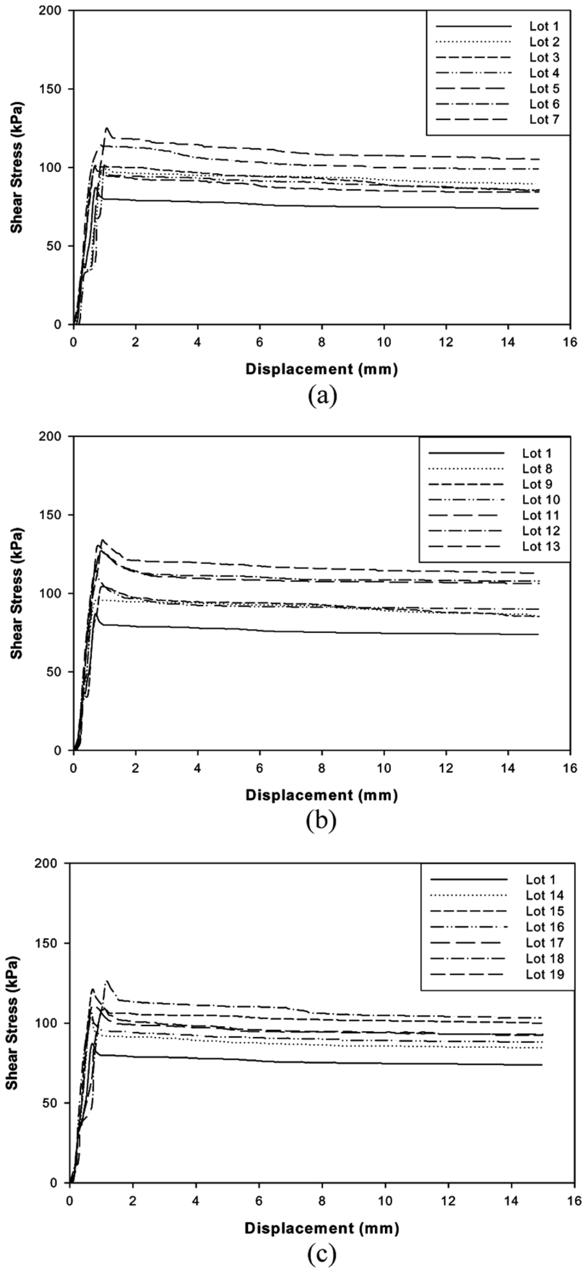


FIGURE 6 Shear stress versus displacement of PET-NW.

TABLE 3 Frictional Coefficient and Friction Angle of Between PVA-NW and Geomembrane for Peak Shear Strength and Residual Shear Strength

	Peak shear strength		Residual shear strength			Peak shear strength		Residual shear strength	
L O T	Frictional coefficient	Frictional angle	Frictional coefficient	Frictional angle	L O T	Frictional coefficient	Frictional angle	Frictional coefficient	Frictional angle
1	0.18	10.20	0.16	9.09					
2	0.25	14.04	0.18	10.20	11	0.21	11.86	0.16	9.09
3	0.27	15.11	0.22	12.41	12	0.23	12.92	0.19	10.76
4	0.24	13.50	0.22	12.41	13	0.26	14.57	0.20	11.31
5	0.23	12.92	0.20	11.31	14	0.24	13.50	0.18	10.20
6	0.22	12.41	0.17	9.65	15	0.24	13.50	0.19	10.76
7	0.21	11.86	0.17	9.65	16	0.26	14.57	0.21	11.86
8	0.21	11.86	0.17	9.65	17	0.21	11.86	0.17	9.65
9	0.27	15.11	0.20	11.31	18	0.22	12.41	0.16	9.09
10	0.23	12.92	0.18	10.20	19	0.29	16.17	0.21	11.86

TABLE 4 Frictional Coefficient and Friction Angle of Between PP-NW-4 and Geomembrane for Peak Shear Strength and Residual Shear Strength

	Peak shear strength		Residual shear strength			Peak shear strength		Residual shear strength	
L O T	Frictional coefficient	Frictional angle	Frictional coefficient	Frictional angle	L O T	Frictional coefficient	Frictional angle	Frictional coefficient	Frictional angle
1	0.12	6.84	0.10	5.71					
2	0.14	7.97	0.12	6.84	11	0.14	7.97	0.12	6.84
3	0.15	8.53	0.12	6.84	12	0.17	9.65	0.15	8.53
4	0.18	10.20	0.14	7.97	13	0.14	7.97	0.11	6.28
5	0.16	9.09	0.13	7.41	14	0.18	10.20	0.13	7.41
6	0.16	9.09	0.12	6.84	15	0.13	7.41	0.11	6.28
7	0.17	9.65	0.12	6.84	16	0.16	9.09	0.14	7.97
8	0.20	11.31	0.14	7.97	17	0.16	9.09	0.12	6.84
9	0.19	10.76	0.15	8.53	18	0.13	7.41	0.11	6.28
10	0.17	9.65	0.15	8.53	19	0.12	6.84	0.11	6.28

TABLE 5 Frictional Coefficient and Friction Angle of Between PET-NW-4 and Geomembrane for Peak Shear Strength and Residual Shear Strength

	Peak shear strength		Residual shear strength			Peak shear strength		Residual shear strength	
L O T	Frictional coefficient	Frictional angle	Frictional coefficient	Frictional angle	L O T	Frictional coefficient	Frictional angle	Frictional coefficient	Frictional angle
1	0.13	7.41	0.11	6.28					
2	0.15	8.53	0.13	7.41	11	0.18	10.20	0.15	8.53
3	0.15	8.53	0.12	6.84	12	0.19	10.76	0.16	9.09
4	0.15	8.53	0.12	6.84	13	0.19	10.76	0.16	9.09
5	0.18	10.20	0.15	8.53	14	0.15	8.53	0.12	6.84
6	0.17	9.65	0.14	7.97	15	0.18	10.20	0.14	7.97
7	0.15	8.53	0.12	6.84	16	0.16	9.09	0.13	7.41
8	0.14	7.97	0.12	6.84	17	0.16	9.09	0.13	7.41
9	0.15	8.53	0.12	6.84	18	0.18	10.20	0.15	8.53
10	0.17	9.65	0.13	7.41	19	0.16	9.09	0.13	7.41

was decomposed by plasma treatment and the degree of fiber surface decomposition is increased to longer plasma treatment period. And these decomposition phenomena were found in all the geotextile specimens.

Tensile Properties

Figures 3 and 4 shows the tensile strength change of nonwoven geotextiles before and after plasma treatment with plasma treatment period, electric power and gas flow rate etc.

PVA-NW shows the tensile strength increase with plasma treatment period and electric power and show the larger tensile strength for gas flow rate, 40 sccm rather than 60 sccm. PET-NW does not show the clear trend with plasma treatment conditions but show the tensile strength increase after plasma treatment.

These increase phenomena of tensile strength after plasma treatment is due to the increase of fiber bonding effect by plasma treatment.

Friction Property

Friction properties of nonwoven geotextiles were examined before and after plasma treatment.

Figures 5 and 6 shows the relationship between peak shear stress and residual shear stress and Tables 3–5 shows the frictional coefficient and friction angle for peak shear stress and residual shear stress.

From this result, the increase of frictional coefficient and friction angle would be found and this is due to the improvement of surface bonding effect of nonwoven geotextiles by plasma treatment.

CONCLUSION

The surface modification by plasma treatment was applied to improve the performance of nonwoven geotextiles. For hydrophobic treatment of nonwoven geotextiles, plasma treatment period and electric power influenced the tensile strength increase and this effect is larger than the gas flow rate, 40 sccm. Frictional coefficient and friction angle between nonwoven geotextiles and geomembrane were also increased by plasma treatment.

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