Enhancement of Adhesion Characteristics of Low-density Polyethylene Using Atmospheric Plasma Initiated-Grafting of Polyethylene Glycol

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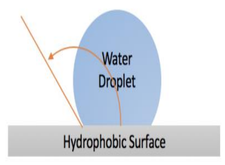
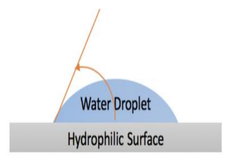
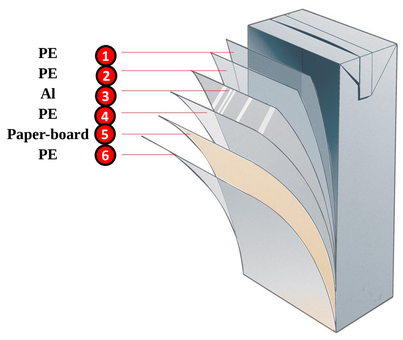
Graduate Students, Energy and Environment

1. INTRODUCTION

Laminates composed by a combination of low density polyethylene, LDPE (20%) and aluminum, Al (5%) in food packaging (Tetra Pak liquid containers, e.g.) provides stability and strength to the inner packaging structure, ensures protection against outside moisture, and maintains the nutritional values and flavors of food without needed for additives . However the poor surface properties of PE leads to lack integration or incomplete adhesion of PE to Al due to inert hydrophobic surface of PE (poor wettability and adhesion). Thus the cold plasma is used for surface treatment of polymer by interactions of electrically charged particles, such as electrons, ions, metastables, radicals with the surface atoms by several surface activation ways such as functionalization, deposition, etching or cross-linking.





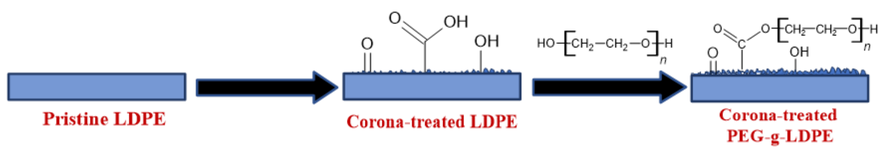


2. RESEARCH OBJECTIVES

Improve the surface characteristics of LDPE surface by corona plasma assisted surface grafting with different molecular weights of polyethylene glycol (PEG) in order to increase the adhesion strength of LDPE/Al joints.

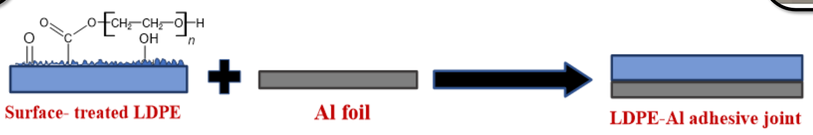
3. MATERIALS AND METHODS

The proposed grafting mechanism of PEG onto corona-treated LDPE surface



1- Surface treatment by 5 sec. atmospheric corona discharge

2- Completely immersion in PEGaqueous solution for 24h



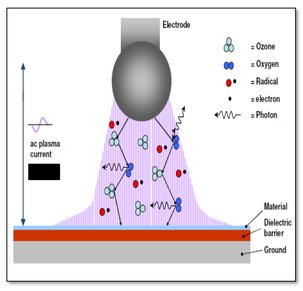
3- LDPE/Al lamination process (2 tons compression molding for 2 min. at 160° C)

Chemical treatment
Grafting PEG onto LDPE

Physical treatment
Corona discharge

Grafting agent

(1) : PEG (M=1000 g/mol) and
(2) : PEG (M=6000 g/mol)
1.5 wt.% , 10.0 wt.% in aq. solution



Moderate experimental conditions

- Room temperature, and atmospheric pressure
- nominal power supply (300 W)
- Frequency (typically 17.20 kHz) of the high voltage
- Uniform treatment time (5s)

5. CONCLUSION

The surface characteristics of LDPE were successfully enhanced using plasma-activated grafting of different molecular weights of PEG onto LDPE surfaces, and thus a significant and positive effect on the interfacial adhesion of LDPE with Al had achieved. The highest adhesive strength (163 N / m) was achieved for 5s corona-treated 10 wt.% PEG (6000 M)-g- LDPE/Al.

6. REFERENCES

[1]:Elbadawi, M. Rheological and mechanical investigation into the effect of different molecular weight poly (ethylene glycol)s on polycaprolactone-ciprofloxacin filaments. *ACS Omega* 2019, 4, 5412–5423.

[2]: Kasalkova, N.S.; Slepicka, P.; Kolska, Z.; Svorcik, V. Wettability and other surface properties of modified polymers. *Wetting Wettability* 2015, *12*, 323–356.

7. ACKNOWLEDGMENT

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4. RESULTS

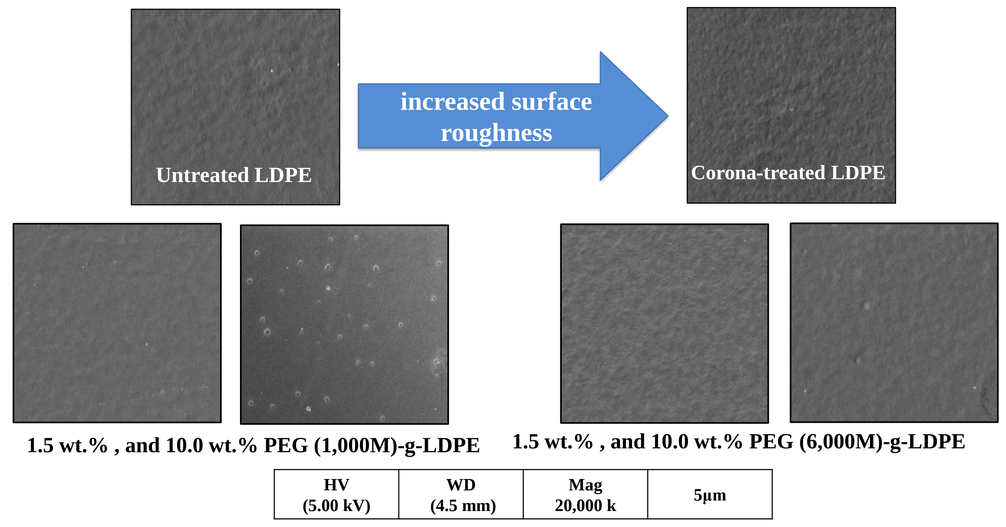


Figure 1 SEM images of LDPE

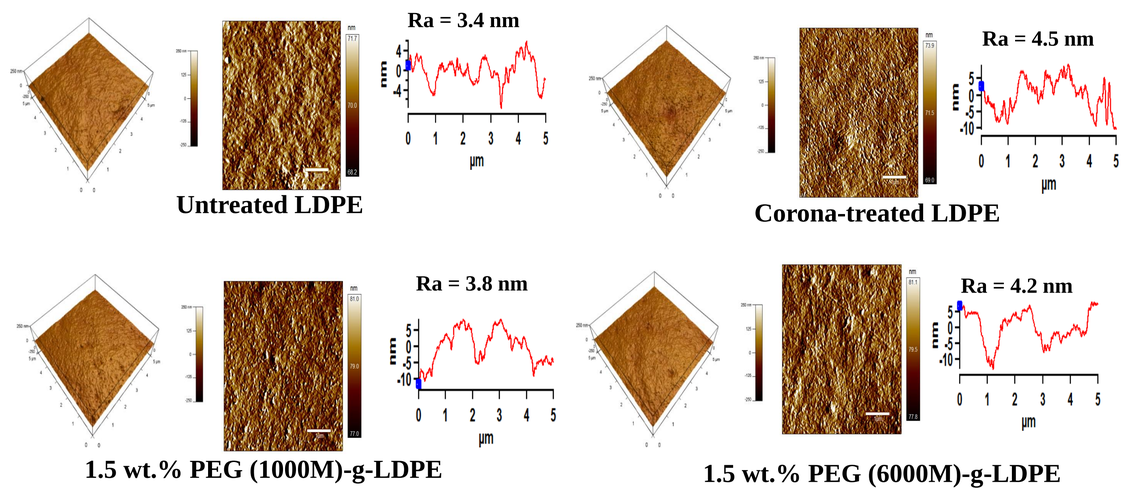
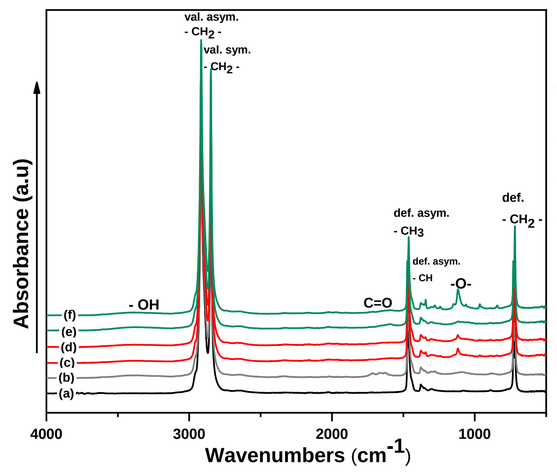


Figure 2 AFM morphological images and line scans of LDPE films



Samples	Element (at. %)		
	C 1s	O 1s	N 1s
(a) Untreated-LDPE	91.2	8.62	0.18
(b) Corona-treated LDPE	88.5	11.3	0.2
(c) 1.5 wt.% PEG (1000M)-g-LDPE	95.18	4.64	0.17
(d) 10.0 wt.% PEG (1000M)-g-LDPE	93.61	6.08	0.31
(e) 1.5 wt.% PEG (6000M)-g-LDPE	95.25	4.51	0.00
(f) 10.0 wt.% PEG (6000M)-g-LDPE	92.33	7.52	0.04

Figure 3 FTIR spectra and XPS elemental compositions analysis of :
(a) Untreated LDPE , (b) Corona-treated LDPE (t=5s)
(c) 1.5 wt.%PEG (1000M)-g-LDPE, (d) 10.0 wt.%PEG (1000M)-g-LDPE
(e) 1.5 wt.%PEG (6000M)-g-LDPE, (f) 10.0 wt.%PEG (6000M)-g-LDPE

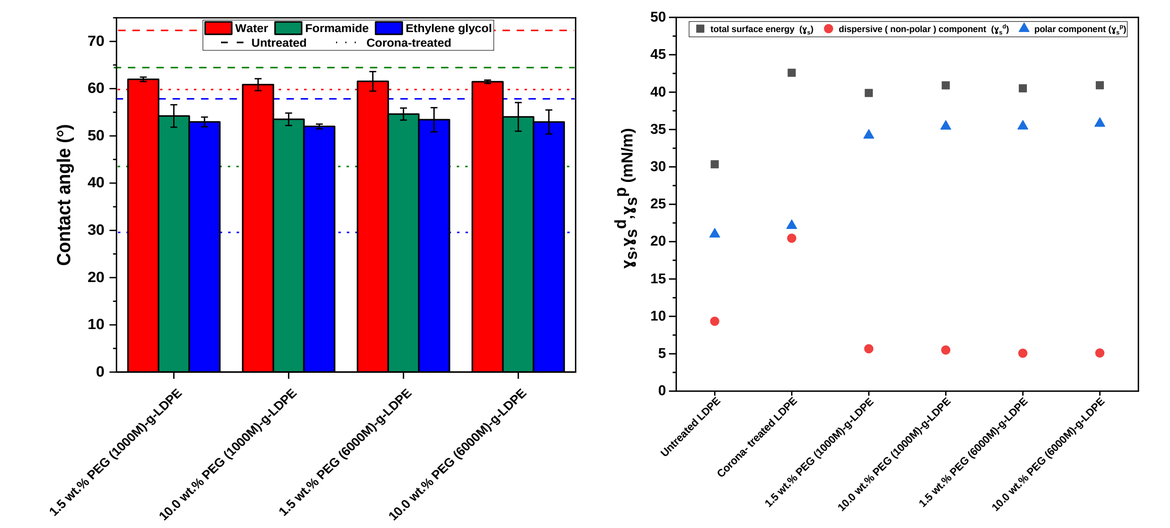


Figure 4 Surface wettability analysis of untreated, corona treated and PEG-g-LDPE films

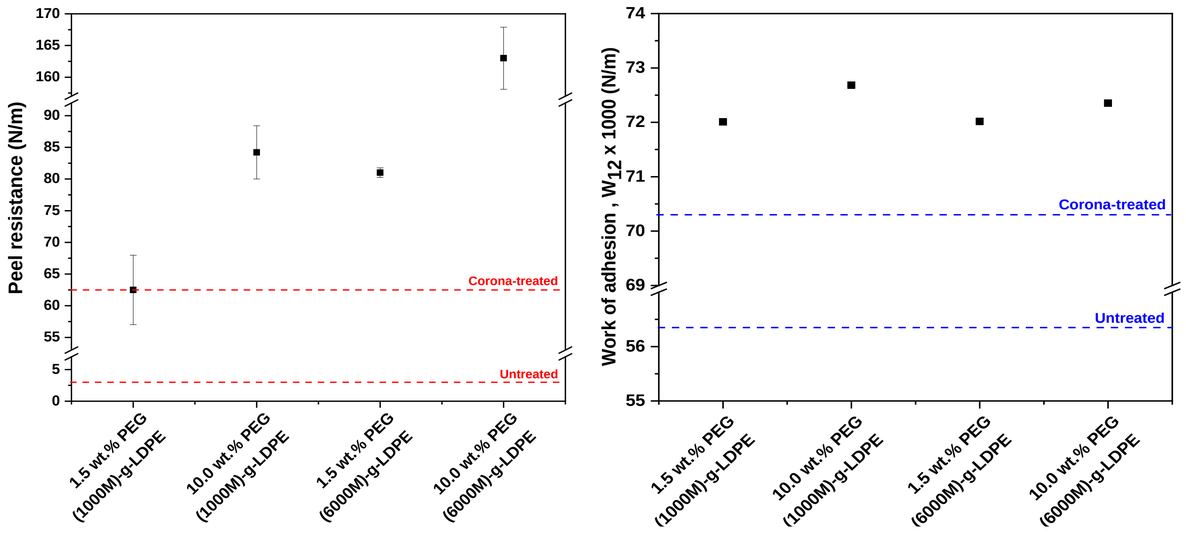


Figure 5 Effect of corona treatment on the peel resistance and work of adhesion of PEG-g-LDPE/Al adhesive joints