MMMS
2018

PROCEEDINGS

THE FIRST INTERNATIONAL CONFERENCE
ON MATERIAL, MACHINES AND METHODS
FOR SUSTAINABLE DEVELOPMENT

Research Development in Industrial Material, Machining and Methods towards Sustainability

Da Nang, Vietnam
May 18 - 19, 2018

Vol 2

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Edited by:
Banh Tien Long, Hyungsun Kim, Kozo Ishizaki, Nguyen Duc Toan, Nguyen Thi Hong Minh

Proceedings
of
The First International Conference
on Material, Machines and Methods for Sustainable Development

MMMS2018

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The conference organizers are especially grateful to Vietnam National Foundation for Science and Technology Development (NAFOSTED) for financial support.

Preface

On behalf of the Organizing Committee, we are delighted to issue the proceedings which contains papers presented at the first International Conference on Material, Machines and Methods for Sustainable Development (MMMS) from 18-19 May, 2018 in Danang, Vietnam. The MMMS2018 continues enabling researchers from all over the world to share their research and accomplishments as well as review the research currently being conducted by their peers.

The purpose of the conference is to explore and ensure an understanding of the critical aspects which contributed to sustainable development, especially materials, machines and methods. From such understanding, the conference aims at an overall approach to assist policy makers, industries and researchers at various levels to position the local technological development towards sustainable development in the global context, to assist decision making towards a greener approach especially for material, machines and methods.

The papers published in this proceedings represent the state-of-the-art in the field of materials science and mechanical engineering. The contents of manuscripts from authors representing universities, research institutes and industrial companies demonstrate the results of very wide spectrum of research, from material design and processing, to the application material, the mechanical engineering technology in industry. The largest number of the papers answer the vital question of how to obtain the advanced properties and technologies required of final task and products by the way of the verifications and selections of the process and control parameters. Other important problems of new special materials are also covered by several researchers. A large group of papers focus on the material modeling as well as the eco-material technologies processes and mechanical manufacturing.

We would like to express our gratitude to the members of International Organizing and Academic Committees of the Conference, for their hard work and advices which were helpful in maintaining the high level of the Conference. We hope that the proceeding will become a source of valuable information in the scientific work for academics, researchers, engineers and students.

Best regards

Banh Tien Long, Hyungsun Kim, Kozo Ishizaki, Nguyen Duc Toan, Nguyen Thi Hong Minh

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CHAPTER 9. MATERIALS PROPERTIES TOWARDS SUSTAINABILITY

Effect of Ethylene Vinyl Axetate (EVA) on the Mechanical Properties of Low-Density Polyethylene/ EVA Blends

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Key words: LDPE/ EVA; Ethylene Vinyl Acetate; Tensile strength; Elongation; Blend

Abstract. The extensive range of fillers used nowadays indicated the major significance of filler in the plastic industry. Although their original purpose was to lower the cost of the molding compounds; prime importance is now attached to selective modification of the properties of a specific plastic. In this study, the examples of LDPE/EVA blends, were put into 0, 3, 6, 9, 12 and 15 wt.% of EVA. The tensile strength, bending strength and impact strength of samples were determined according to ASTM D638, ISO 178 and ISO 179. Results showed that when increasing ratio of EVA in LDPE/ EVA blends, tensile strength decreased from 10.9 MPa to 8.6 MPa. Bending strength decreased linearly from 9.63 MPa to 5.46 MPa. Charpy impact strength decreased from 47.5 kJ/m^2 to 6.3 kJ/m^2. On the contrary, elongation in 100% LDPE is 78.3%; with the appearance of EVA, elongation of the LDPE/ EVA blends increased upto 109.1%. In addition, SEM micrographs indicated that, it was more crystal-clear when the EVA content is less; in the highest EVA content with 15%, it can be seen that the specimen after pressing is slightly opaque and darker than the orthers. From that showed the addition of EVA to the polymer leads the tensile strength, bending strength were not affect much, impact strength decreased but elongation experienced an increase.

Introduction

Low-Density Polyethylene (LDPE) is thermoplastic with the basic features of LDPE such as low density, toughness, impact resistance at low temperature, good insulation, durable chemicals and good anti-worn [1]. EVA (Ethylene Vinyl Acetate Copolymer) is one kind of plastic which is a compound between Ethylene and Acetate, produced by high pressure stage with pressure above 2,500 atm [2]. Among the types of PE, LDPE has many properties that can match with EVA better such as low-density branching, melting points are close to EVA... So choosing LDPE blends with EVA can overcome the limitations of each component polymer, contributing to increased mechanical properties, increased flexibility, elasticity, toughness and resistance to cracking under the impact of the environment [3, 4].

According to the study of H. Azizi the mechanical properties of XLPE/ EVA blends improve by increasing the EVA content by up to 15% by weight, in addition, the tensile strength of XLPE/ EVA blends is slightly reduced [5]. The study of Bistra Borisova with the wt.% of EVA in LDPE/ EVA blends were 1.8, 3.6, 5.4, 7.1, and 8.9, it has been shown that EVA particles are capable of blocking cracks propagation, increasing the toughness of the material and reduce the elongation [6]. The study of S. M. A. Salehi, LDPE and mixtures of LDPE with 5, 10, 20, and 30% EVA, in all cases, it has been found that the gel-content variations increased with increasing absorbed dose [7]. M. A. Rodri´guez-pe´rez studied about the effect of EVA addition on the technical characteristics of LPDE/ EVA foam, with LDPE/ EVA blend containing 10, 30, 90% EVA; and 25% EPR, EVA 75% [8]. The study of Siqin Dalai shown that, when the percentage of EVA in the LDPE/ EVA blends was 0, 20, 25, 30, 50 and 100%, the tensile strength of the LDPE/EVA blend increased with increasing gel percentage on the LDPE / EVA blends [9]. According to G. Takidis, tensile strength and elongation at break of LDPE/ EVA blend increased almost linearly by increasing EVA content [2].

In LDPE/EVA blends, the mechanical properties of the blends will increase linearly as the EVA increases the same amount of radiation or time and temperature of mixing increase. However, there are some studies that indicate that LDPE/EVA and PE/EVA blends will reduce the mechanical, namely tensile strength when increasing the EVA in the mixture. To clarify the effect of EVA on the LDPE/ EVA blends, the mechanical properties of LDPE/ EVA blends were tested such as tensile strength, bending strength and impact strength of the mixture with EVA content in the LDPE/ EVA blends are 0, 3, 6, 9, 12, 15 wt.%.

Experiment

Materials and chemicals was used in this study: Polyethylene (LDPE): SABIC - LDPE 4024 origin Saudi Arabia, provided by Thuan Thang Plastics Co., Ltd; Ethylene vinyl acetate (EVA) is supplied by Dong Nhat Phat Company. The test specimen consisted of LDPE and EVA was mixed and pressed in the proportions given in Table 1.

Table 1: Proportion of LDPE and EVA in the test specimens

Sample / Component	M1	M2	M3	M4	M5	M6
EVA (%)	0	3	6	9	12	15
LDPE (%)	100	97	94	91	88	85

The ASTM D638 was used to measure plastic tensile strength. Samples were processed according to the size shown in Figure 1. The experiment was carried out at a speed of 50 mm / min at room temperature and mounted on the test machine. The experiment was carried out on a Shimadzu Autograph AG-X Plus 20 kN (Japan) with longitudinal extension, a high resolution (1.8 µm) camera with no contact with the specimen and basic specifications. as follows: The maximum test power was 20 kN, speed range 0.001 - 1600 mm/ min, speed accuracy: ± 0.1% test speed, operating temperature at 5 – 50^{0}C, data acquisition speed 1000 Hz. The sample size was shown in Figure 1.

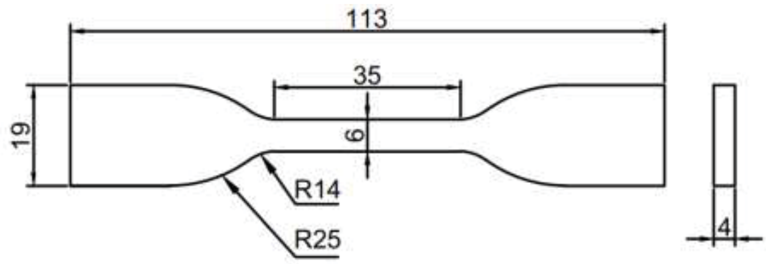

Figure 1: Sample size of the tensile test [10]

The analogous test to determine bending strength of materials in the ISO system is ISO 178. Test specimens for bending strength and impact strength was mixed and pressed using a Shine Well SW-120B injection machine. The size of the sample tested in this experiment was processed according to the parameters: 125 × 12 × 3.2 mm (Figure 2). The device was used in this method is the Instron 5566 machine with load capacity is 10 kN (2250 lbf); maximum power is 200 VA; weight of load frame is 136 kg (300 lb).

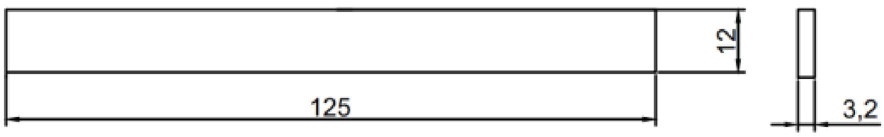

Figure 2: Sample size for bending strength testing [11]

Impact strength was determined according to ISO 179-1. Size of the samples in this experiment were calculated by the following parameters: 125 × 12 × 3.2 mm (Figure 3). The device was used to test the impact velocity is impact tester machine model IT504 -Tinius Olsen-England.

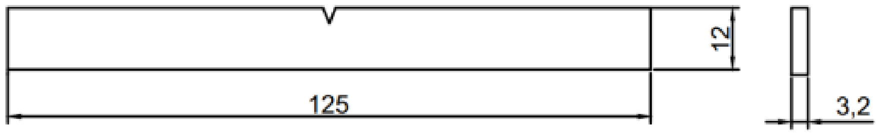

Figure 3: Sample size for Charpy impact strength [12]

Results

The tensile strength' results of each sample group were showed in Figure 4. The tensile strength of the LDPE/EVA blends decreased as EVA content in the mixture increased. The tensile strength of the sample containing 100% LDPE was 10.9 MPa, however, when adding 3% EVA to the LDPE/EVA blend the tensile strength was reduced to 10.3 MPa. When the EVA content of the mixture was increased to 6%, the tensile strength of the mixture was 9.8 MPa, ie 0.5 MPa lower than that of the LDPE/EVA containing 3% EVA. EVA content increased to 9% in the mixture, the tensile strength decreased to 9.3 MPa. With an EVA content of 12% LDPE / EVA, the tensile strength was reduced by 0.3 MPa compared to the EVA by 9%, which means that the tensile strength was only 9.0 MPa. With the highest EVA of 15%, the tensile strength was reduced by 0.4 MPa to 8.6 MPa.

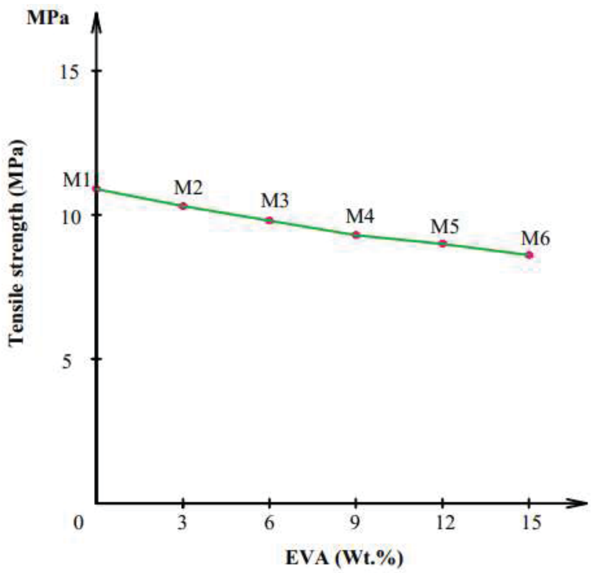

Figure 4: The average tensile strength of test samples

The elongation' results were shown in Figure 5. The elongation of samples containing 100% LDPE was the lowest (78.3%). The elongation increased when the EVA was added into the LDPE/EVA blends. Specifically, when adding 3% EVA, the elongation increased to 95%, 6% EVA increased slightly (95.8%), then dropped to 93.4% for samples containing 9% EVA. As the EVA content increased to 12%, the deformation increased sharply, up to 109.1% and dropped to 87.5% when the blends contained 15% EVA.

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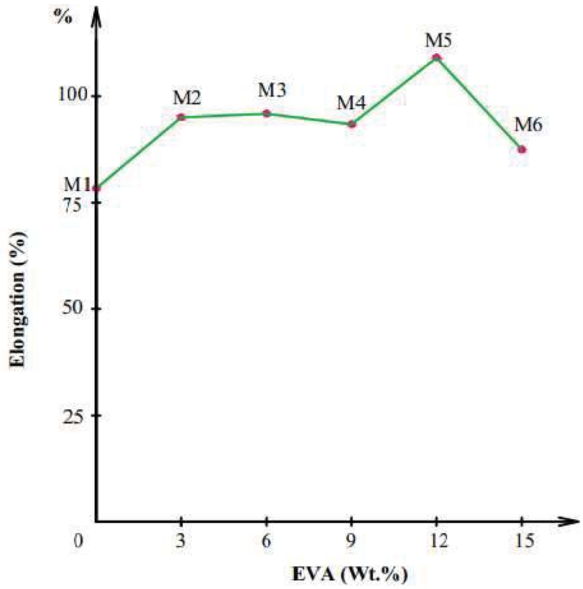


Figure 5: The average elongation of test samples

Figure 6 summarized the bending strength' results of samples M1, M2, M3, M4, M5, M6. The average reduction in pressure from M1 (9.63 MPa) to M2 (6.88 MPa) continued to decrease to M3 (6.51 MPa) and slightly increased in M4 (6.56 MPa), followed by reduction in B6 (6.08 MPa) and sample M6 (5.46 MPa). This results shown that when the EVA content in the blends increased, the bending strength decreased.

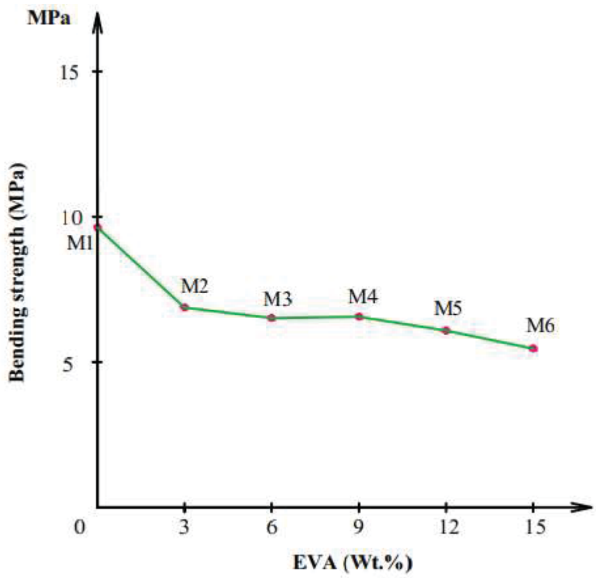


Figure 6: The average bending strength of test samples

The results of Charpy Impact strength was shown in Figure 7. The maximum impact velocity of the sample was 100% LDPE, when EVA was added into LDPE / EVA blends, the impact strength decreased very strong. For the EVA ratios in the LDPE / EVA blend, 3% EVA had the highest impact strength of 8.3 kJ/m^2, then it decreased slightly by increasing wt % of EVA to 6% and 9%. At 12% of EVA, the impact strength was increased to 7.1 kJ/m^2, and then decreased to 6.3 kJ/m^2 by increasing the wt % of EVA upto 15%.

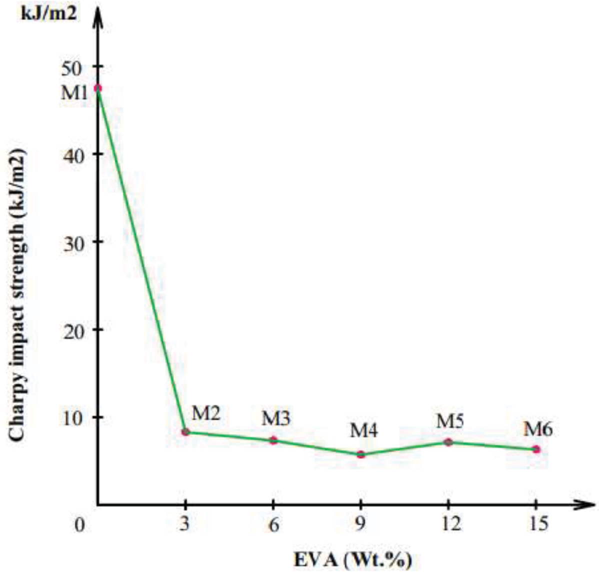
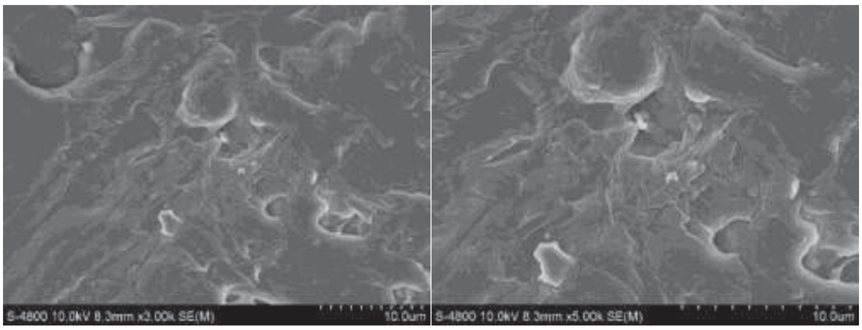
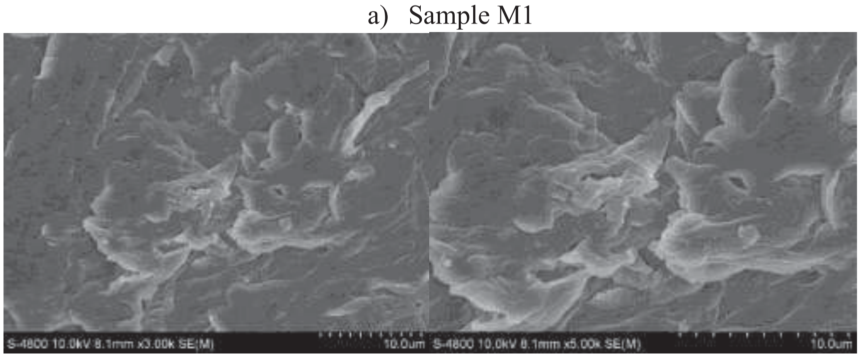


Figure 7: The average Charpy impact strength of test samples

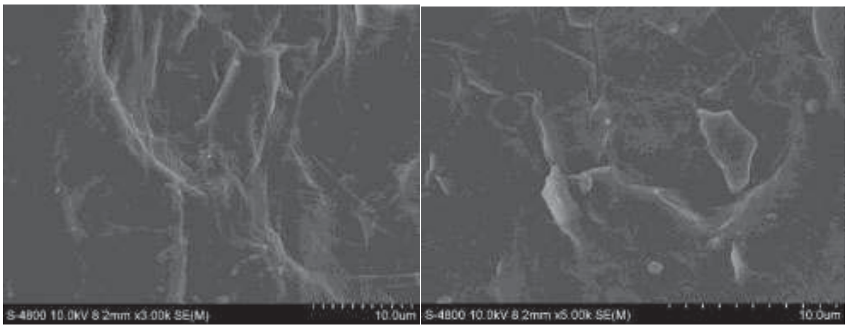
To better analyze the mechanical properties of the LDPE / EVA mixture. SEM micrographs for the LDPE/EVA blends was conducted. The results was shown in Figure 9 (a-b-c-d-e-f).



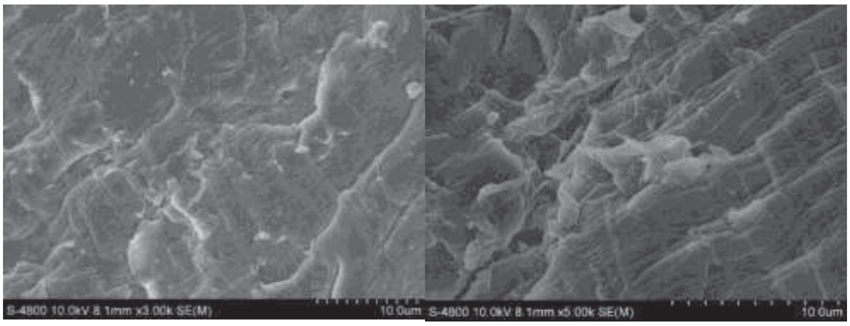
a) Sample M1



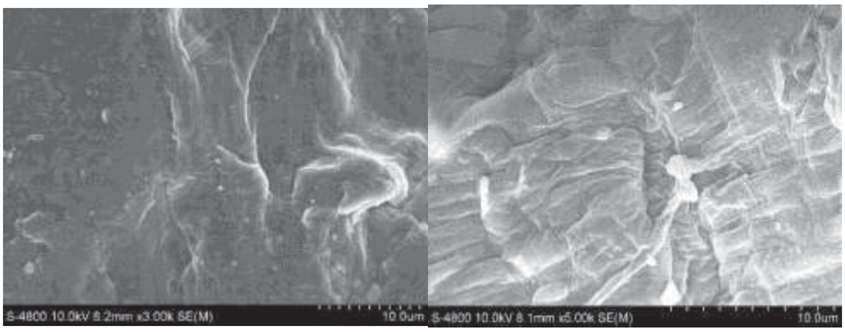
b) Sample M2



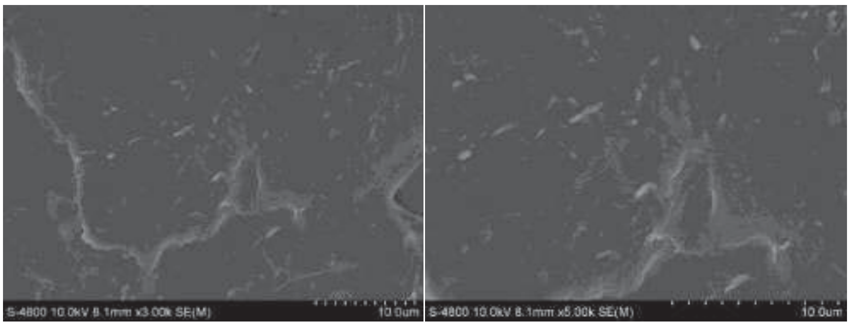
c) Sample M3



d) Sample M4



e) Sample M5



f) Sample M6

Figure 9: SEM micrographs for the LDPE/EVA blend with different weight percent of EVA

Discussion

About the tensile strength and elongation of LDPE/EVA blends, the reaction between the radicals of PE and EVA to form copolymers and block copolymers (PE-g-EVA and PE-b-EVA) acting as a compatibilizer for these two polymers is unlikely. As for LDPE, low density polymers and during fabrication, the mixing process is merely a labyrinthine hybridization of LDPE and EVA under mechanical impact. LDPE and EVA are different with their chemical nature, chemical structure, polarization, surface energy interaction… compatibility of the two polymers is low. Therefore, the material obtained does not enhance the outstanding properties of the component polymers [2, 9]. In studies about the tensile strength of the LDPE/ EVA blends, when irradiated with radiation to alter the chemical structure of the mixture, the same absorbed dose, the mechanical properties of the LDPE/ EVA blend will increase linearly when increasing wt % of EVA. Based on empirical data, it was found that when EVA was increased in the mixture of LDPE/ EVA blends, the tensile strength of the LDPE/EVA blends material decreased linearly as the wt % of EVA in the blends increased.

To explain the result of Charpy impact strength, enhanced compatibility of LDPE and EVA had been explained by the occurrence of chemical reactions during the melting process. Because the large molecule EVA is capable of generating free radicals easily, so EVA-free radicals may react with the vinylylene group or the free radicals of LDPE at high temperatures. The cross-link between LDPE and EVA polymers is made to increase adhesion between polymers in the blend. For the samples to be prepared the mixing process is a mix and macromolecules of LDPE and EVA under mechanical impact. Therefore, the increase in the EVA ratio in the LDPE/ EVA blends does not increase the impact strength of the mixture [4, 9].

The results of the SEM images, from the sample M2, there were EVA spherical particles dispersed on the LDPE substrate, in the sample with the highest EVA content of 15% (M6), the number of these particles appears was quite high. The number of EVA particles increased from the M2 to M6 dispersed fairly evenly across the surface. The size of EVA particles decreased and the number of particles increased as the EVA content in the blend increased. Clear bipartite boundaries and relatively poor adhesion.

Conclusion

Based on the above results, when increasing 0, 3, 6, 9, 12 and 15 wt.% of EVA into LDPE/ EVA blends, the tensile strength decreased. Bending strength of samples decreased when the EVA content in the blends increased. When adding EVA to LDPE/ EVA blends, the impact strength decreased strongly. Elongnation increased with the appearance of EVA, compared to samples containing 100% LDPE.

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