EVALUATION OF ALTERNATIVE MATERIALS TO IMPROVE THE THERMAL, OPTICAL AND MECHANICAL PROPERTIES OF PIPES USED IN COMPACT PHOTOBIOREACTORS

Camila Agner D'Aquino, camidaquino@yahoo.com.br
Center of Research and Development for Self-Sustainable Energy (NPDEAS), Federal University of Paraná, Curitiba, Paraná, Brazil

Marilda Munaro, marilda@lactec.org.br
Institute of Technology to Development, LACTEC, Curitiba, Paraná, Brazil

José Viriato Coelho Vargas, vargasjvcv@gmail.com
Center of Research and Development for Self-Sustainable Energy (NPDEAS), Federal University of Paraná, Curitiba, Paraná, Brazil

Abstract. *The evaluation of different materials to application in photobioreactors and the development of new ones is essential to enable the cost of microalgae production, mainly for the purpose of biofuel production. It is known that the materials commonly used had some environmental and economical controversy relating to the use thereof. In despite this, blends of polypropylene random copolymer (RCP) with an oleofinic elastomer as an alternative to materials currently used were studied. Samples were studied by adding 10% (w/w) an oleofinic elastomer, ethylene-propylene based, in RCP matrix, which are with or without addition of anti-UV. The results showed that after 15 weeks of exposure to natural weathering the sample of 100% RCP resulted in a fragile behavior while the addition of the oleofinic elastomer helped to maintain the thermal, mechanical and optical properties of the material. Furthermore, it was observed a tendency of crosslinking formation in the samples with the addition of the oleofinic elastomer, resulting in a delay of the termination process of aging. The best results during the analyses was observed for the samples with the addition of anti-UV, once these samples showed no significant changes in their thermal, optical and mechanical response.*

Keywords*: polypropylene copolymer random, anti-UV, photobioreactor, aging*

1. INTRODUCTION

The energy, as the air and the water, is essential to human existence. However, the high consumption patterns and the current main sources are being exhausting, demanding new studies about renewable energy sources. It is in this context that the microalgae have been detached. These microorganisms are photosynthetic ones that present higher grow rates when compared with superior plants, also had the capacity of biological fixation of CO_2 and a good adaptation in harsh environments (D'Aquino and Schroeder, 2009).

The microalgae cultivation has been practiced since 50 years, in opened and shallow ponds, with a small or even without operational and contamination control (Sheehan et al., 1998; Borowitzka, 1999). This cheap cultivation method has a limited production and to a competitive fuel production the scale it is an important parameter (Tredici, 2004; Pérez, 2007). To supply this, photobioreactors has been developed. Photobioreators are closed reactors that allows better control of contamination, light provision, and other important variables (Lehr et al., 2009). All the same, still are expensive the microalgae cultivation in photobioreator, mainly because the apparatus costs, that involve expensive materials, as polycarbonate, acrylic and glass (Burgess and Fernández-Velasco, 2007). The materials used to photobioreactors implementation have to be durable under natural weathering condition, once these reactors are exposed to solar radiation due the photosynthesis process.

In this context, this paper will present the development and study of an alternative material to application in photobioreators. Was studied the natural aging of polypropylene copolymer random, because the optical and mechanical properties caused by the presence of ethylene in the polypropylene matrix. Also, these properties were improved by the addition of an oleofinic elastomer of isotatic polypropylene, with 15% (m/m) of ethylene.

2. EXPERIMENTAL

2.1 Blends preparation and composition

Were studied three different formulations: RP100 (100% of RCP), RP90 (addition of 90% of elastomer) and RP90UV (the previous formation with 0.5% of anti-UV additive). The formulations were prepared in a laboratory mixer (Draiz MH 100) at 3600 RPM.min^{-1}, thermopressed at 150 °C in aluminum molds protected with acetate and slowly cooled up to room temperature (cooling rate 3 °C.min^{-1}).

Table 1 shows the characteristics of each material used to development the transparent pipes.

Table 1. Characteristics of each material

Material	Provider	Density ($g.cm^{-3}$)	Melt flow index ($g.10min^{-1}$)
Polypropylene copolymer random (RCP)	Braskem	0.902	10
Oleofinic elastomer	QuantiQ	0.861	18
Anti-UV additive	Ciba	0.470-0.570	-

2.2 Natural aging

The prepared specimens were exposed at natural aging, according to ASTM D1435-05. After three different periods, five samples were collected and submitted to following tests.

2.3 Mechanical characterization of aged material

Tensile tests were proceed according to ASTM D638 , using an Instron 4467 materials tester, with a 100 kgf load cell. Five specimens of each sample were tested at crosshead speed of 10 $mm.min^{-1}$ and initial length (L_0) was around 10 mm.

2.4 Thermogravimetry Analysis (TGA) of aged material

TGA experiments were performed using a NETZSCH STA 449 for TGA measurements. The experiments the temperature was increased from 20º to 550ºC with a heating rate of 10ºC.min^{-1} in nitrogen atmosphere, then the samples were heated from 550ºC to 800ºC in oxygen atmosphere, to burn all organic material.

3. RESULTS AND DISCUTION

As can be observed by the tensile strength values (Figure 1), the elastomer addition did not change significantly the initial values. However, during the aging process, the elastomer helped in the maintenance of mechanical properties, once the sample RP100 showed a high decrement of tensile strength after 3144 hours of exposure.

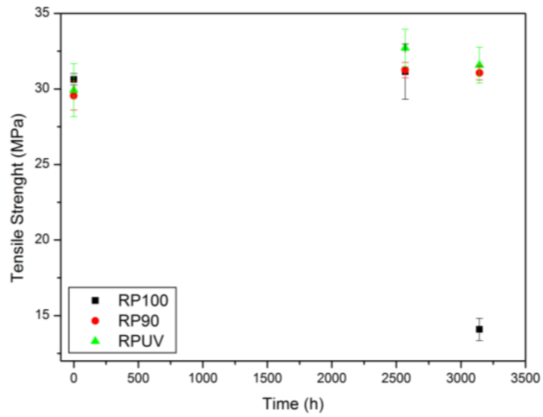


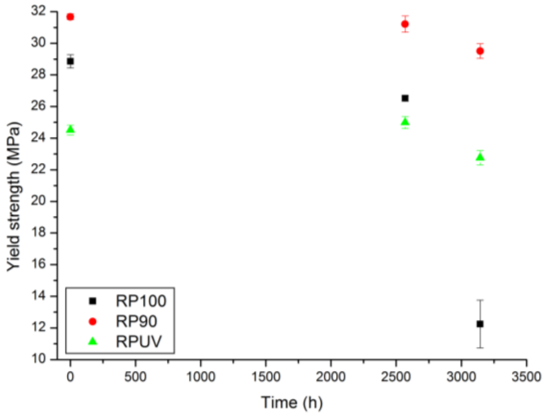
Figure 1. Tensile strength values: (a) RP100; (b) RP90 and (c) RP90UV.

The sample RP100 presented a decrement of yield strength (Figure 2a), the same behavior of tensile strength. These properties are improved with the elastomer addition. What could be explained by the increase of amorphous phase, helping the improvement of mechanical properties through the stress absorption.

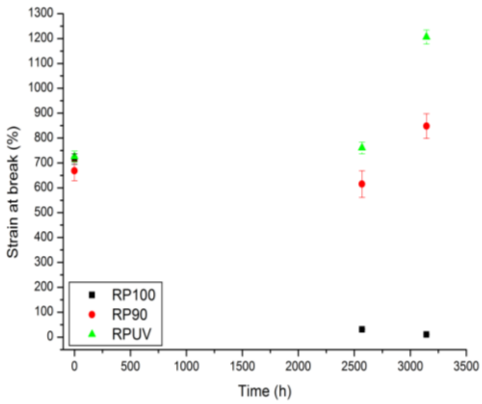
The elongation at break it is a parameters that represent the percentual increment of the sample length under tensile in the time of break. As can be noted in the Figure 2, this property showed an initial decrement to samples RP90 RP90UV. These values, across to confirm the preposition of crosslinking phenomenon, they could be explained by the better dispersion of the elastomer in the matrix during the aging process, what could improve the mechanical properties.

Observing the decrement of the tensile strength and the increment of the elongation at break values, mainly to initial samples, we can consider the phenomenon of crosslinking to samples RP90 and RP90UV. The crosslinking behavior is observed after the first time of exposure by the rearrangement of crystalline structures, followed by chain scission of them.

As well expected, the sample that contained anti-UV additive obtained the best results, due the radiation protection supplied by the additive.



(a)



(b)

Figure 2. (a) Yield strenght for RCP blends as a function of time of exposure; (b) Strain at break for RCP blends as a function of time of exposure.

The Figure 3 shows the profile of thermogravimetric curves after 34 weeks of exposition.

These curves represent the percentage of mass loss as function of temperatures. The samples present no significant change in the thermal resistance. Also, the sample RP90UV is detached due the better profile. That can be because the anti UV addition consequence.

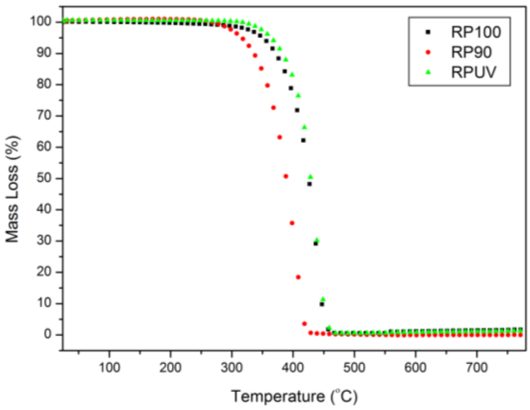


Figure 3. Thermogravimetric curves obtained after 34 weeks of natural exposition.

The sample RP90 shows a decrease of thermal resistance, due the incorporation of a compound with less thermal stability – the ethylene.

4. CONCLUSIONS

The incorporation of elastomer in polypropylene matrix increased the mechanical properties. However, the anti-UV addition was conclusive to manufacture a weather-resistant material while the material optical properties were improved by elastomer addition. Therefore, these blends can be considered a good choice to application in photobioreactors.

5. ACKNOWLEDGEMENTS

The authors acknowledge the support of the Brazilian National Council of Scientific and Technological Development, CNPq. We also thank to all the providers by materials supply to this study.

6. REFERENCES

AMERICAN SOCIETY FOR TESTING AND MATERIALS. ASTM D638M: Standard Test Method for Tensile Properties of Plastics (Metric). West Conshohocken. 1996.

AMERICAN SOCIETY FOR TESTING AND MATERIALS. ASTM D1435-05: Standard Practice for Outdoor Weathering of Plastics. West Conshohocken. 2005.

BOROWITZKA, M. A. Commercial production of microalgae: ponds, tanks, and fermenters. Progress in Industrial Microbiology, v. 35, p. 313-321, 1999.

BURGESS, G.; FERNANDEZVELASCO, J. Materials, operational energy inputs, and net energy ratio for photobiological hydrogen production. International Journal of Hydrogen Energy, v. 32, n. 9, p. 1225-1234, 2007.

D'AQUINO, C.A.; SCHROEDER, L.. Proposta de sistema de baixo custo para cultivo de microalgas. 100 p. Trabalho de conclusão de curso (Tecnologia em Química Ambiental) – Departamento de Química e Biologia, Universidade Tecnológica Federal do Paraná, Curitiba. 2009.

LEHR, F.; POSTEN, CLEMENS. Closed photo-bioreactors as tools for biofuel production. Current opinion in biotechnology, v. 20, n. 3, p. 280-5, 2009.

POSTEN, C.. Production of energetic and high value products with microalgae in photobioreactors. Rotterdam: World Biofuels Markets. Anais... p.22, 2011.

PÉREZ, H. E. B. Biodiesel de microalgas. São Paulo, 2007.

TREDICI, M. R. Mass production of microalgae: Photobioreactors. In: A. Richmond (Ed.); Handbook of microalgal culture: biotechnology and applied phycology. p.178-214, 2004. Oxford: Blackwell Science.

6. RESPONSIBILITY NOTICE

The authors are the only responsible for the printed material included in this paper.