TITLE	TOUGHNESS IMPROVEMENT OF POLY(LACTIC ACID) USING EPOXIDIZED HYDROGENATED NATURAL RUBBER
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ABSTRACT	The main objective of this research is to improve the toughness of poly(lactic acid) by using epoxidized hydrogenated natural rubber (EHNR) as a toughening agent. Natural rubber (NR) was chemically modified via two chemical pathways: hydrogenation using diimide generated from the reaction of hydrazine and hydrogen peroxide, and epoxidation using formic acid and hydrogen peroxide. The synthesized EHNRs were separately prepared with the difference in the epoxide content at 10 mol% (EHNR-10) and 30 mol% (EHNR-30) by fixing the hydrogenation content. Fourier transform infrared (FT-IR) and nuclear magnetic resonance (1H-NMR) spectroscopy were employed to confirm the chemical structure of the synthesized EHNRs. Moreover, the thermal stability and glass transition temperature of the synthesized EHNRs were also evaluated by using thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC), respectively. The NR and modified NRs were then melt blended with PLA, i.e. NR/PLA, EHNR- 10/PLA and EHNR-30/PLA, using various rubber concentrations from 1 to 10 wt% in an internal mixer. Mechanical, thermal, morphological, dynamic mechanical, and optical transparent properties of these blends were investigated. The results revealed that impact strength and elongation at break of PLA in the blends were enhanced significantly by the presence of NR and both EHNRs in the whole proportion used. On the other hand, the tensile modulus and strength tended to decrease after the rubbers were added. The impact strength of PLA was entirely increased about 2 times, 3 times, and 8 times for NR/PLA, EHNR-10/PLA, and EHNR-30/PLA blends containing 10 wt% rubber content, respectively, when compared to the neat PLA. At 7 wt% rubber content for each PLA blend, the elongation at break exhibited the highest plastic deformation, which dramatically elongated from 3.44% of neat PLA up to 4.83%, 15.36% and 16.41% for NR/PLA, EHNR-10/PLA, and EHNR- 30/PLA blends, respectively. The morphologies of PLA blends typically displayed the immiscible blend characteristic where spherical rubber particles were uniformly dispersed in the PLA matrix.

	The partial compatibility of EHNR with PLA blends affected smaller dispersed rubber particles than NR and many fibrils appeared in the fractured surfaces. These results are clear evidence that the brittle PLA was transformed into ductile material. Thermal stability of EHNR/PLA blends were reasonably improved as compared with the NR/PLA blends. The glass transition behavior of PLA in the blends did not evidently change by the introduction of these rubbers, when evaluated by DMA and DSC techniques. The rigidity of PLA blends was decreased with an increase of rubber content. Also, with the presence of NR and EHNRs, the crystallinity of PLA was reduced. Furthermore, the transparency of EHNR/PLA blend films are higher than that of NR/PLA blend films, which clearly proved a better compatibility of EHNR with PLA when compared to the use of unmodified NR.