NATURAL RUBBER COMPOSITE MIXED WITH POLYETHELENE - ALUMINUM FROM USED BEVERAGE CARTONS WASTES

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Keywords: Natural rubber composites, Polyethylene-aluminum composite, Recycling of used beverage carton, Used beverage carton waste, PolyAl

A large amount of beverage carton

Increasing products values

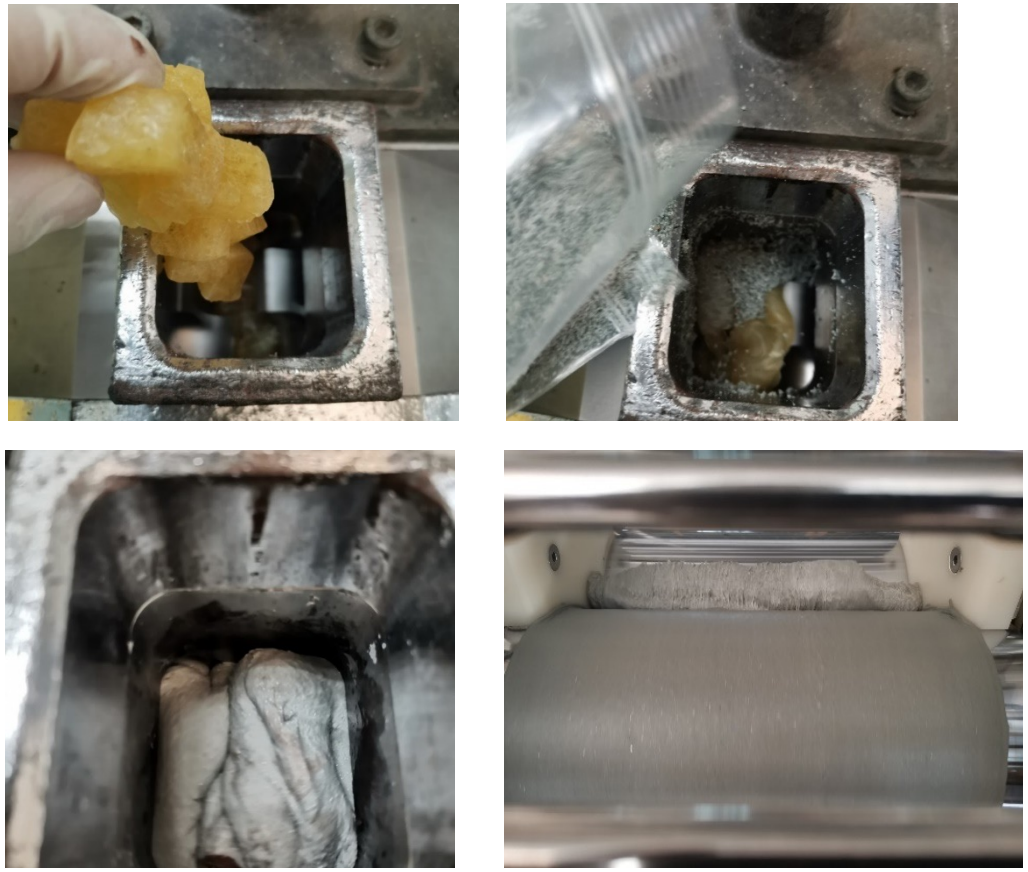
Figure 1 Natural rubber
(ref: https://www.enjoythailandtravel.com/wp-content/uploads/2018/11/01-4.jpg
https://vietnamnews.vn/economy/481209/tetra-pak-veolia-tie-up-on-recycling.html)

Problems and solution for rubber price fall

Figure 2 Natural rubber
(https://www.raot.co.th/images/article/news6874/n20180823013411_27455.jpg)

Natural rubber composites

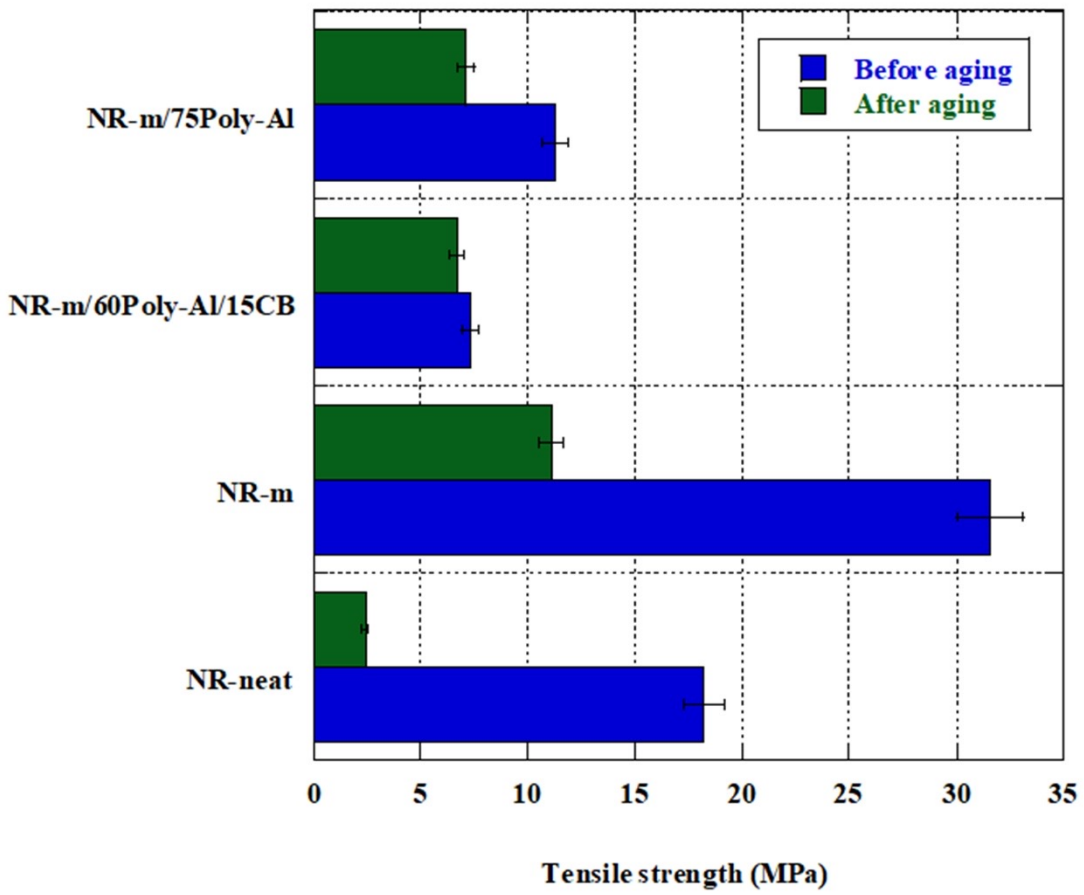
Regarding the aforementioned, this research focuses on studying and designing natural rubber compounds that incorporate recycled UHT cartons (PolyAl) as reinforced fillers with varying phr levels. The objective is to explore the mechanical properties of NR-PolyAl composites, making them suitable for rubber manufacturing.



Compounding process using internal mixer and two roll mill for preparing samples each case

Table 1 The composition of the rubber compounds.

Ingredients	Part I (phr)	Part II (phr)
NR (STR5L)	100	100
Reinforcement	PolyAl 0, 50, 100, 150	0, 60PolyAl/15CB, 75PolyAl
Zinc oxide (ZnO)	5	5
Magnesium oxide (MgO)	-	30
6PPD	-	2
Stearic acid ($C_{18}H_{36}O_2$),	2	2
Dibenzo thiazyl Tetramethyl thiuram disulfide (TMTD)	1	1
Disulphide (MBTS),	1	1
Sulfur (S_8)	2	2



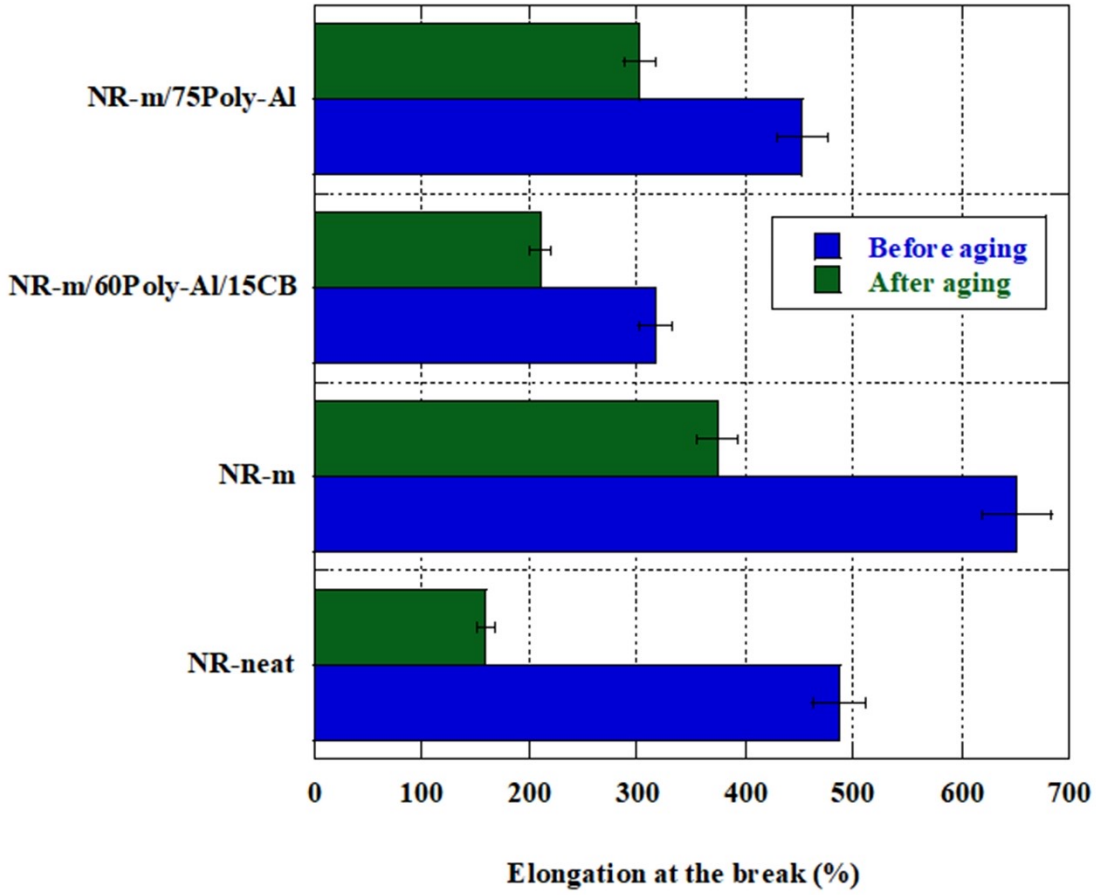


Fig. 1. The tensile properties of rubber composites as reinforcing fillers at 75 phr. (A) Tensile strength, and (B) Elongation at the break.

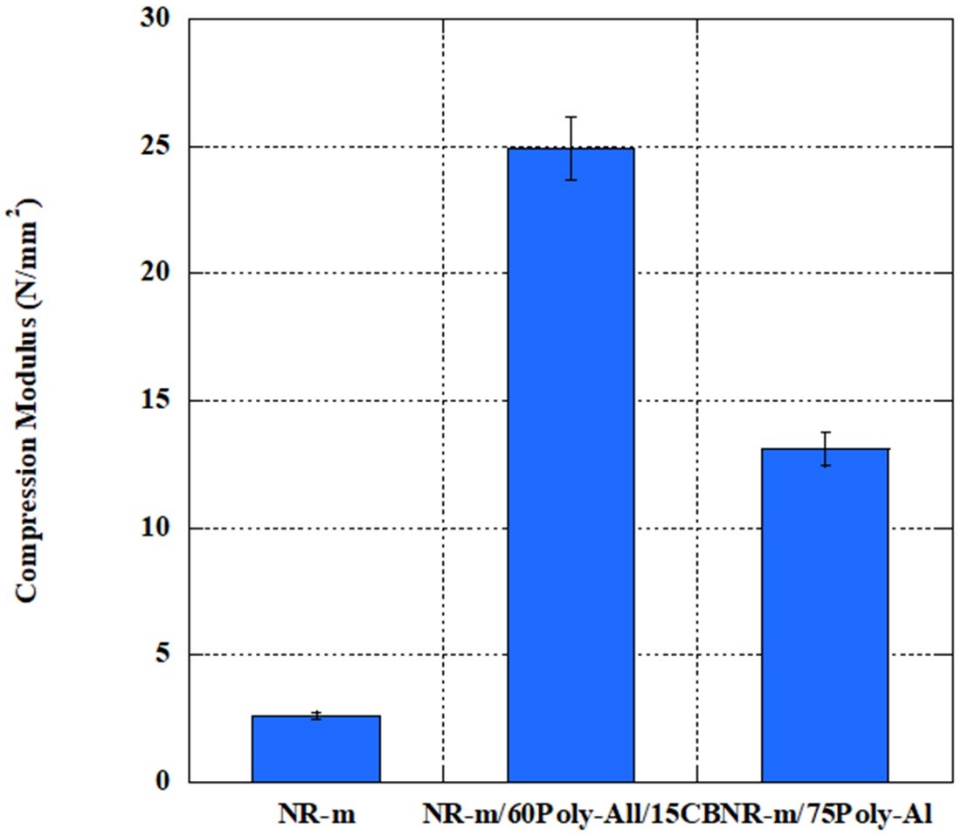


Fig. 2. The compression properties of rubber composites as reinforcing fillers at 75 phr.

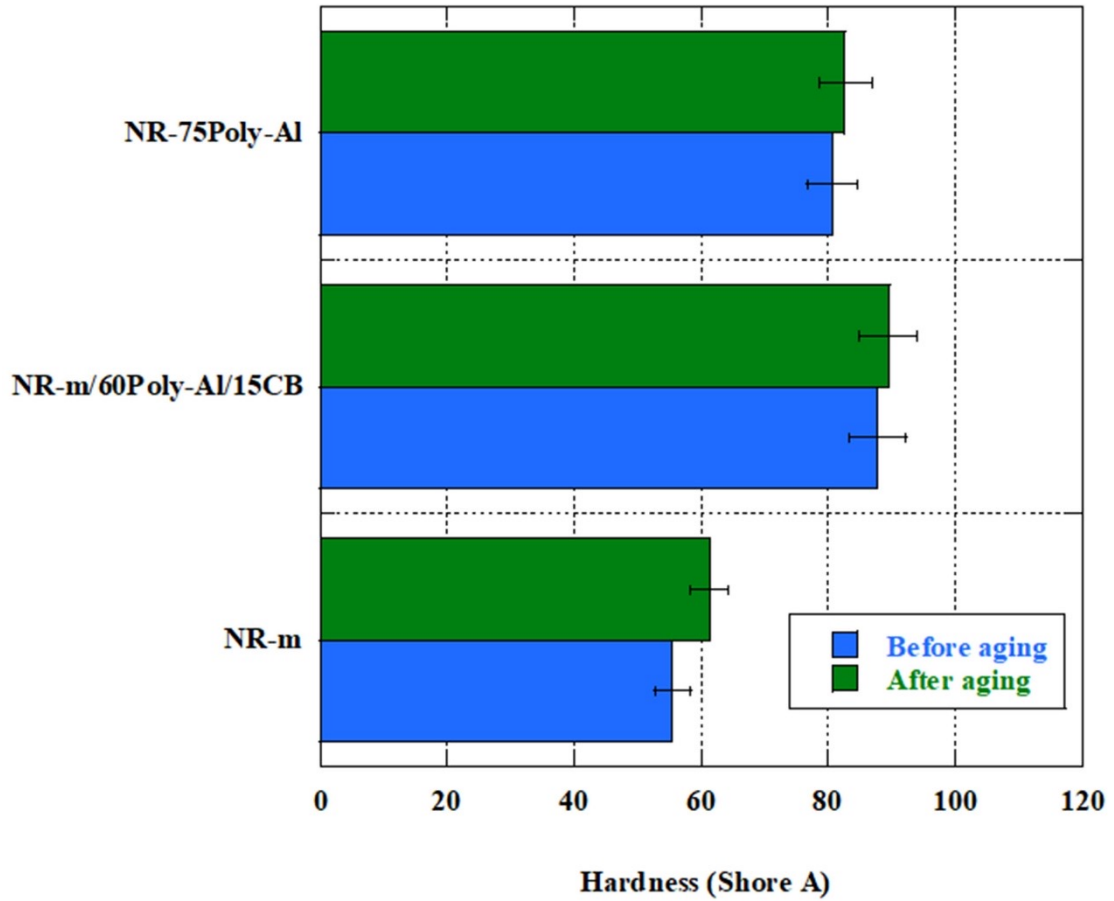


Fig.3. The hardness results of rubber composites as reinforcing fillers at 75 phr.

Figures 8 and 9,it is evident that the hybrid fillers, NR-m with 60PolyAl/15CB and NR-m with 75PolyAl, have significantly enhanced the compression. According to the data presented, the composites exhibited a strength of 24.9 N/mm2 and were 857% higher than the Nr-m composites.

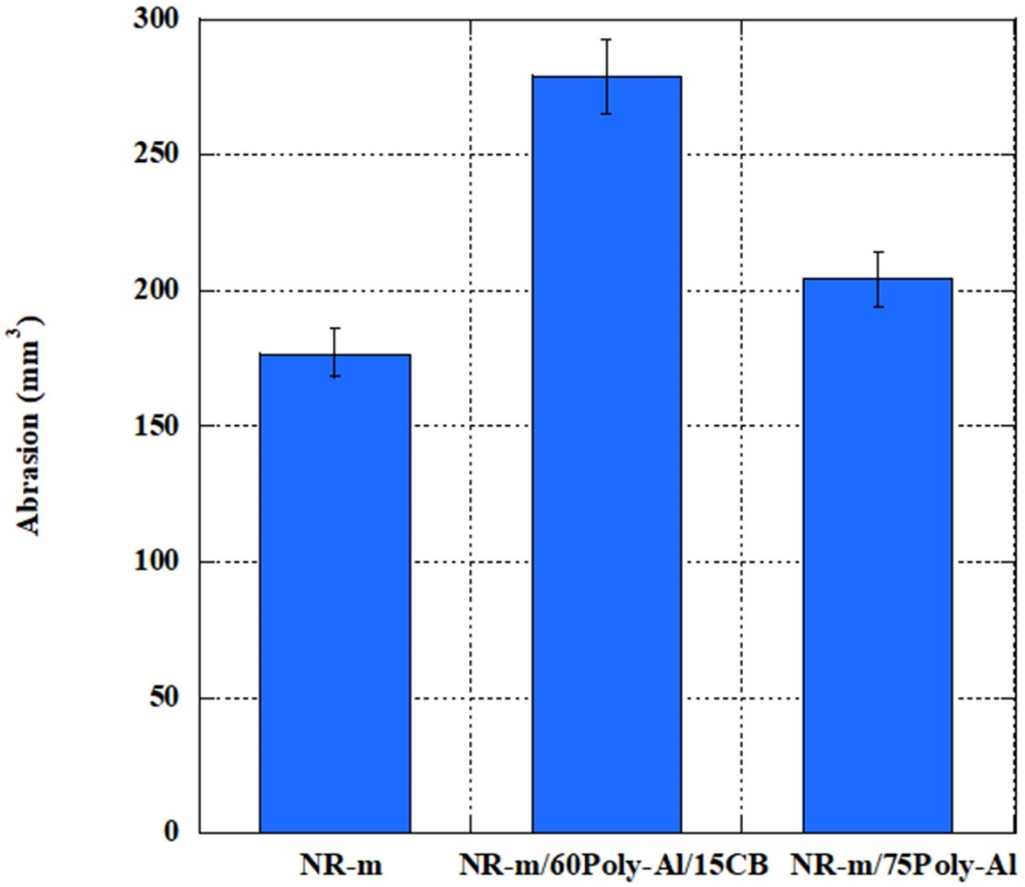
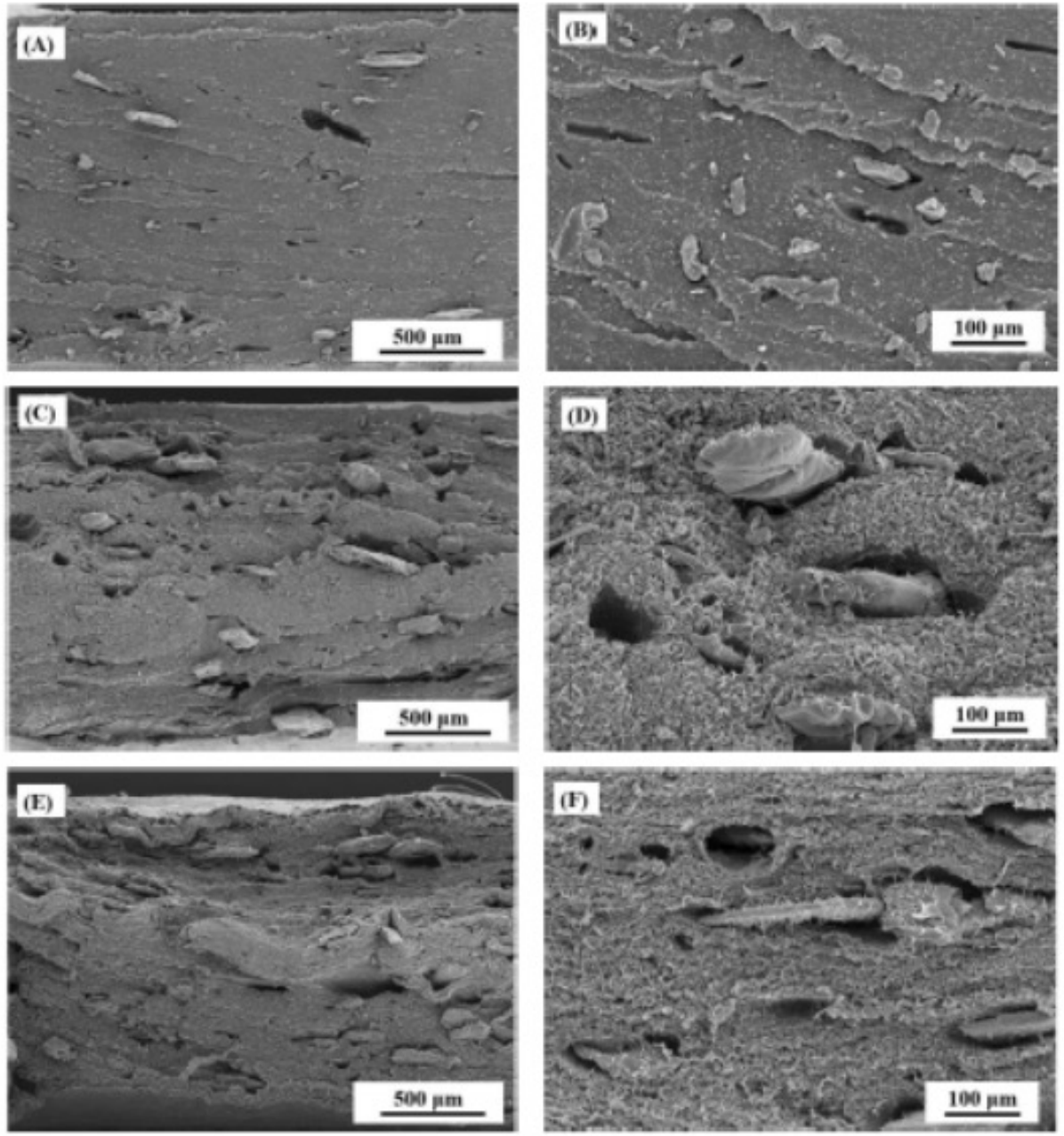


Fig. 4. The abrasion results of rubber composites as reinforcing fillers at 75 phr.

Additionally, the NR-m with 75PolyAl showed a hardness of 89.6 shore A and abrasion of 279 mm3, which was 57.6% greater than the Nr-m composites in both categories.

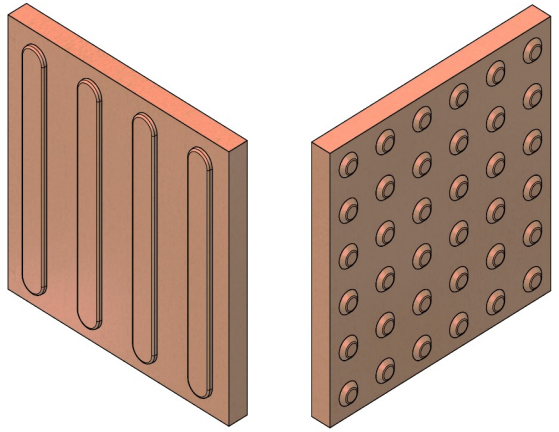


The dispersion behaviors of PolyAl reinforcing fillers in the NR matrix are displayed at 100 µm and 500 µm. The study analyzed different compositions, including (A) and (B) of NR/50PolyAl, (C) and (D) of NR/100PolyAl, and (E) and (F) of NR/150PolyAl.

- As the amount of PolyAl increased, the distance between its particles decreased, which was observed through a comparison. The dispersion behavior of NR/50PolyAl depicted in Figure (A) and (B) revealed the highest dispersion between PolyAl particles. The increase in PolyAl had an impact on the stress between the interfaces of the matrix and reinforced fillers, resulting in a tendency to decrease the tensile strength and elongation at break.
- Figure (C) to (F) demonstrate that the dispersion of PolyAl in the NR matrix is good at 100 phr and 150 phr. Adding a significant amount of PolyAl particles has a positive impact on improving the 100% modulus, tensile strength, elongation at break, compression set, and hardness.

CONCLUSIONS

- The research found that the PolyAl reinforcing fillers were very effective in improving tensile strength and elongation at break. After thermal aging, the hybrid fillers showed even greater improvements in these areas compared to NR. After conducting tests, it was found that NR combined with 150PolyAl showed improved 100% modulus, compression set, and hardness. However, it was observed that increasing the amount of PolyAl in NR-PolyAl composites resulted in decreased insulation properties. Upon analyzing the morphology with SEM, it was determined that increasing PolyAl from 100 phr to 150 phr resulted in enhanced particle dispersion within the NR matrix. This improved dispersion ultimately led to better mechanical properties of NR composites.
- Incorporating magnesium hydroxide led to NR-m composites displaying superior mechanical properties in terms of tensile strength and elongation at break when compared to NR composites. When comparing hybrid fillers of NR with PolyAl and CB against a single filler of PolyAl at 75 phr, it was discovered that the 60PolyAl/15CB combination demonstrated the highest 100% modulus, compression set, hardness, and abrasion. However, a single PolyAl at 75 phr displayed greater tensile strength and elongation at break than the hybrid fillers.



Guiding tactile flooring

Warning tactile flooring

Fig. 5. Indoor braille block use for accessibility information of Japan

(Ref : https://accessible-japan.jp/img/accessibility/block.jpg;
https://www.wazzadu.com/article/5158)