MRC ILF Industry-University Interaction Session 2022

Eversafe Rubber Works Sdn. Bhd. & Universiti Sains Malaysia

A success story of MRC ILF100703

Malaysian Green Pre-cured Tire Tread Liner

永安橡胶
EVERSAFE RUBBER BERHAD
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MRC
MALAYSIAN RUBBER COUNCIL

KAMI MEMIMPIN
USM
UNIVERSITI SAINS MALAYSIA

PROFILE OF RESEARCHERS

Project Leader

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General Manager - Production

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Assoc. Prof. Ir. Dr. Nadras Othman

USM

Project Team

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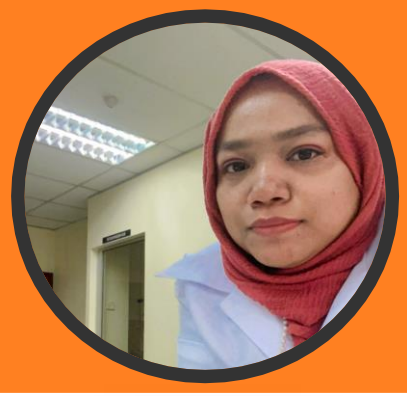
CEO

Eversafe Rubber Works Sdn. Bhd.

Project Team

Assoc. Prof. Dr. Raa Khimi Shuib

USM



PhD Student

Nur Raihan Mohamed

USM

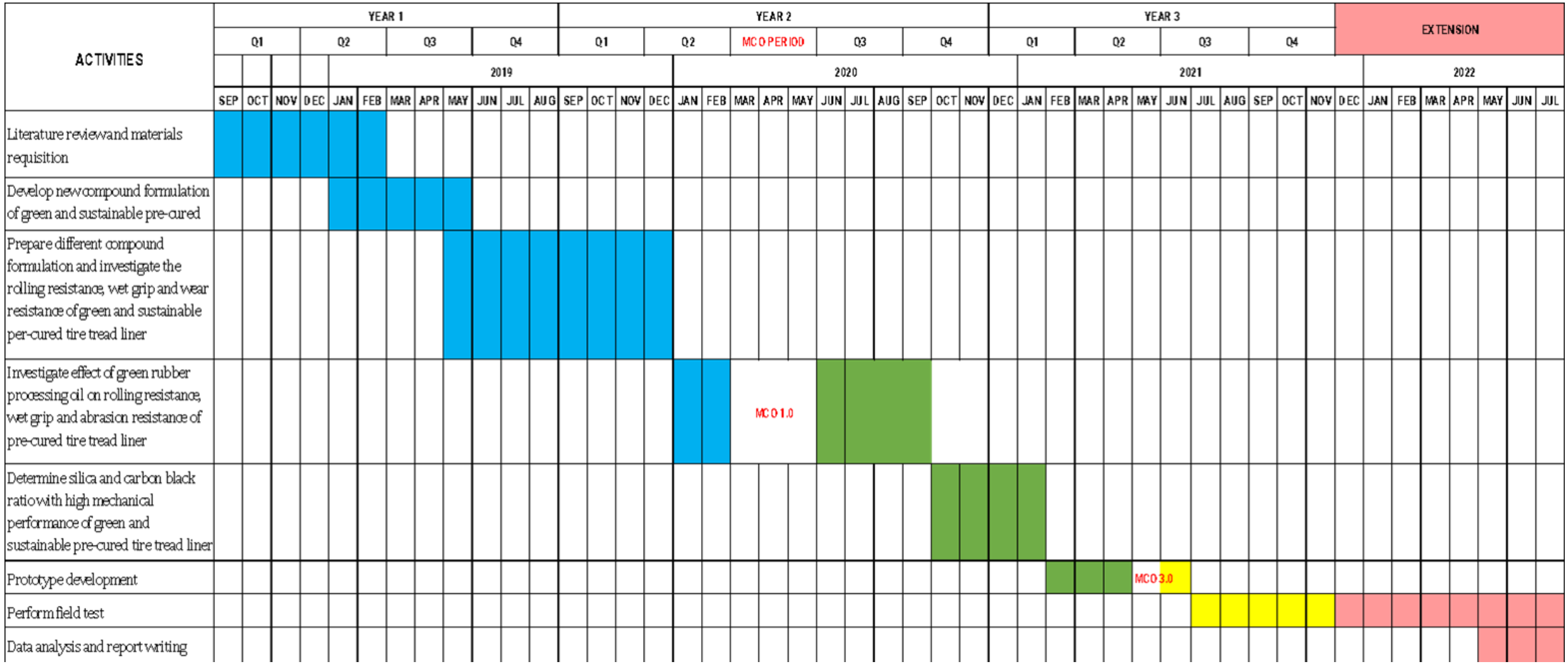
OBJECTIVE

1. Develop new formulation of green and sustainable pre-cured tire tread liner
2. Determine hybrid fillers ratio with high mechanical performance
3. Investigate tire performance of the proposed formulations
4. Investigate effect of green rubber processing oil on properties of tire tread liner
5. Fabricate Malaysian green and sustainable pre-cured tire tread liner

PROJECT MILESTONES

- Literature review and material requisition
- Develop new compound formulation of green and sustainable pre-cured tire tread liner
- Prepare different compound formulation and investigate the rolling resistance, wet grip and wear resistance of green and sustainable pre-cured tire tread liner
- Investigate the effect of green rubber processing oil on rolling resistance, wet grip and abrasion resistance of pre-cured tire tread liner
- Determine silica and carbon black ratio with the high mechanical performance of green and sustainable pre-cured tire tread liner
- Prototype development
- Perform field test
- Data analysis and report writing

Gantt Chart


ACTIVITIES
YEAR 1
YEAR 2
YEAR 3
EXTENSION
Q1
Q2
Q3
Q4
MCO PERIOD
2019
2020
2021
2022
SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL
Literature review and materials requisition
Develop new compound formulation of green and sustainable pre-cured
Prepare different compound formulation and investigate the rolling resistance, wet grip and wear resistance of green and sustainable per-cured tire tread liner
Investigate effect of green rubber processing oil on rolling resistance, wet grip and abrasion resistance of pre-cured tire tread liner
MCO 1.0
Determine silica and carbon black ratio with high mechanical performance of green and sustainable pre-cured tire tread liner
Prototype development
MCO 3.0
Perform field test
Data analysis and report writing

Research Work

Objective 1 : Development of new compound formulation of green and sustainable pre-cured tire tread liner

Trial compounds (1)

Blend composition
1.6 L Intensive mixer

Large scale trial run (2)

4 proposed blend compositions
160 L Banbury mixer

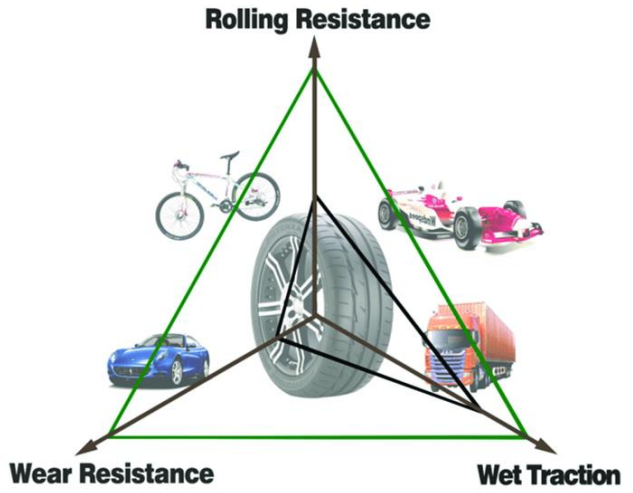
Characteristic of selection (3)

Wear resistance

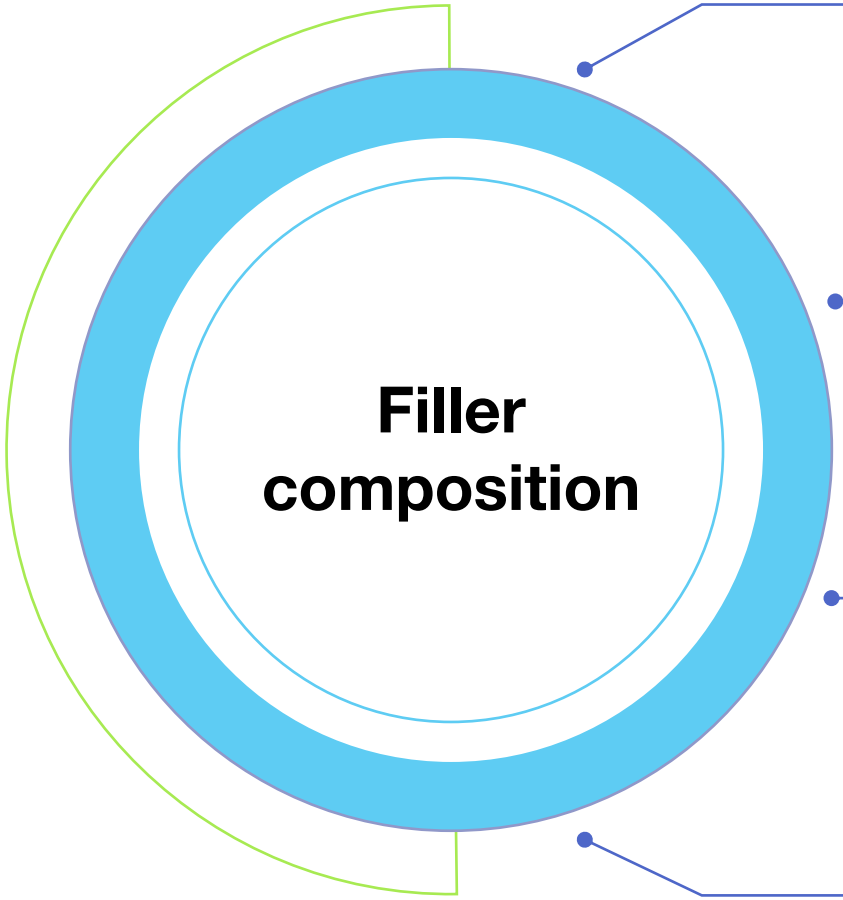
Dynamic mechanical properties (4)

Tyre performances
Rolling resistance
Skid resistance

Magic triangle of tire technology as indicator for tire performances:



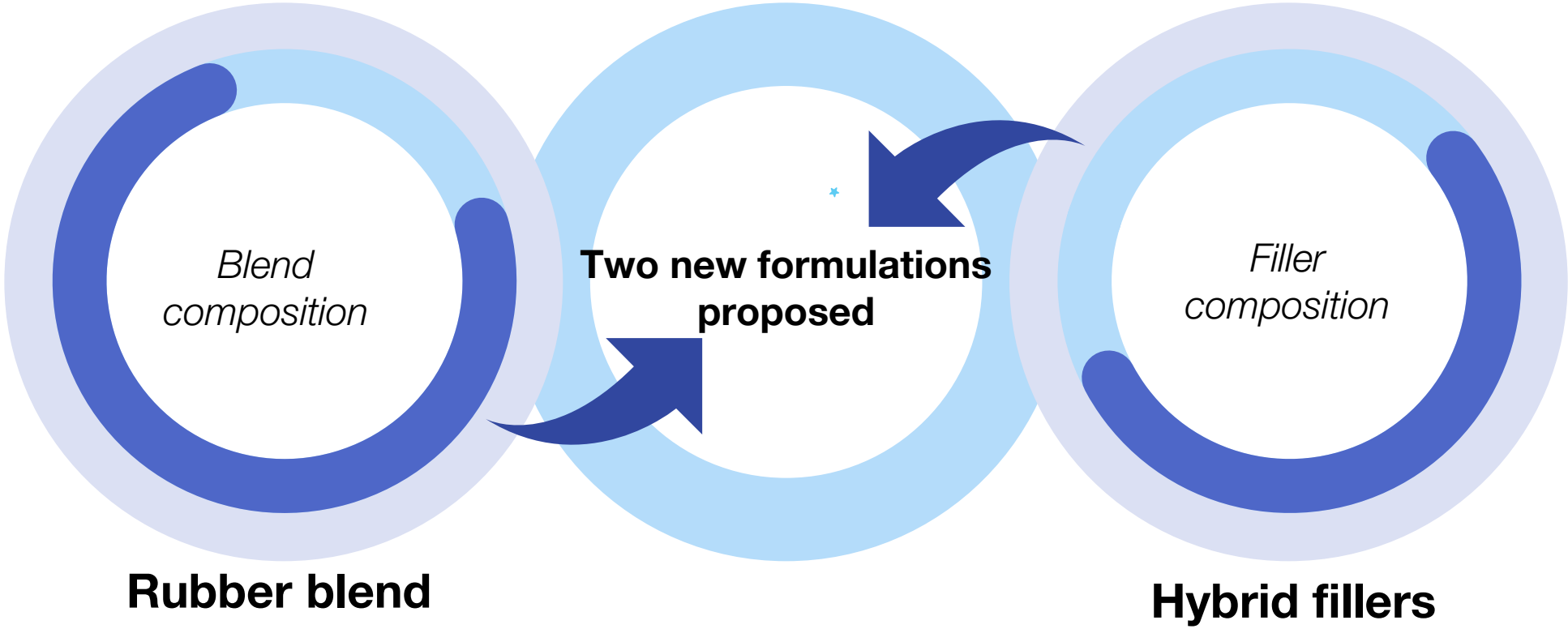
Objective 2 : Determination of fillers ratio with high mechanical performance of green and sustainable pre-cured tire tread liner



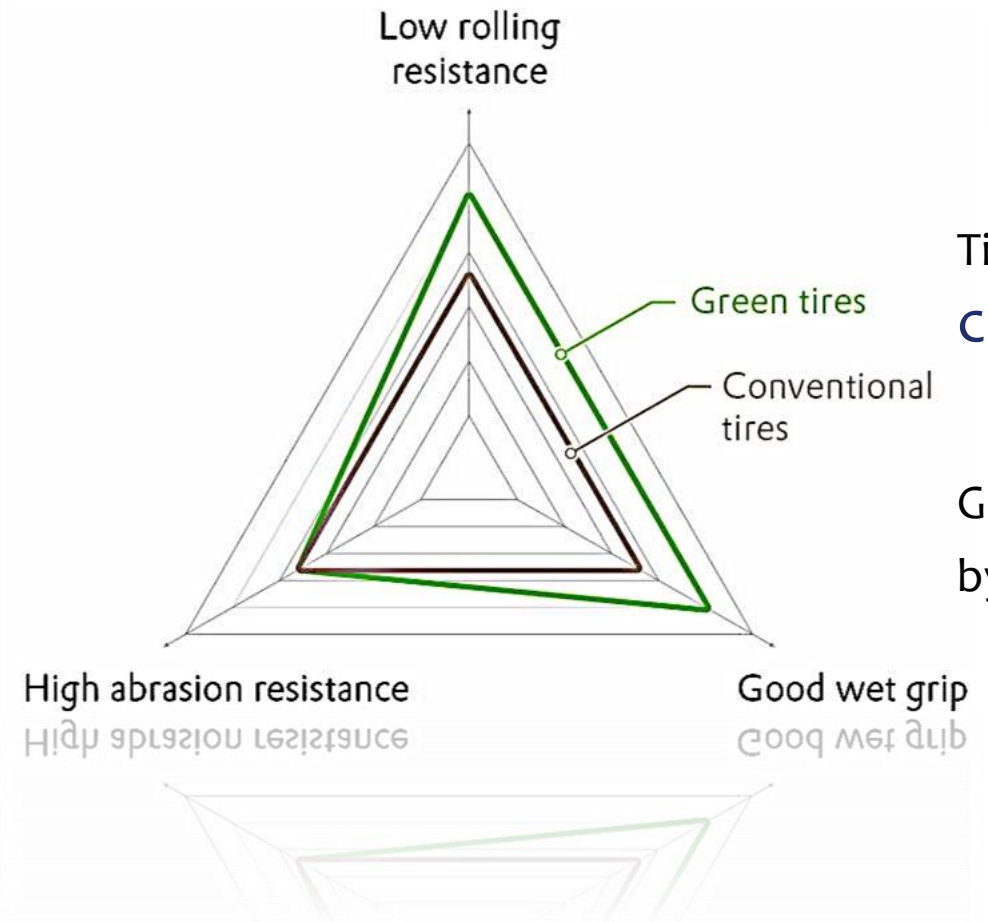
1. Hybrid fillers compositions were varied
2. Adjustment on key active ingredient according to published literature
3. Five compositions of hybrid fillers were proposed and processed using 1.6 L lab-use intensive mixer and 160 L Banbury mixer
4. Further study on cure characteristics, mechanical properties and dynamic mechanical properties were performed

Reference:
**Kaewsakul, W., Sahakaro, K., Dierkes, W. K., & Noordermeer, J. W. M. (2014). Flocculation Kinetics and Filler-Rubber Interaction in Silica-Reinforced NR Compounds. In Proceedings of 186th Technical Meeting ACS Rubber Division (pp. 1-20). ACS Rubber Division.*

Final formulations for rubber blend and fillers composition



Objective 3 : Investigation effect of different compound formulation on tire performance of green and sustainable pre-cured tire tread liner



Magic Triangle Tyre Technology

Tires with the Silica/Silane-system can reduce fuel consumption by up to 8% due to lower rolling resistance.

Good good wet grip allows tyre to reduce braking distance by many meters and thus improve driving safety.

Objective 3 : Investigation effect of different compound formulation on rtire performance of green and sustainable pre-cured tire tread liner

Measured at the peak of Tan δ and peak of loss modulus graph – plasticization of processing oil

Storage modulus and loss modulus

Glass transition temperature

Rolling resistance and skid resistance

Measured at DMA graph under temperature sweep (- 100 to 100 ℃)

Indication for rolling resistance (Tan δ at 60 ℃) and skid resistance (Tan δ at 0 ℃)

DMA8000

Measure viscoelastic properties of rubber and polymer compounds as functions of temperature, frequency, time, stress, and/or strain

Objective 4 : Investigation effect of different compound formulation on tire performance of green and sustainable pre-cured tire tread liner

Bio-based oil 1

Epoxidized Palm Oil

Bio-based oil 3

Sunflower Oil [SFO]

Petroleum-based oil

[RPO]

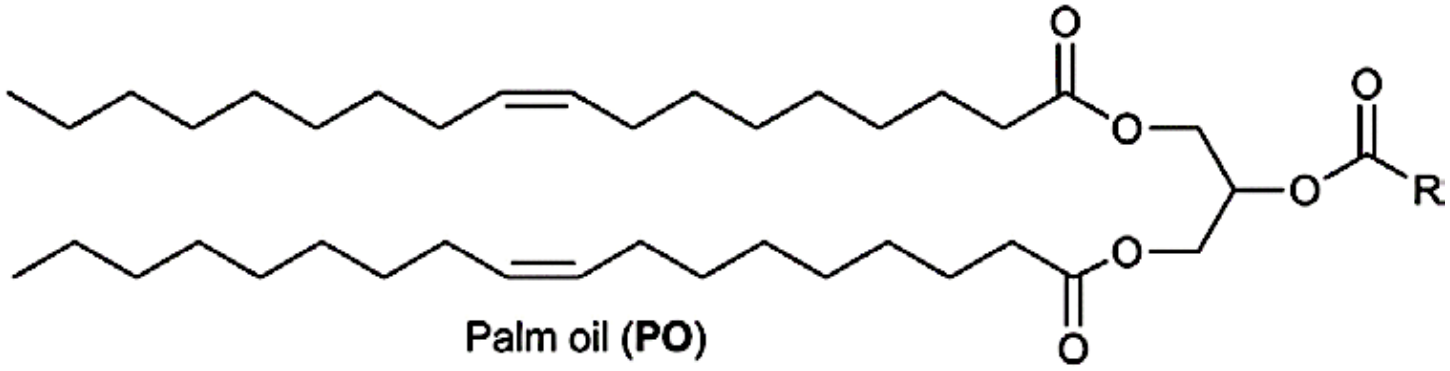
Bio-based oil 4

Soybean Oil [SBO]

Bio-based oil 2

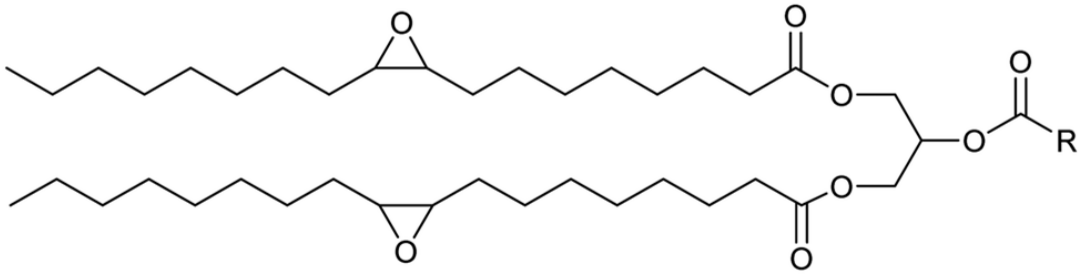
Coconut Oil [CO]

Selection of EPO as bio-based oil in prototype development



Palm oil (**PO**)

Epoxidation process



Epoxidized palm oil (**EPO**)

- Selection based on the **readily commercialized** bio-based oil in Malaysia.
- Furthermore, based on current study, EPO shows a promising results in **rolling resistance and skid resistance** in some of the compositions but low in wear resistance compared to control compound.
- Thus, the compositions of processing oil using EPO in the compounds were reduced from **46% - 77%**

Selection of final formulation

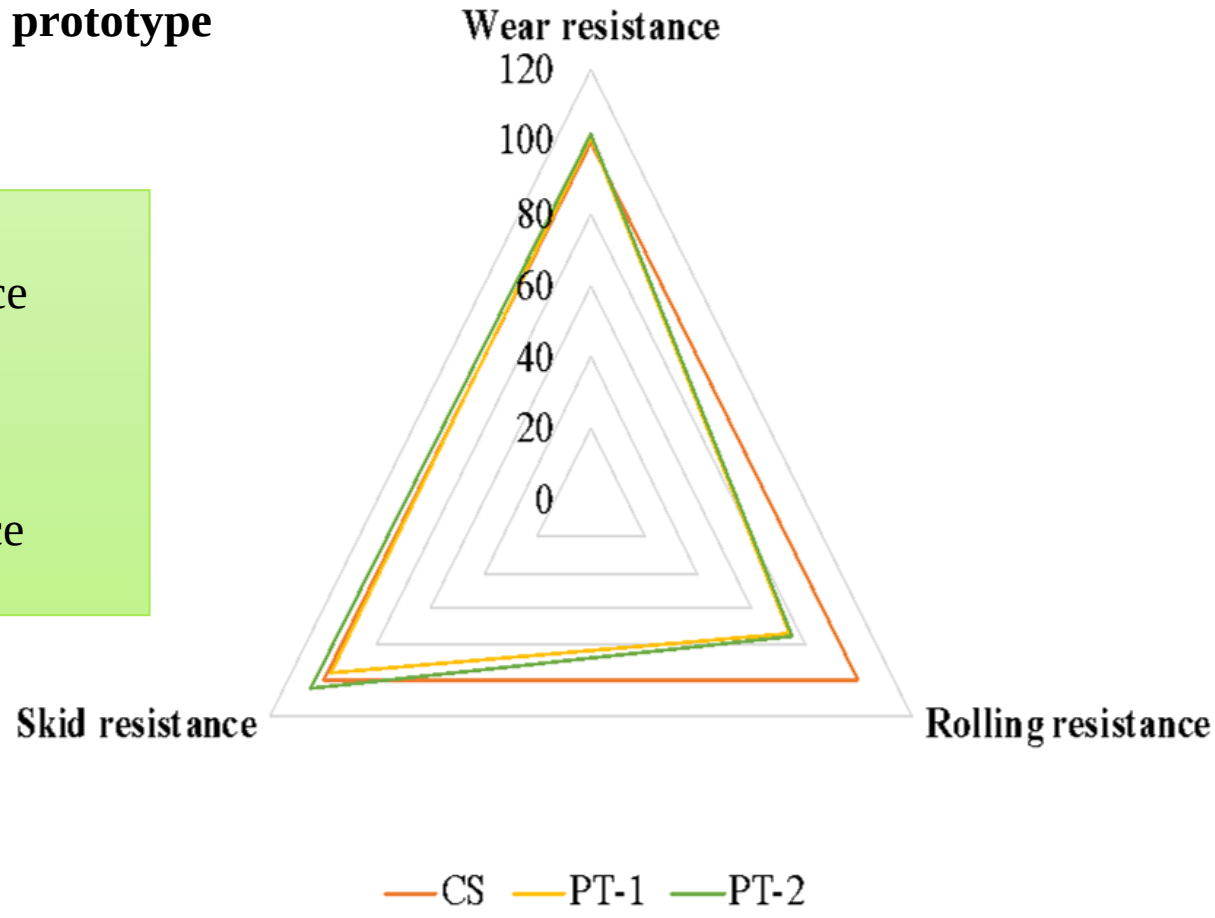
The following formulations were selected for the prototype development

PT- 1

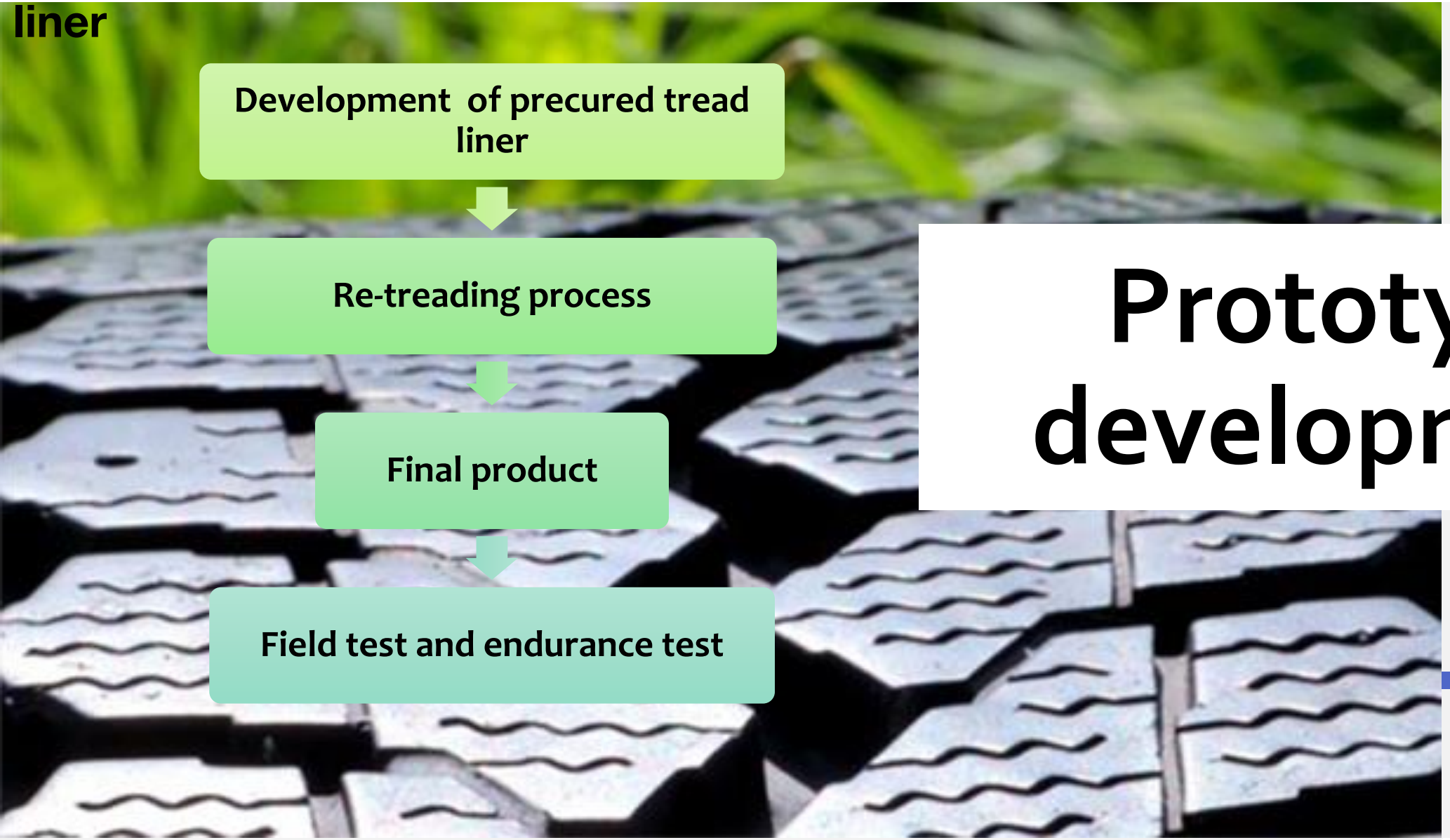
Good wear resistance and lower rolling resistance

PT-2

Lower rolling resistance and better skid resistance



Objective 5: To fabricate Malaysian green and sustainable pre-cured tire tread liner



Prototype development

Development of precured tread liner

Objective: To investigate the performance of new retread tires using Malaysian green and sustainable pre-cured tire tread liners.

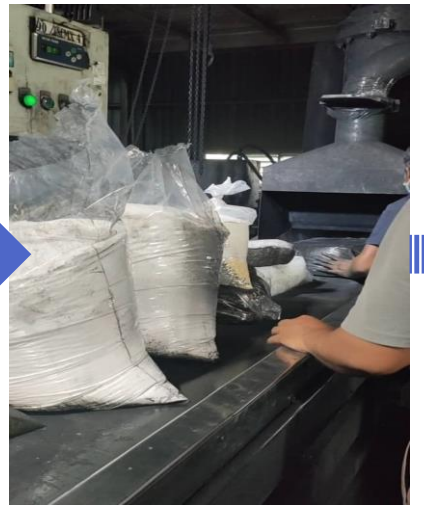
Development of precured tread liner for the prototype compounds consist of 3 main stages:

Compounding → **Extrusion** → **Hot Press**

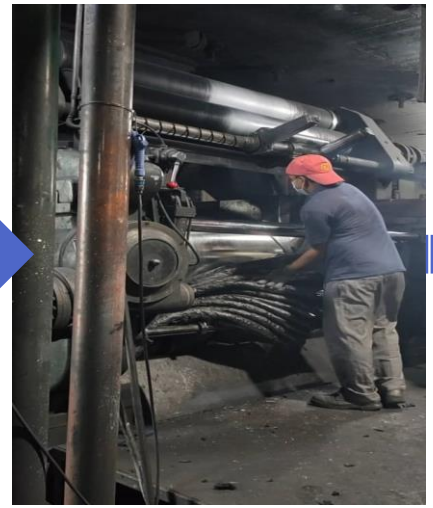
Compounding process of the prototype compounds

Masterbatch

Weighing process of dry and wet ingredients



Compounding process using 160 L Banbury mixer



Sheeting process using the two roll mill

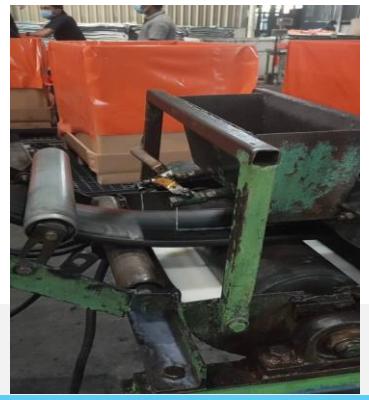
Final mix

After 24 hours, masterbatches were compounded with sulfur, accelerator and scorch retarder using the same Banbury mixer

Extrusion

Rubber sheet was loaded into the extruder with screw diameter 200 mm and screw length 14:1

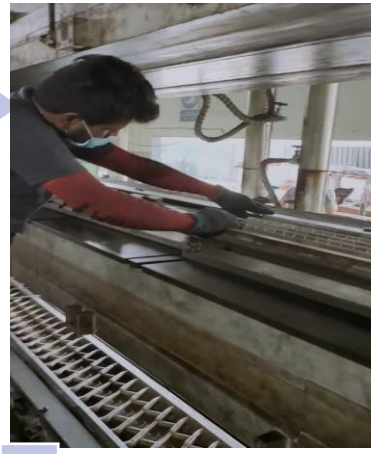
Liner was extruded from die. Die with the size 180 (width) x 17mm (thickness) was used.



As a finishing touch, anti-tack was applied on the surface of the liner.

Hot Press

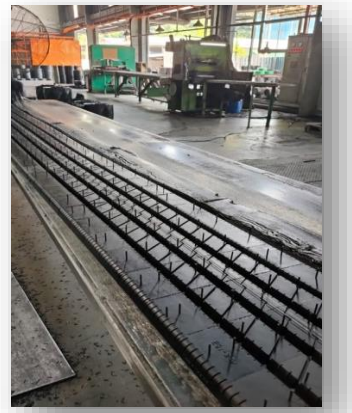
Selection of tread pattern in accordance to the Eversafe's tread pattern for the highway truck



Installation of the tread mould in the hot press machine

Liner was pressed at 150°C for 20 minutes.

Finished product



- All the works in objective 1 to 5 were accomplished at Eversafe Rubber Works Sdn. Bhd., Ipoh.
- This included compounding process, testing, developing the prototype of pre-cured tread liner and field testing of prototype tyres.

Retreading process

Retreading process

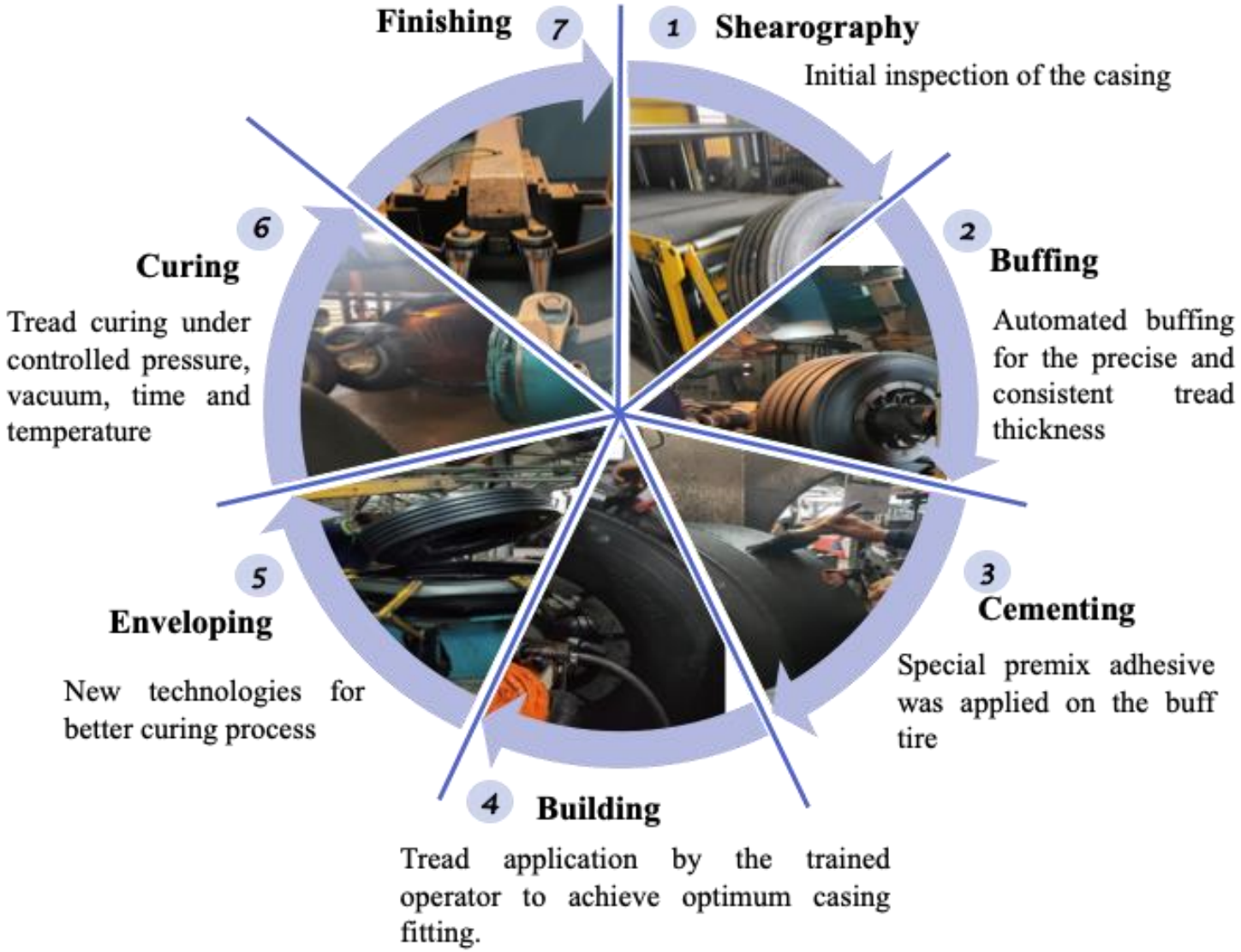
- New tires were used as the casing for the retreading process. The specification of the new tire as follows:

  Brand: Bridgestone

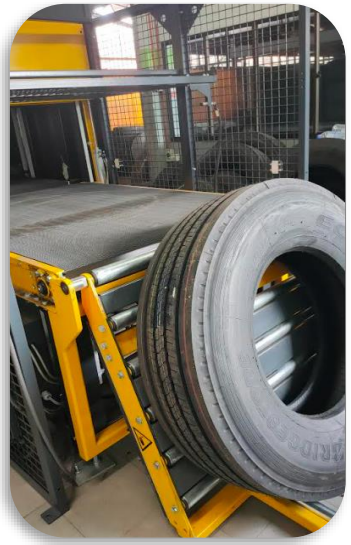
  Model: Ecopia R156

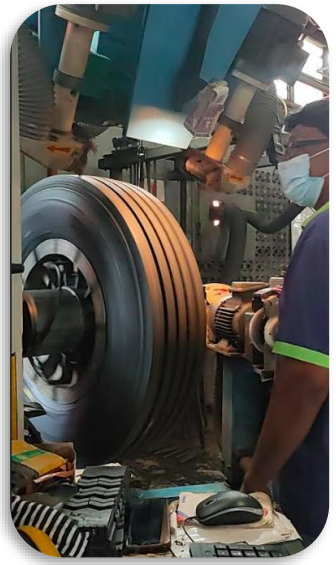
  Size: 295/80R22.5 152/148M

- The retreading process was summarized in the following diagram.

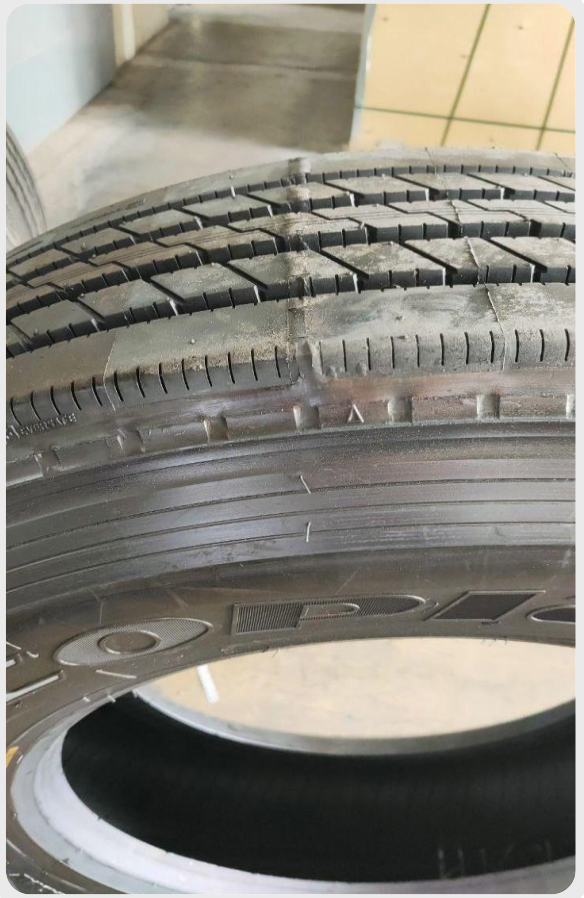


Retreading process at Olympic Retread Sdn. Bhd.





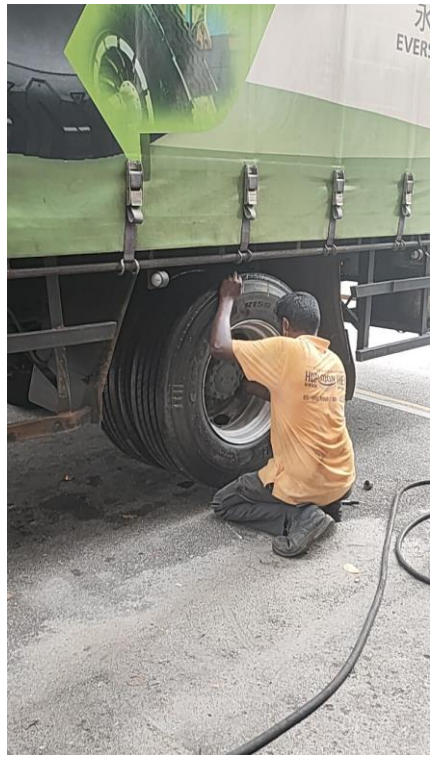
Final product



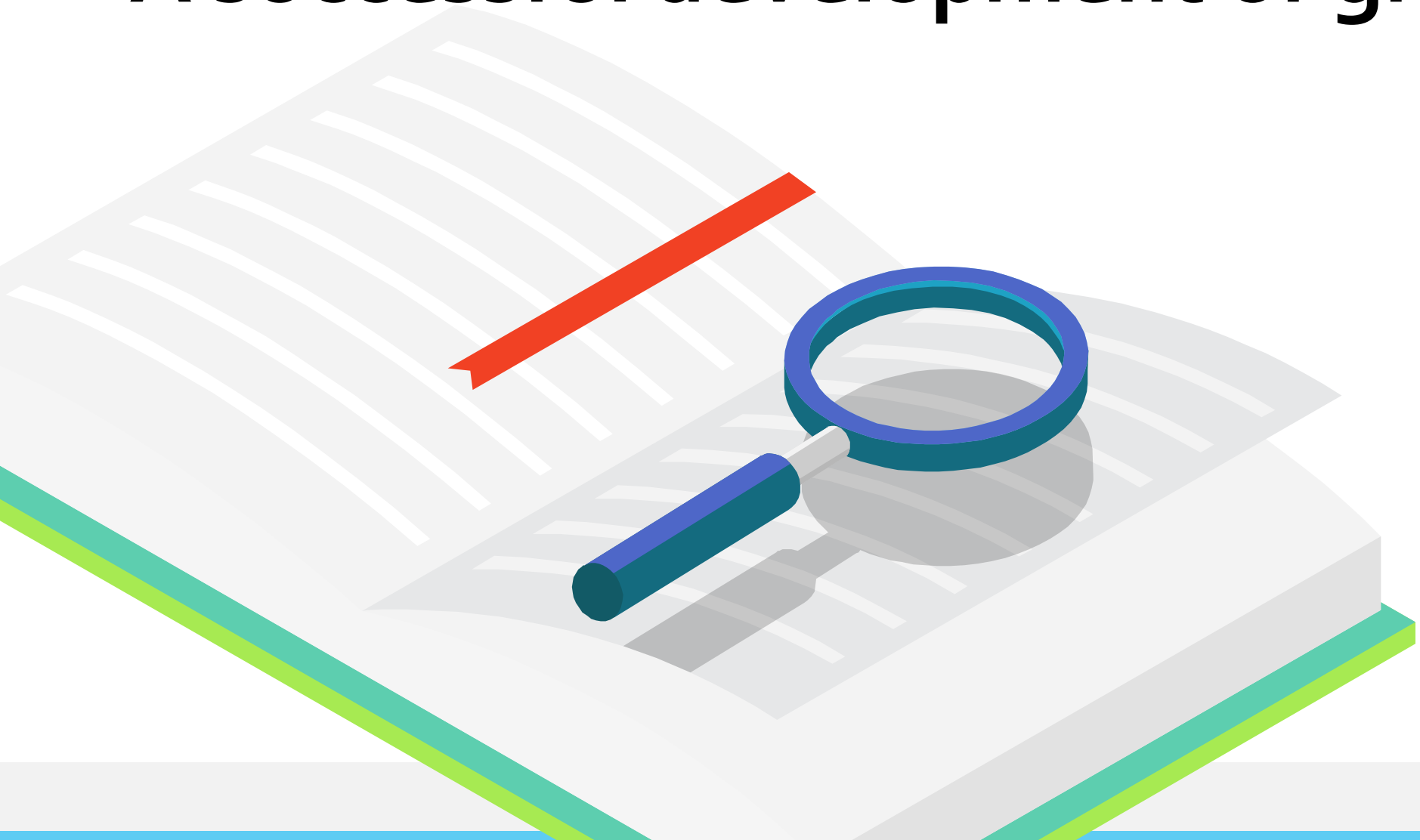
Installation of casing

10 tonnes lorry

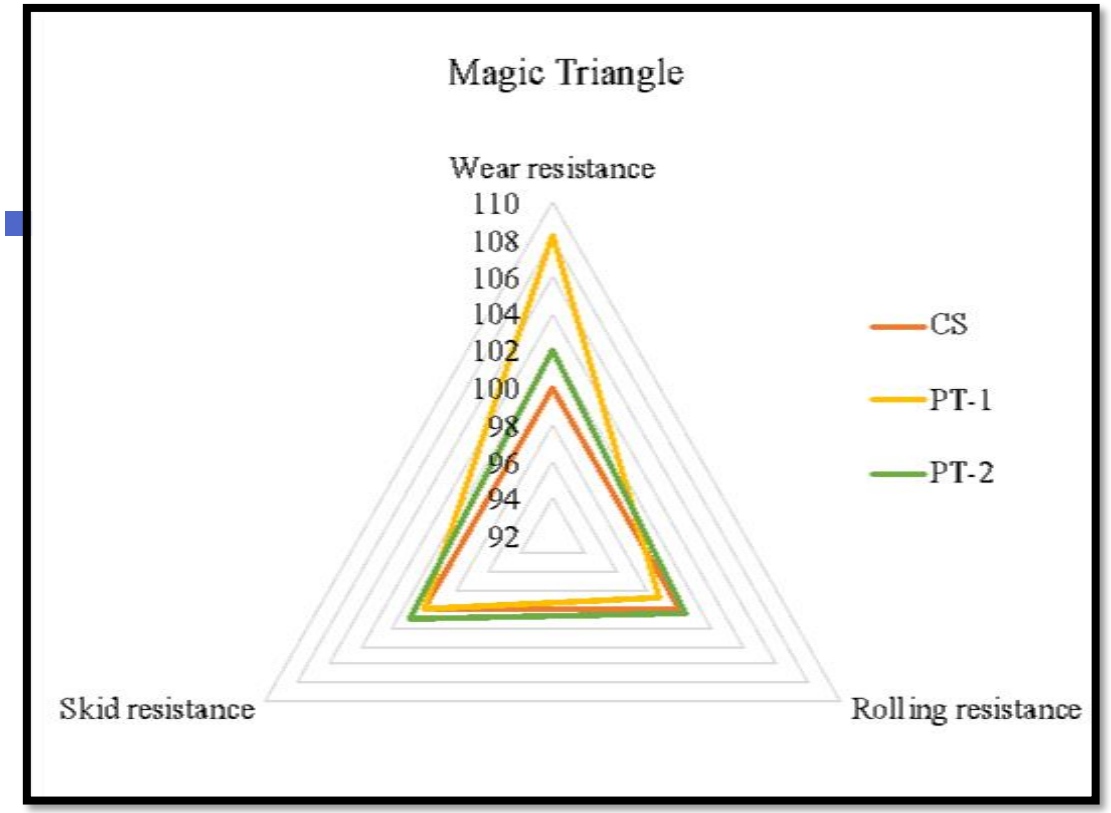
The tires were assembled to the 10 tonnes lorry.



A successful development of greener tire

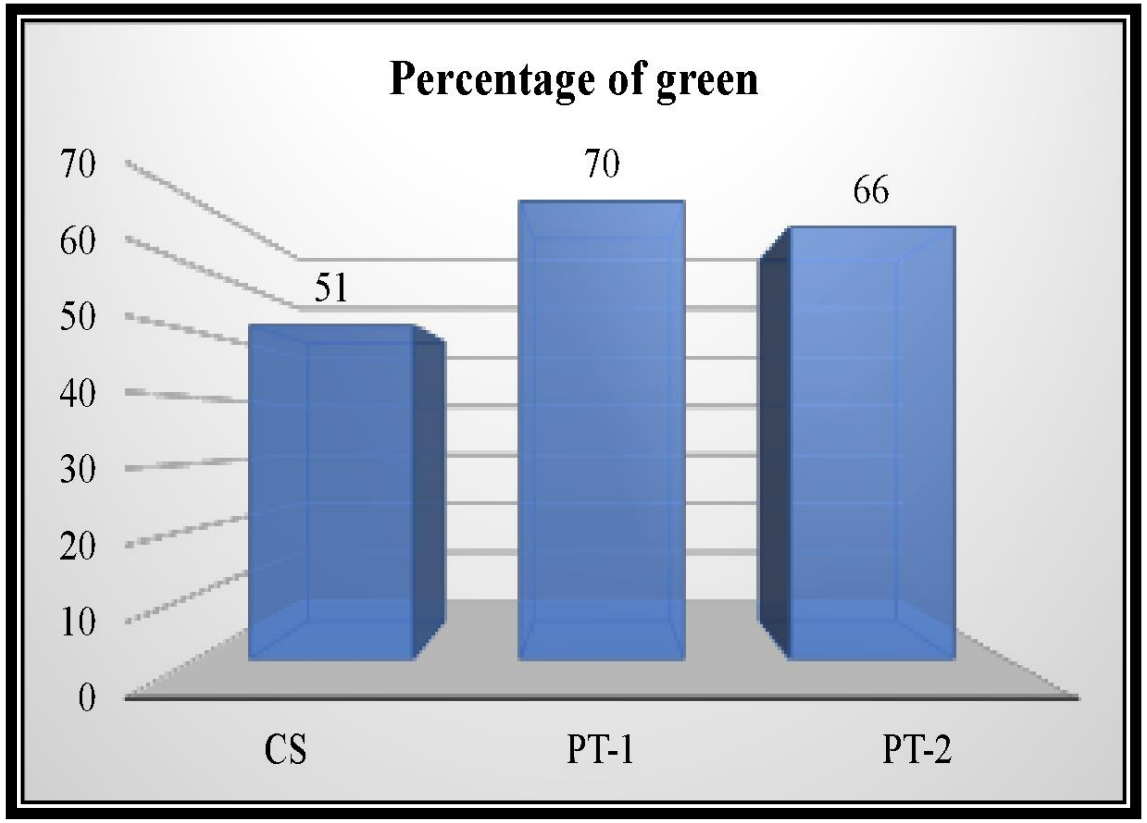


Magic Triangle



- PT-1 shows better wear resistance and lowering the rolling resistance for the better fuel efficiency.
- PT-2 increased in wear resistance and slightly enhanced in skid resistance compared to the CS.

Percentage of green in the compounds

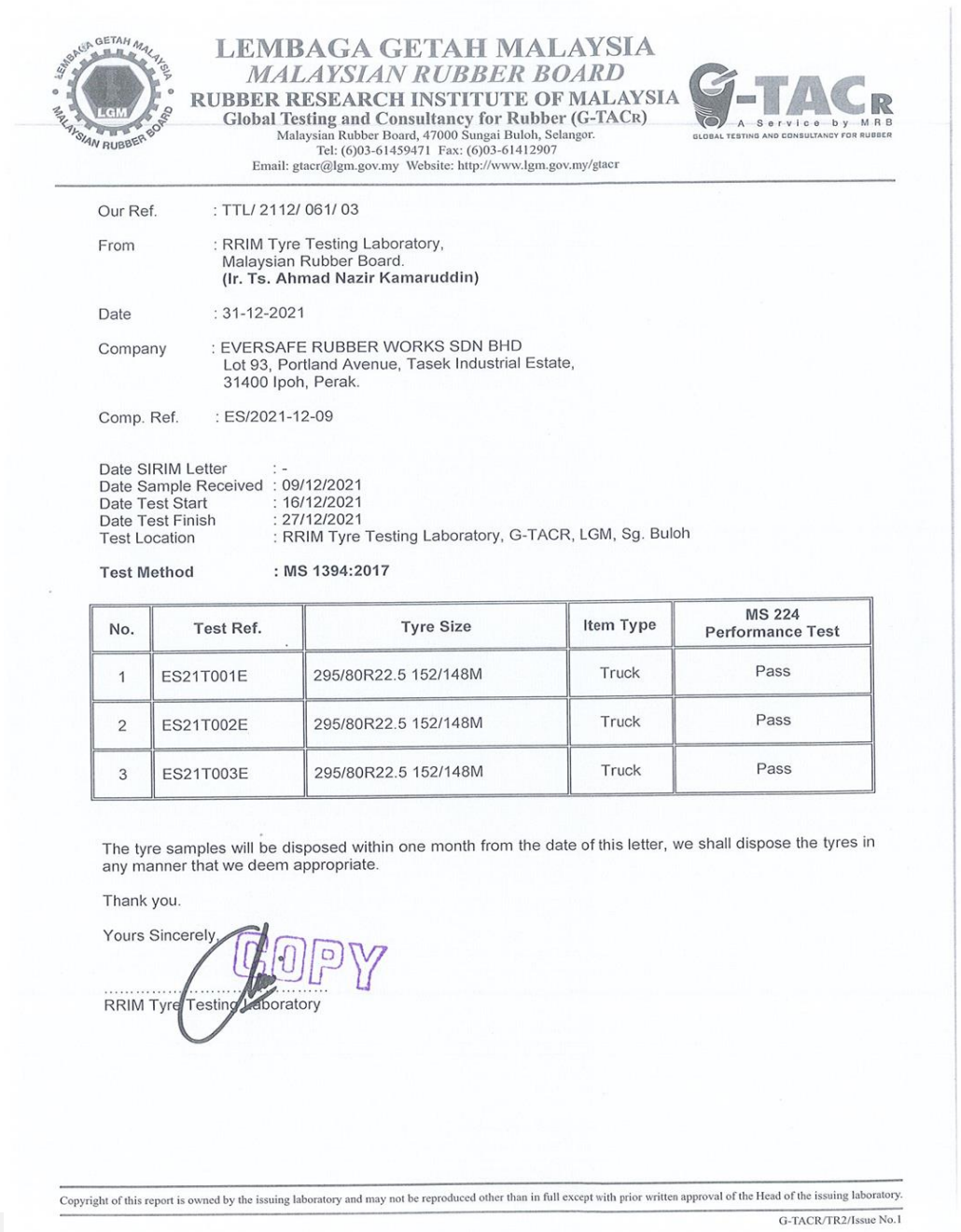


- The percentage of green in the prototype compounds increased about 29 - 37 %

Endurance test

- An endurance test was conducted at MRB according to MS1394:2017.
- Testing was run for 24 hours at room temperature (24–30 ºC) with speed maintained at 72 km/h under specific loads.
- The tire's condition was observed after 7, 16, and 24 hours.

Sample	Endurance test
CS	Pass
PT-1	Pass
PT-2	Pass



LEMBAGA GETAH MALAYSIA
MALAYSIAN RUBBER BOARD
RUBBER RESEARCH INSTITUTE OF MALAYSIA
Global Testing and Consultancy for Rubber (G-TACR)
Malaysian Rubber Board, 47000 Sungai Buloh, Selangor.
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Email: gtacr@lgm.gov.my Website: http://www.lgm.gov.my/gtacr

G-TACR A Service by MRB GLOBAL TESTING AND CONSULTANCY FOR RUBBER

Our Ref. : TTL/ 2112/ 061/ 03

From : RRIM Tyre Testing Laboratory,
Malaysian Rubber Board.
(Ir. Ts. Ahmad Nazir Kamaruddin)

Date : 31-12-2021

Company : EVERSAFE RUBBER WORKS SDN BHD
Lot 93, Portland Avenue, Tasek Industrial Estate,
31400 Ipoh, Perak.

Comp. Ref. : ES/2021-12-09

Date SIRIM Letter : -
Date Sample Received : 09/12/2021
Date Test Start : 16/12/2021
Date Test Finish : 27/12/2021
Test Location : RRIM Tyre Testing Laboratory, G-TACR, LGM, Sg. Buloh

Test Method : MS 1394:2017

No.	Test Ref.	Tyre Size	Item Type	MS 224 Performance Test
1	ES21T001E	295/80R22.5 152/148M	Truck	Pass
2	ES21T002E	295/80R22.5 152/148M	Truck	Pass
3	ES21T003E	295/80R22.5 152/148M	Truck	Pass

The tyre samples will be disposed within one month from the date of this letter, we shall dispose the tyres in any manner that we deem appropriate.

Thank you.

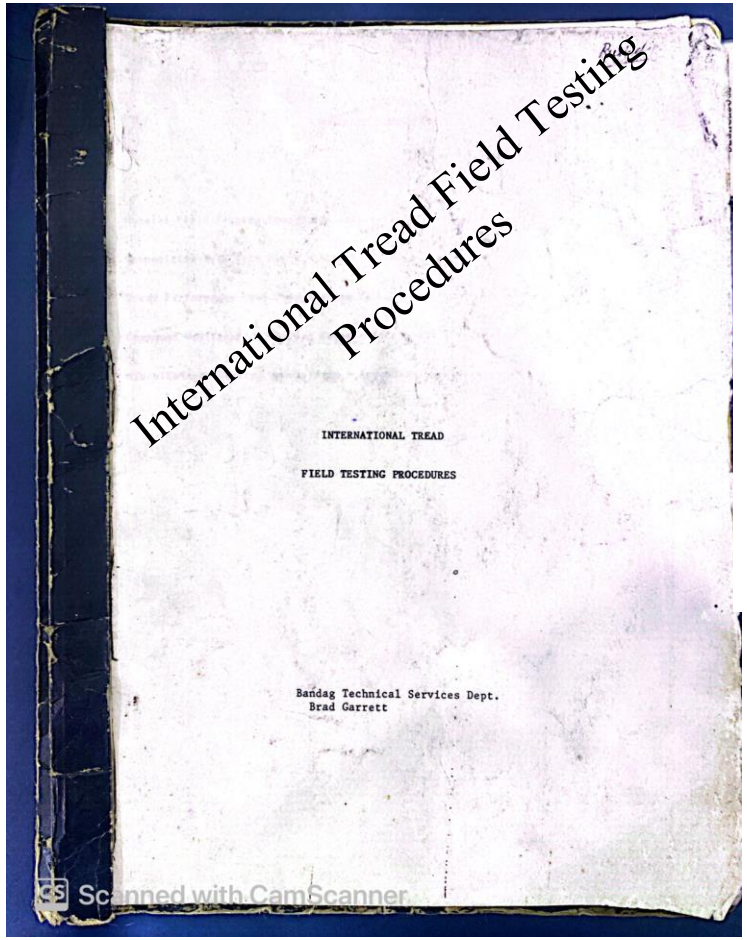
Yours Sincerely,

COPY

RRIM Tyre Testing Laboratory

Field test

The field test was performed based on "International Tread Field Testing Procedures" from the Bandag Technical Services Department

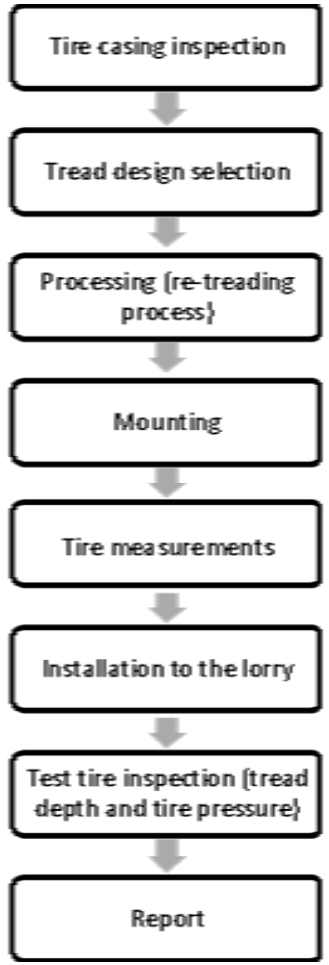


Locators of measurements were marked as I,II,III and IIII.

Measurement points of each locators

- ✓ The tread depth measurements were taken at 10,000 km, 20,000 km and 30,000 km.
- ✓ The minimum test duration was at least 50% wear or ½ the original mounted tread depth (Bandag Procedure).

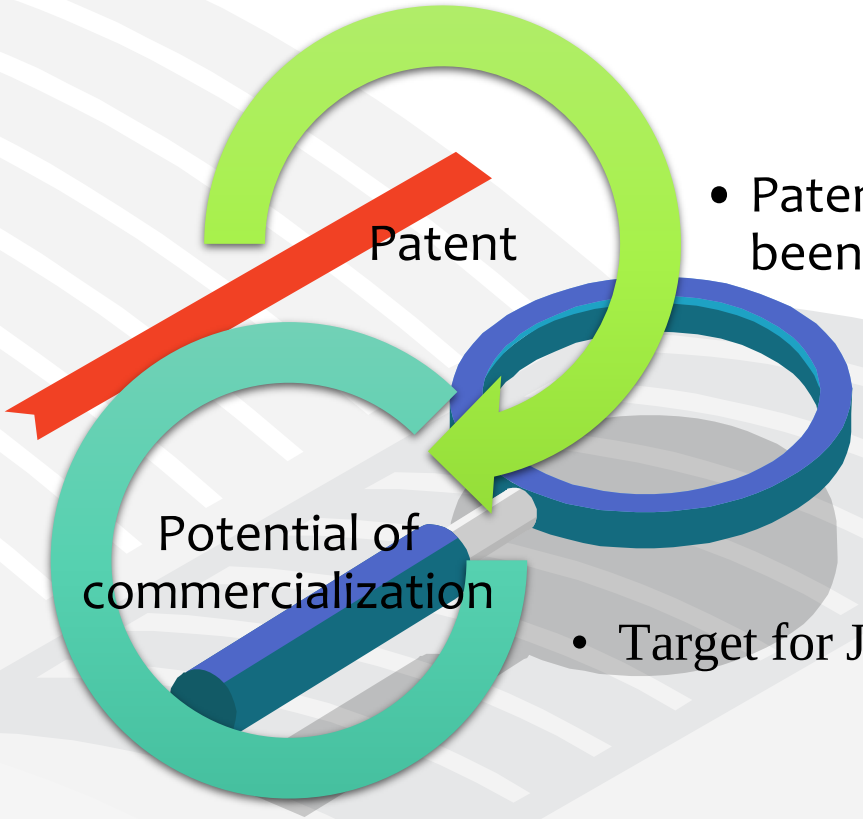
Process flow of field test



SUMMARY

Percentage of green	• Achieved 29 % (PT-2) and 37 % (PT-1) from the control sample
Mechanical properties	• Substitution of bio-based oil (EPO) as rubber process oil at a lower composition shows positive results in tensile strength, modulus, and wear resistance
Skid resistance and rolling resistance	• PT-1 achieved highest reduction in rolling resistance, thus providing a better fuel efficiency. • PT-2 slightly improved skid resistance.
Field test - assemble retread tire in 10 tonnes lorry (with full load)	• PT-1 can sustain up to 37000 km • PT-2 can sustain up to 27000 km

Final Process



- Patent application has been submitted
- Target for Japanese market

Appreciation to Eversafe and Olympic Retread Sdn. Bhd.

Thank You