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Evaluation of various ground tyre rubber and rPP grades as potential alternative TPE blends in high performance applications

By

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enter for rubber science and technology (CRST)

BACKGROUND

% Self-propelled Vehicles, Fatal Crashes and AARTO Speed Infringements per Vehicle MAKE & MODEL							
	Total:	11 546 383		32 333		32 333	
	% Of Total:	40,4%		49,3%		41,9%	
	Subtotal:	4 668 098		15 952		5 071 360	
#	Vehicle MAKE & MODEL	VehPop	% Of Total	Fatal Crashes	% Of Total	AARTO SI	% Of Total
1	VOLKSWAGEN | POLO	795 613	17,0%	2 668	16,7%	1 091 912	21,5%
2	TOYOTA | HILUX	592 021	12,7%	2 272	14,2%	372 843	7,4%
3	TOYOTA | QUANTUM	152 742	3,3%	1 954	12,2%	310 706	6,1%

BACKGROUND

Internal Door panel

Doorpanel from Scrap yard = R3500 – R5500

Dealership (Tevcor) =R4150

- Impact strength
- Flexural strength

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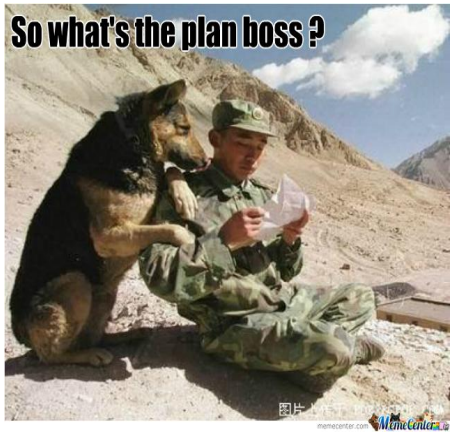
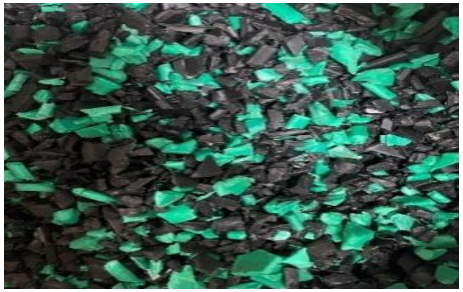
So what now?



Objectives:

- Partial replacement of the plastic medium (PP) with recycled PP
- Partial replacement of the impact modifier with GTR
- Evaluation and testing of thermal, physical and mechanical properties of the blends to simulate the high performance of the automotive components.

Recycled plastic



Mixed crates rPP (R6/Kg)

MFI (g/10min) : 16

Tm : 173 ˚C

PP Xc:20 %

Domestic rPP (R8/Kg)

MFI (g/10min) : 20

Tm : 171 ˚C

PP Xc:27 %

Automotive rPP (R12/Kg)

MFI (g/10min) : 8

Tm : 166 ˚C & 126 ˚C

PP Xc:12 %

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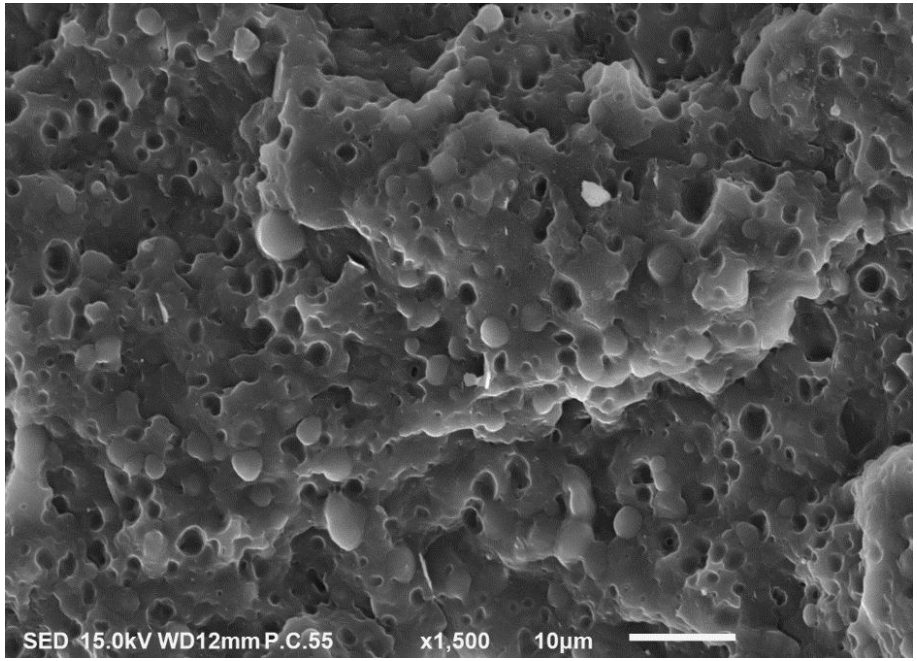
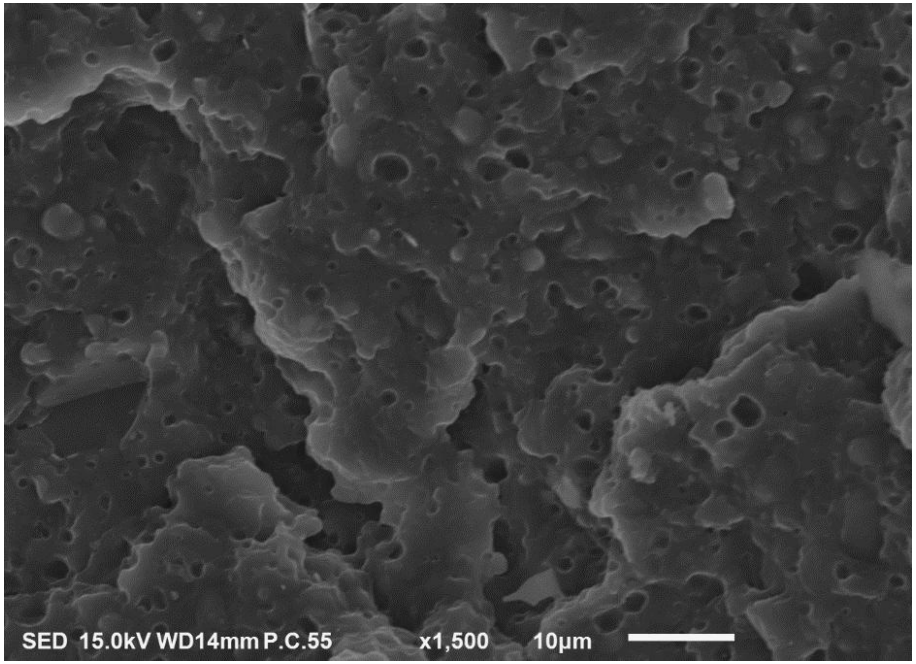
Maybe lets consider morphology?

Morphology analysis of rPP using SEM

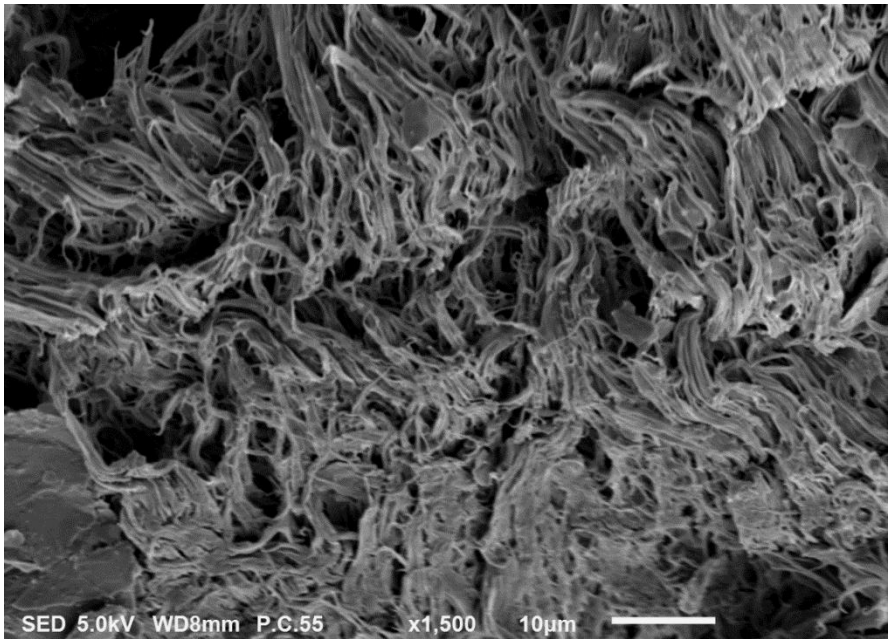




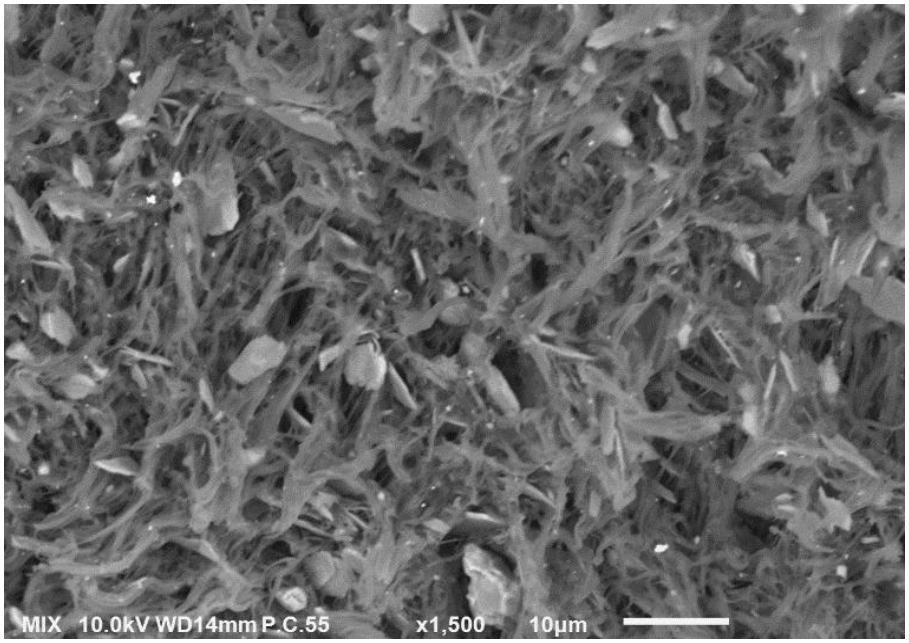
Domestic rPP

Crates rPP

Morphology analysis using SEM of rPP



Automotive rPP



Base formulation

WASTE TYRES

GTR

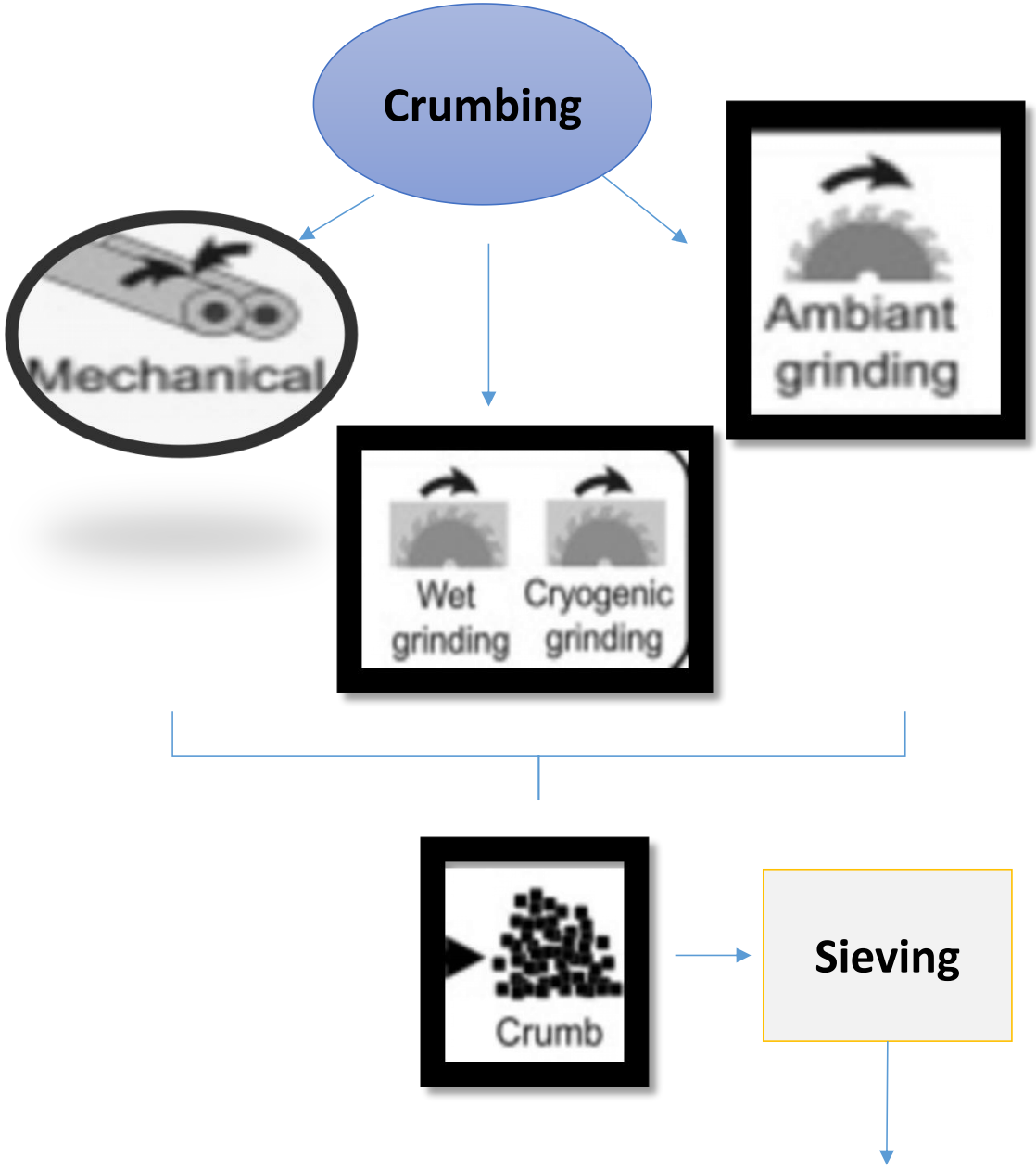
Remolds/ Retreads

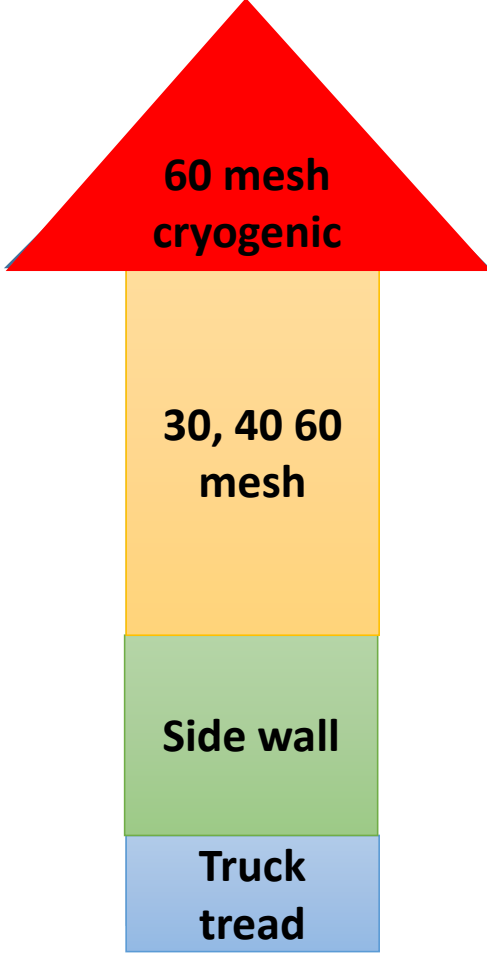
Grinding

Buffing Dust

Buffing

Crumbing


Crumbing
Mechanical
Ambiant grinding
Wet grinding
Cryogenic grinding
Crumb
Sieving
Different mesh sizes


60 mesh cryogenic
30, 40 60 mesh
Side wall
Truck tread

Costing

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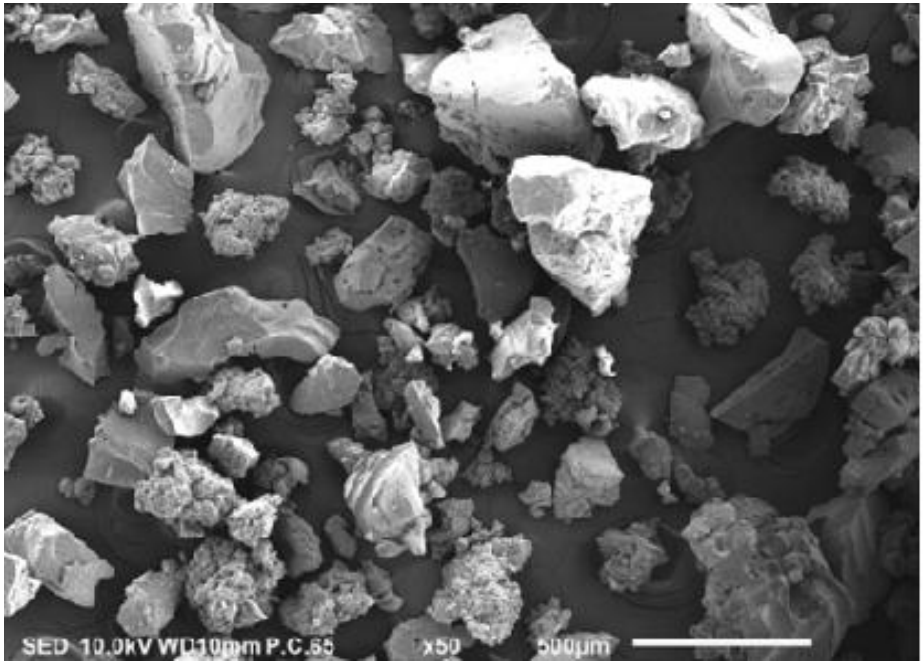
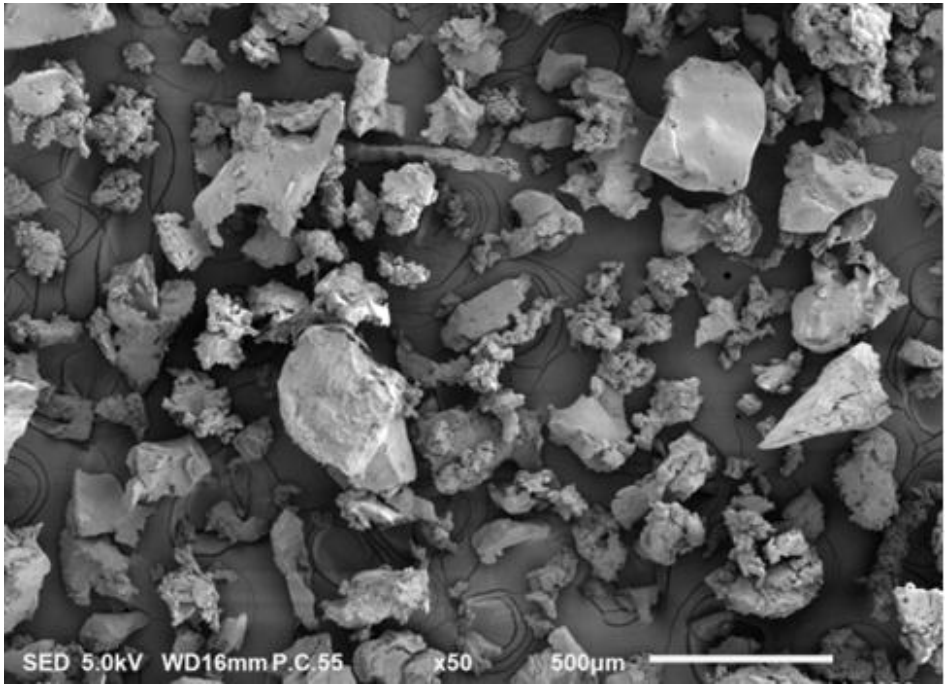
Does size and shape matter?

Particle size & Shape analysis using SEM



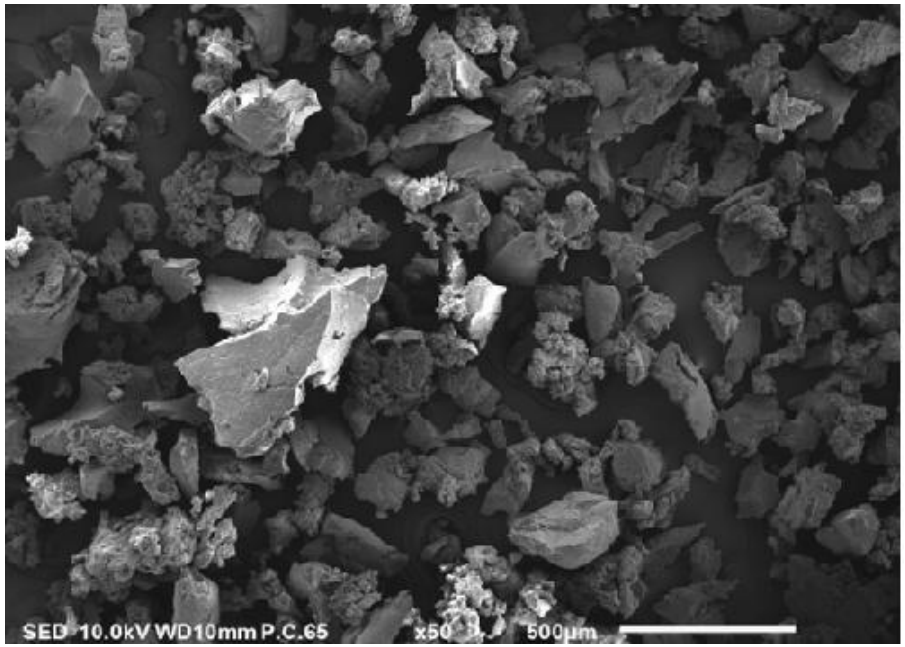


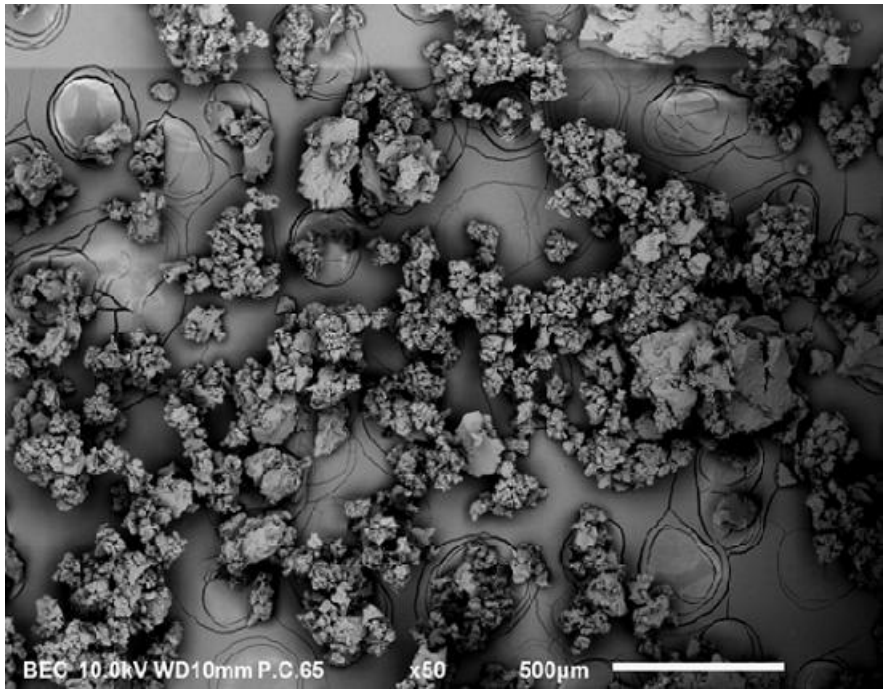
30 mesh (≈600 microns)

40 mesh (≈ 400 microns)

Random Particle shape and wider PSD

Particle size & Shape analysis using SEM





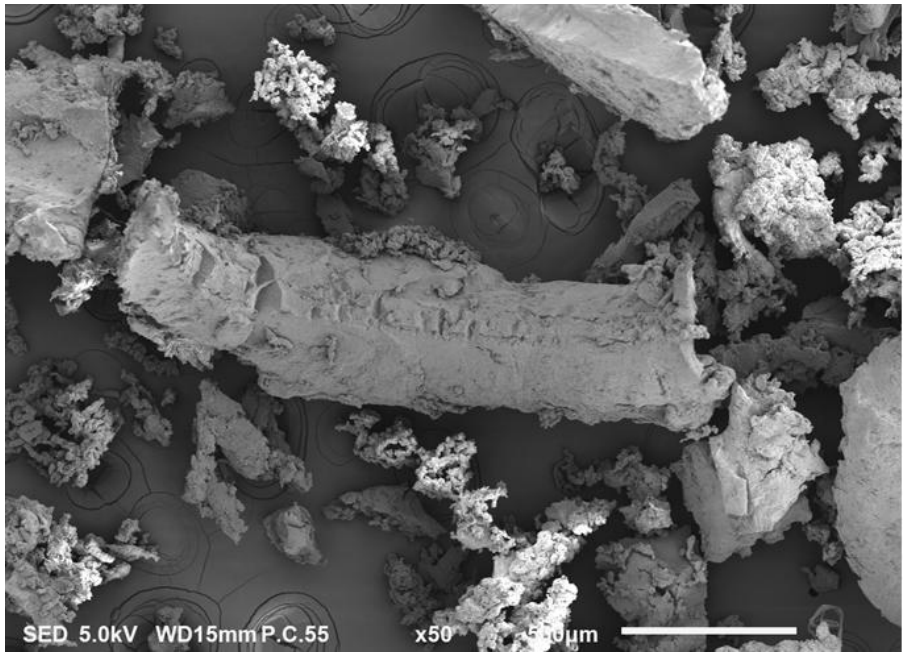
60 mesh (≈ 250 microns)

Random shapes
Narrow PSD

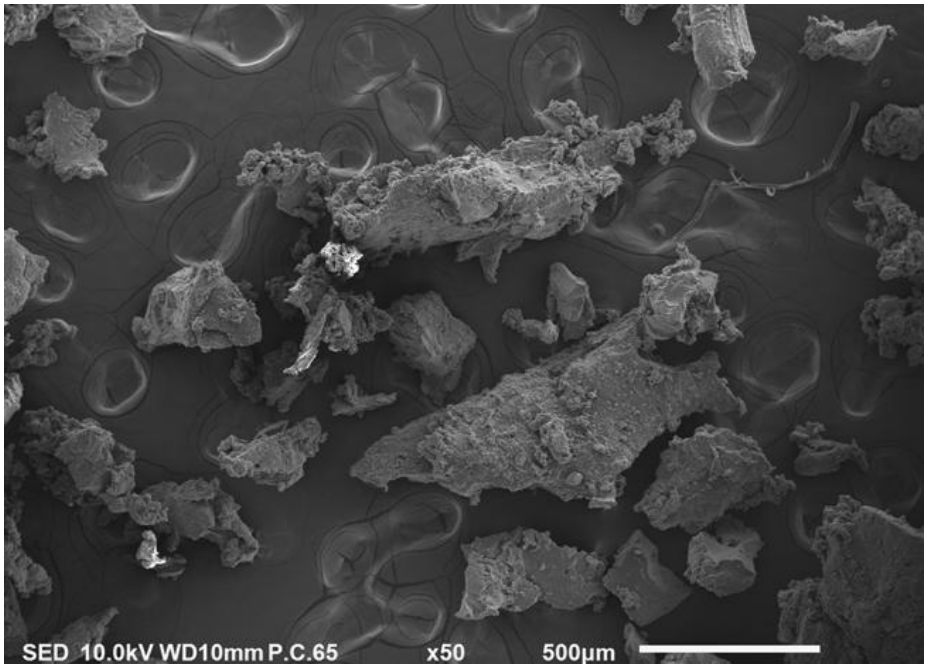
60 mesh cryo (≈ 250 microns)

Narrow PSD

Particle size & Shape analysis using SEM



Buffing dust side wall



Buffing dust truck tread

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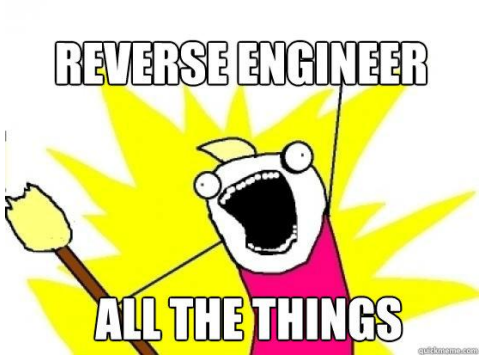
What about the composition?



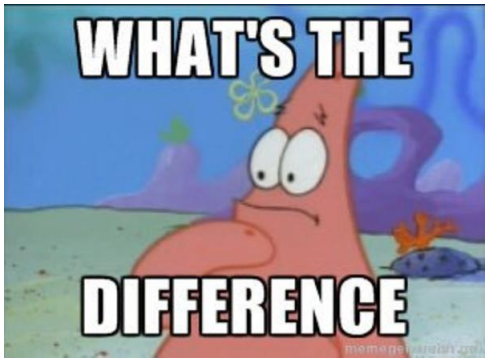


Table 1: Composition analysis

GTR Type	Polyisoprene (%)	Butadiene Derivatives (%)
30-60 mesh	35	21 (SBR + BR)
tread **Buffing dust**	29	24 (SBR)
Sidewall **Buffing dust**	25	29 (BR)

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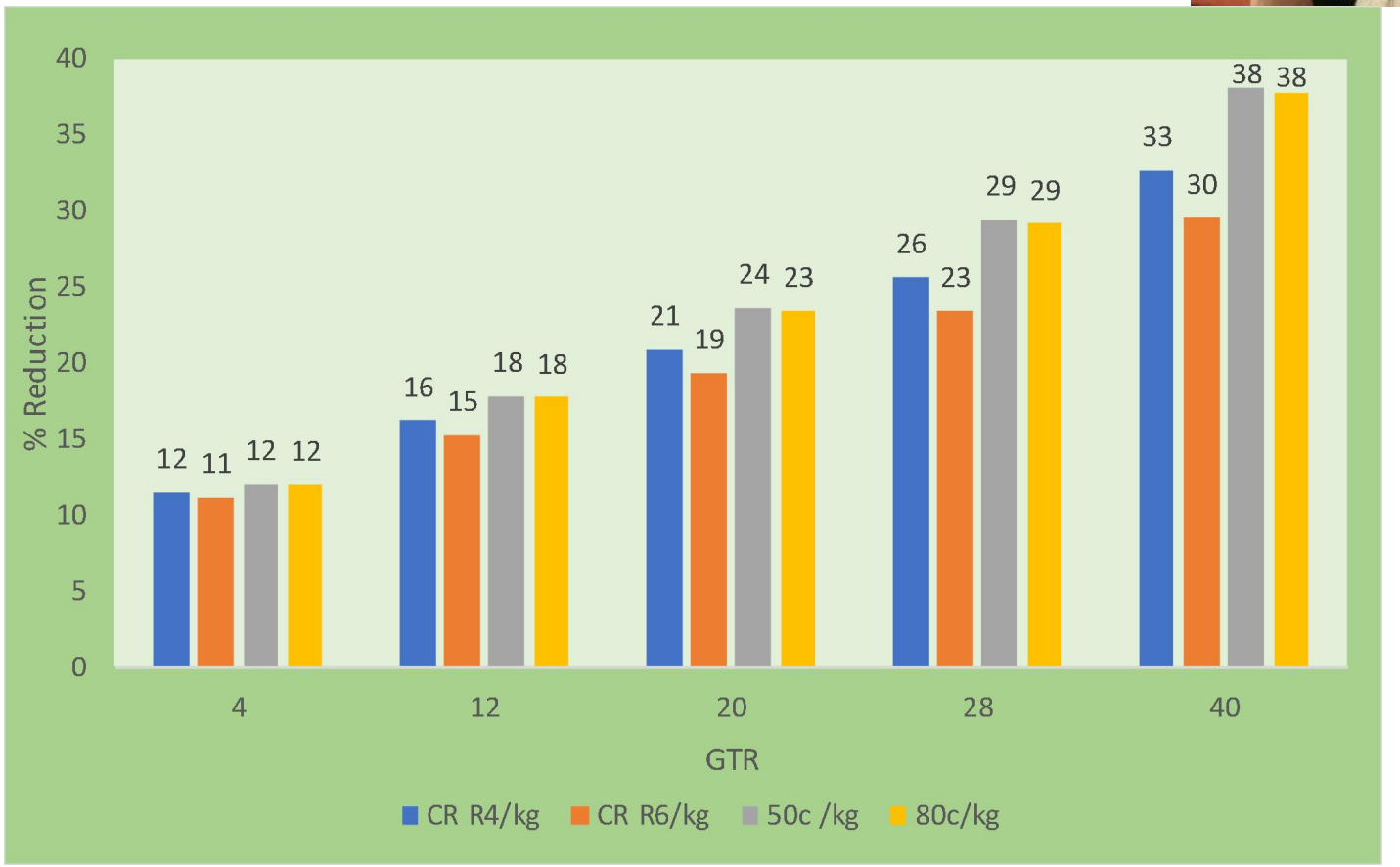
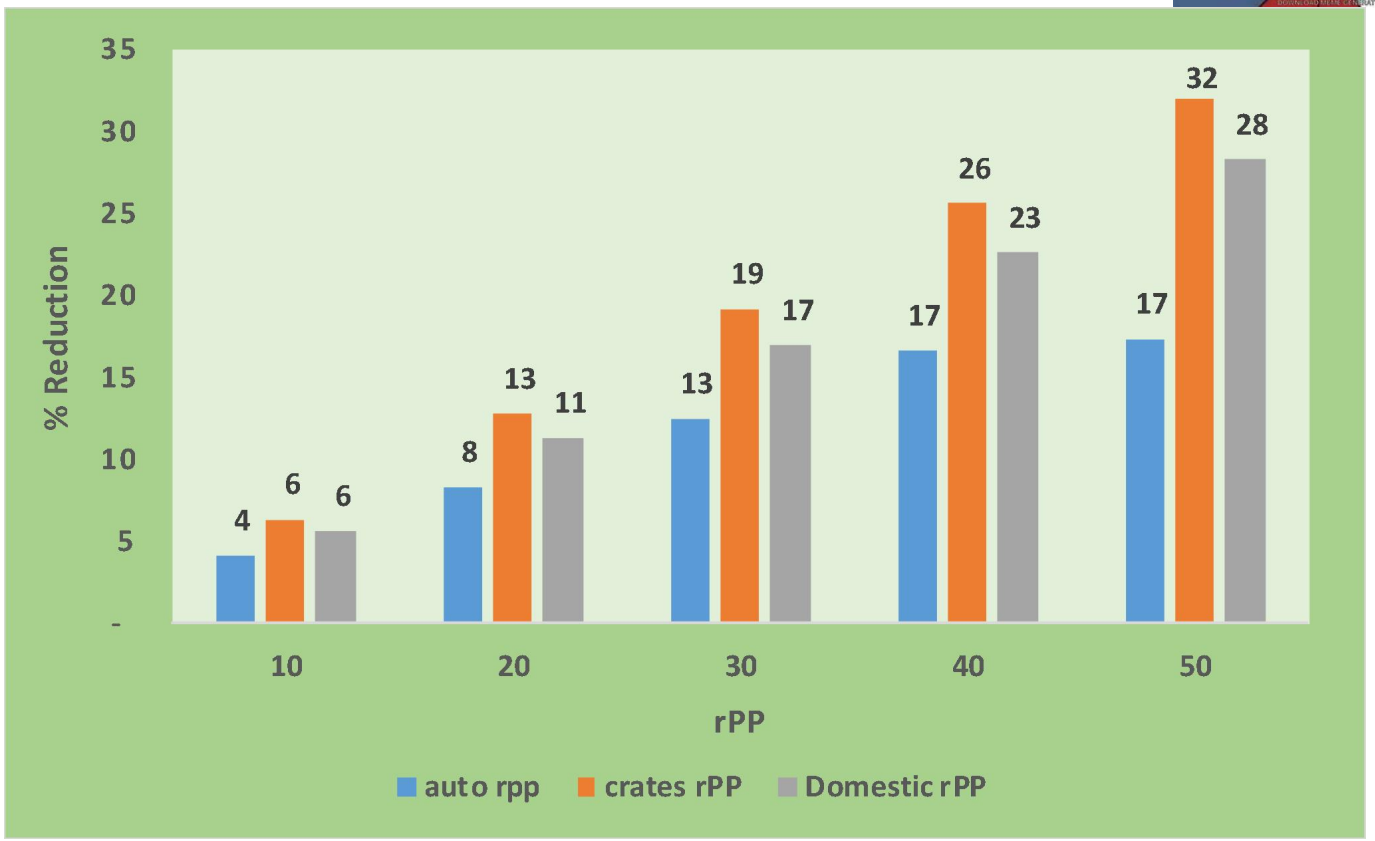
What are the cost implications?

Base formulation = R25.50

GTR Compound cost



rPP Compound cost



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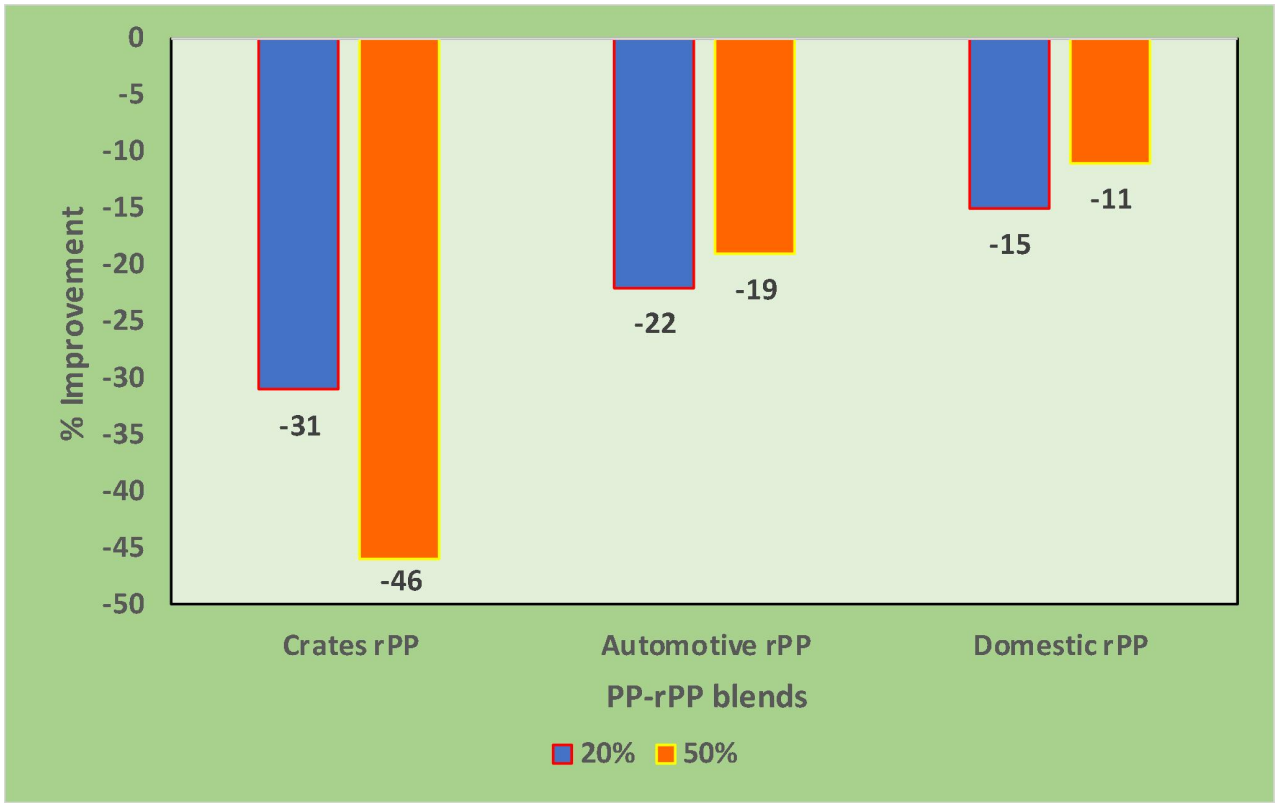
What does the data say?

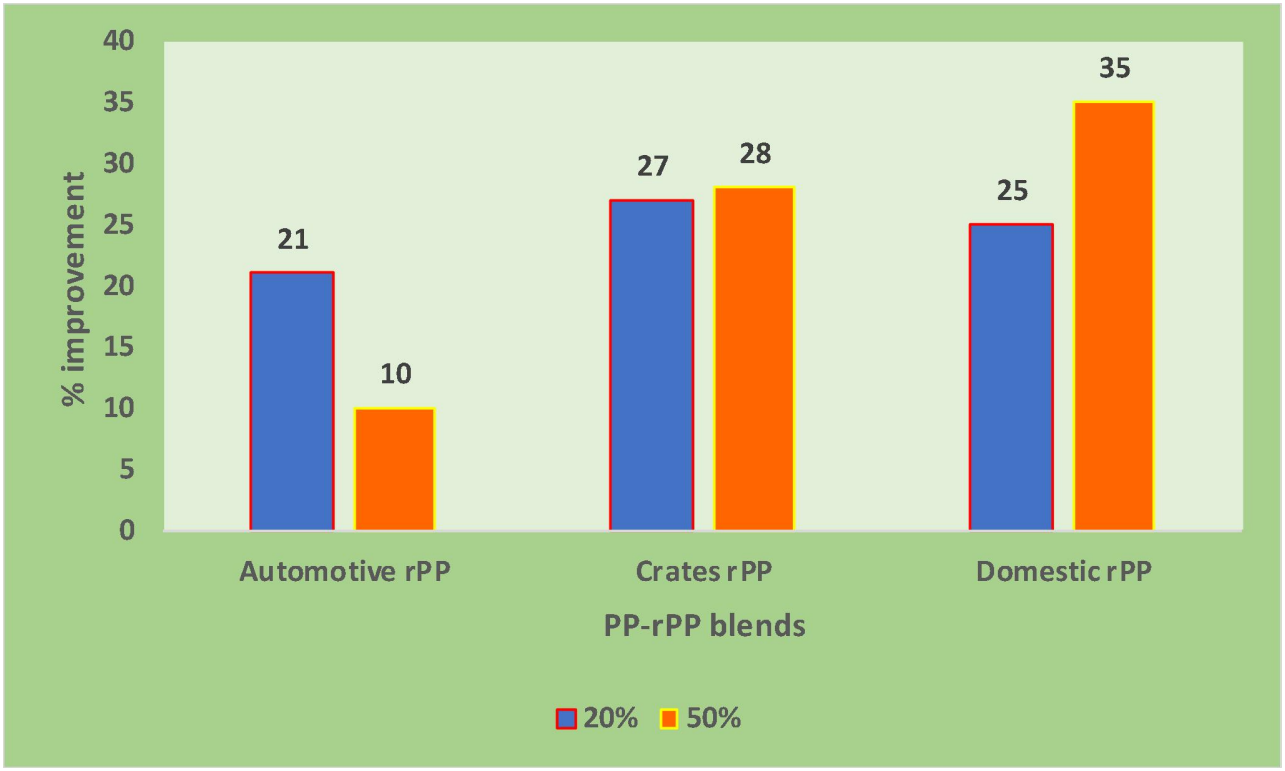
Partial replacement with rPP

Doorpanel Impact strength



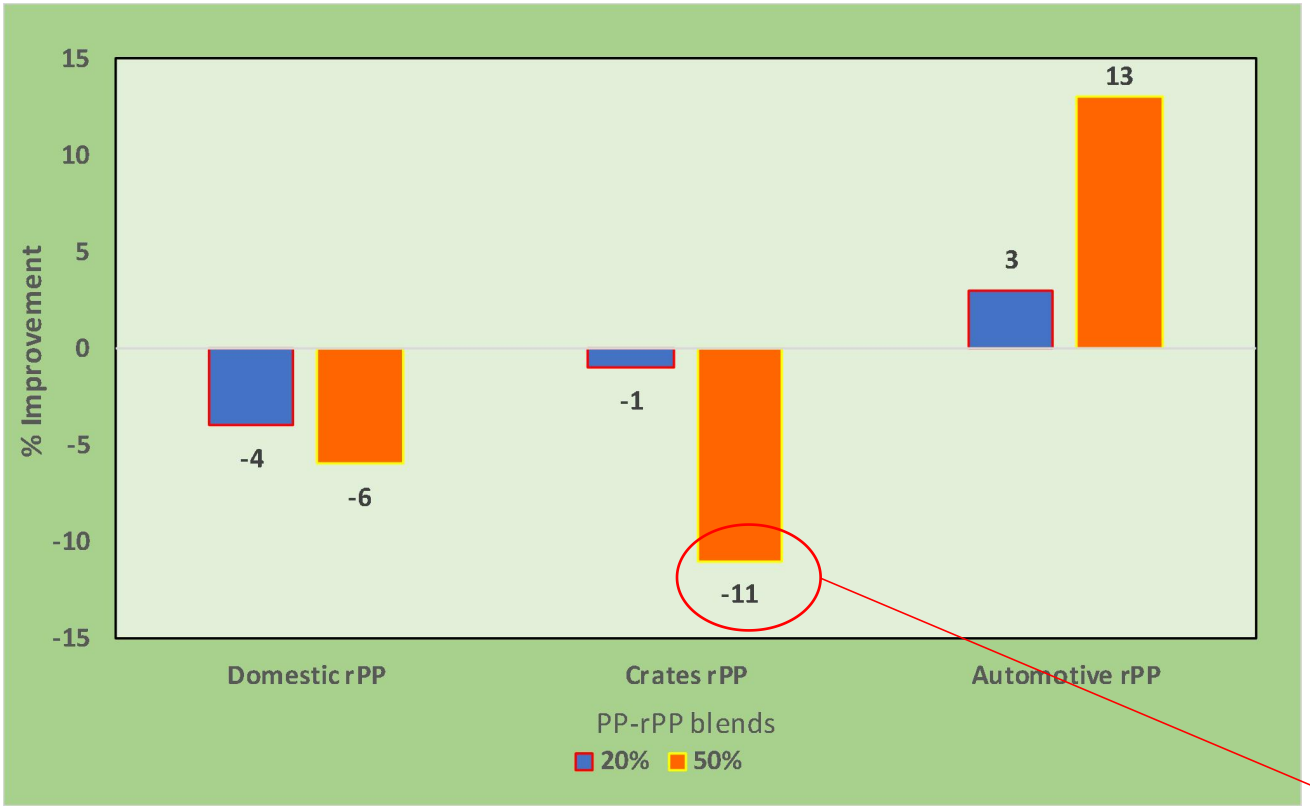
Partial replacement with rPP

Doorpanel flexural strength



Partial replacement with rPP

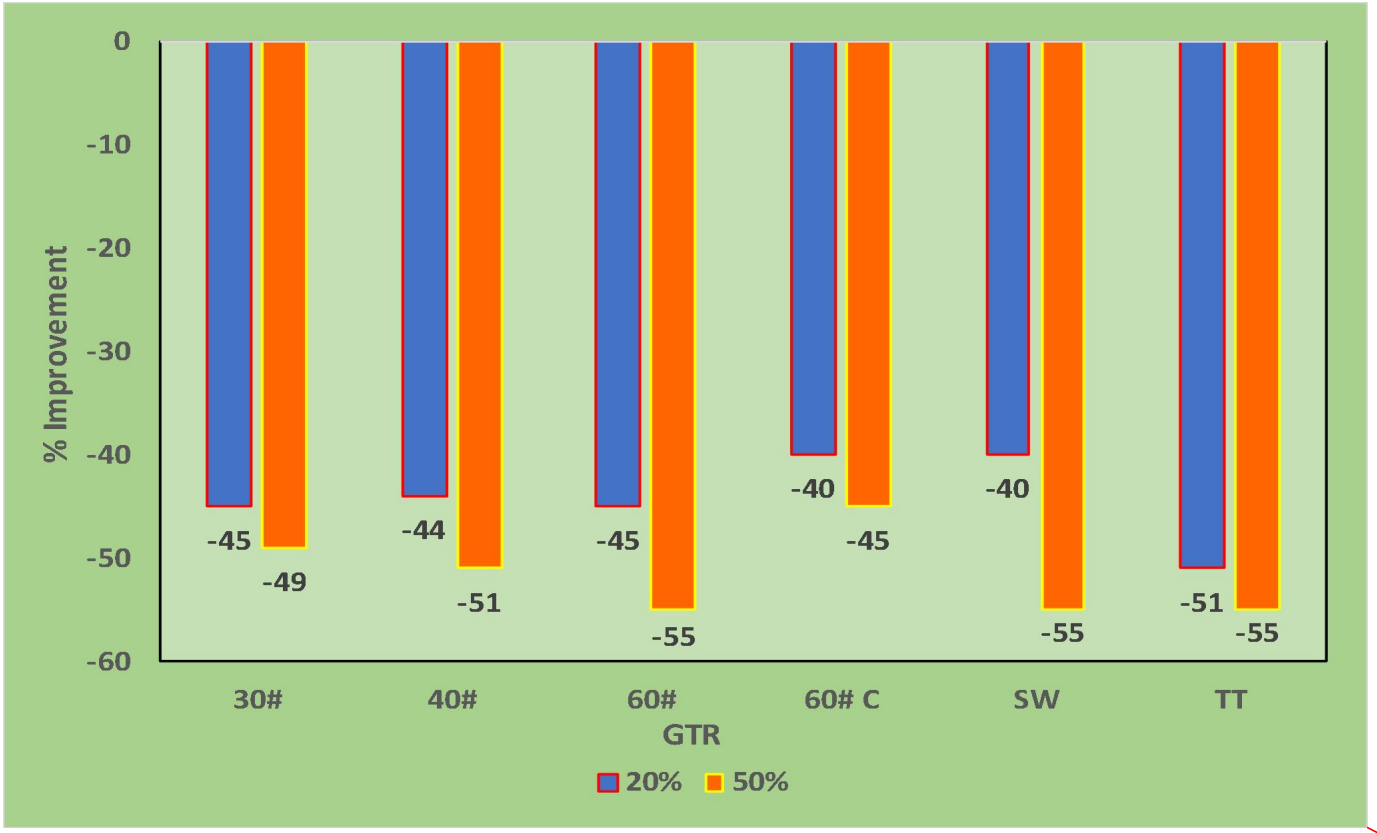
Doorpanel hardness - rPP



Is a drop of 11% significant?

Partial replacement with GTR

Doorpanel hardness



all **FAIL**

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What can we take from this?

DOORPANEL SUMMARY

- **GTR - Fail**
- Flimsy
- **Automotive rPP – Fail**
- Impact strength – Fail
- Flexural strength – Fail
- Hardness – Pass
- **Crates rPP**
- Impact strength – Fail
- Flexural strength – Pass
- Hardness – Pass
- **Domestic rPP**
- Impact strength – Fail
- Flexural strength –Pass
- Hardness - Pass

Alternative automotive components

Underbody cover:

IMPACT STRENGTH= 35 kJ/m^2

Improvement>35 kJ/m^2

FLEXURAL STRENGTH = 1.72 % deformation strain

Improvement <1.72%

T_g= 26 °C

Radiator grill:

HDTUL = 84 °C

Partial replacement with GTR

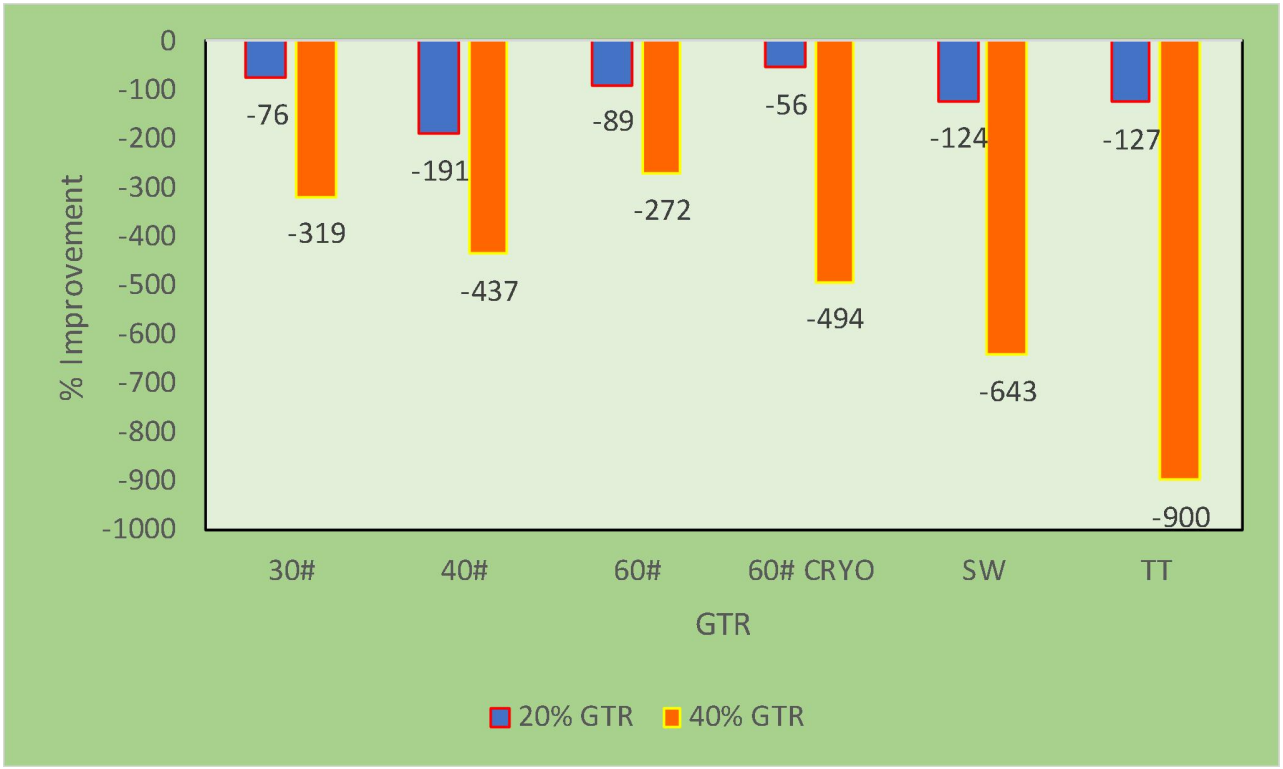
Underbody cover impact strength

Partial replacement with GTR

Underbody cover impact strength

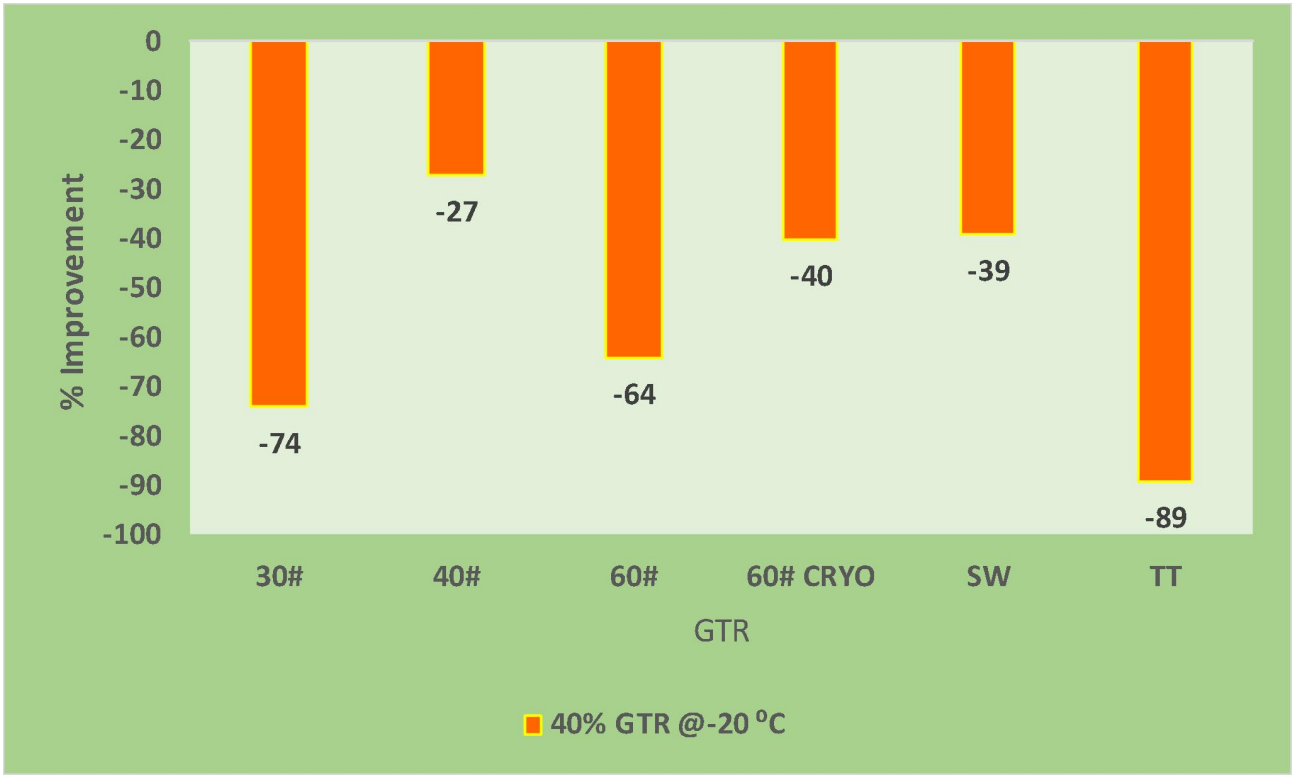
Partial replacement with GTR

Underbody cover flexural strength



Partial replacement with GTR

Underbody cover flexural strength @ -20 °C



Partial replacement with GTR

Table 7: Tan delta and temperature @40% GTR

GTR	Onset temperature		
	°C	T_g °C (glass transition)	Tan delta (damping)
Base Formulation	-7	26	0.1
30 #	0.51	7	0.4
40 #	-4	19	0.2
60#	1	10	0.3
60 # C	-8	23	0.2
SW	-31	-3	0.7
TT	9	19	0.2

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So what did we learn?

UNDERBODY COVER SUMMARY

- **GTR improves impact at loading of 40%**
  - **60# Cryo**
  - **40#**

- **Special case: 20% SW**

- **Flexural strength – ALL FAIL**
  - **Less reduction at -20 °C**

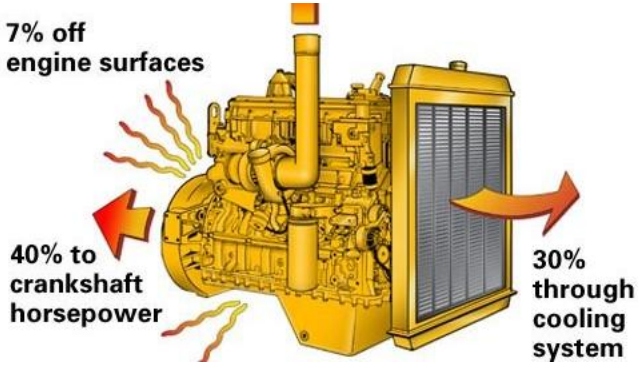
RADIATOR GRILL

55 kW

- **Higher Power Output >>> Higher exothermic Heat yield**

180 kW

- **Higher Exothermic Heat >> Require more rapid cooling**



- **More Rapid heat exchange >> More thermally stable Grill**

Partial replacement with rPP

Radiator grill

Table 5: Radiator grill HDTUL

Materials	HDTUL (˚C) ASTM D648	Working temperature range (˚C)
Base formulation	84	79
Domestic 20/80	92	87
Crates 20/80	97	90
Automotive 20/80	83	76
Domestic 50/50	93	86
Crates 50/50	95	87
Automotive 50/50	82	74

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Which recycled plastic works best?

RADIATOR GRILL SUMMARY

- **Domestic rPP and Crates rPP**
- **Improved HDTUL and wider working temperature range**

- **Automotive rPP**
- **Still can work**

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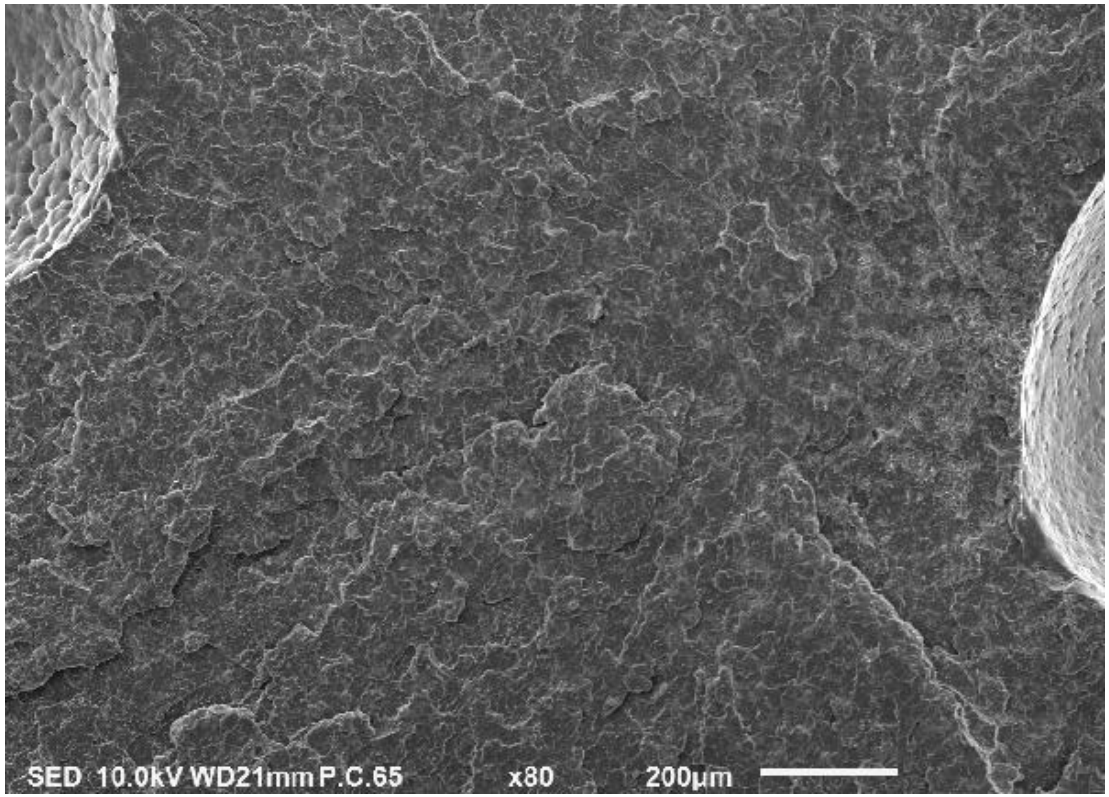
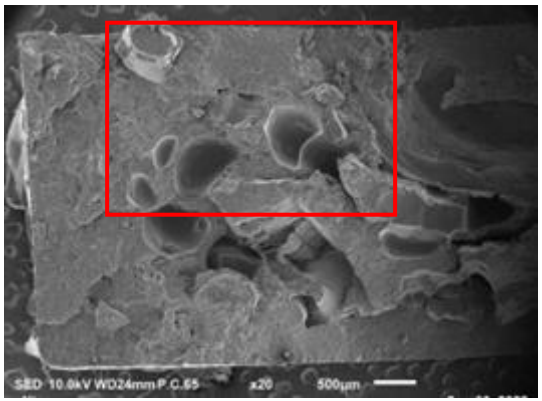
What is morphology telling us?

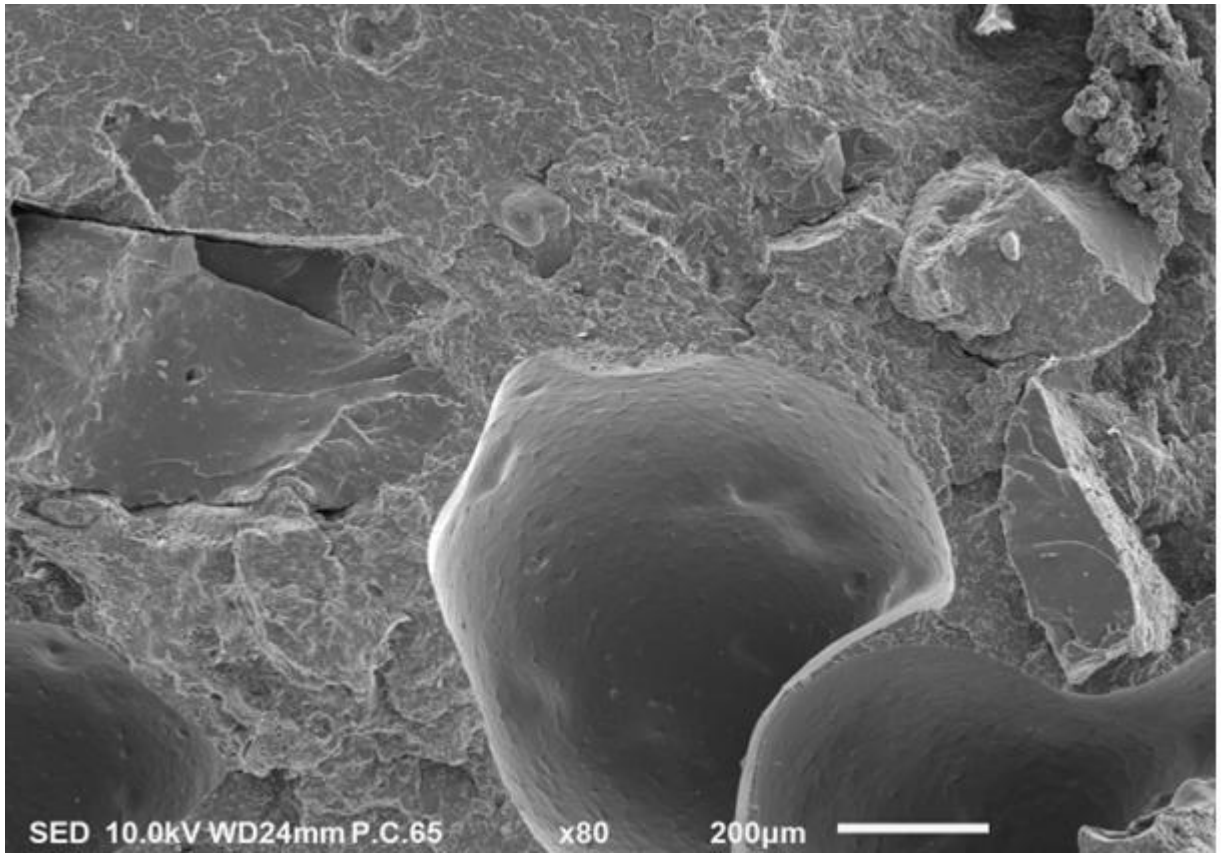
Failure analysis using SEM



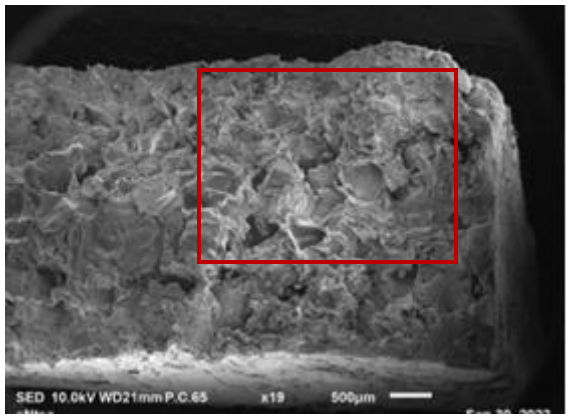
PP matrix

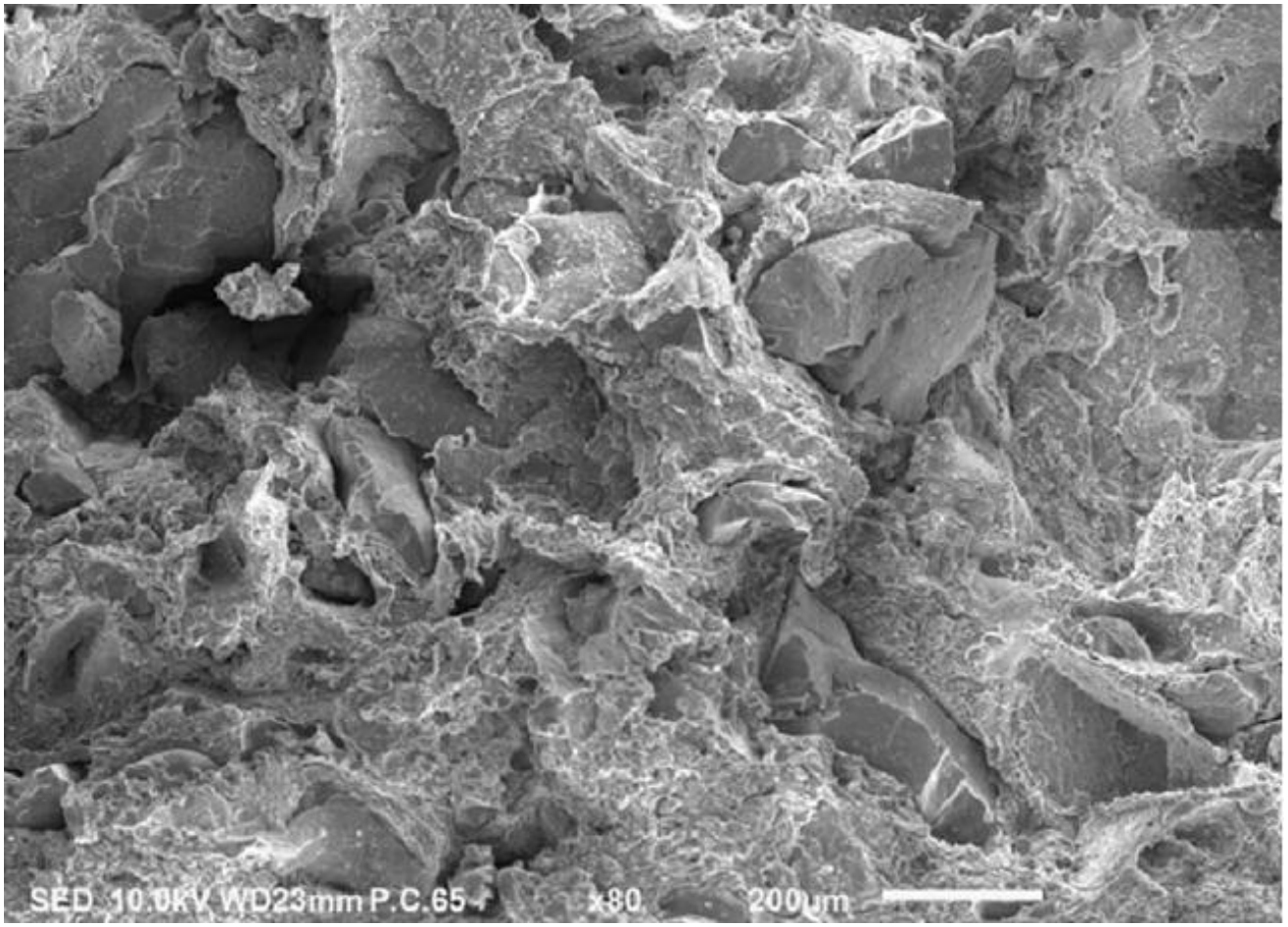
Morphology analysis using SEM of 40 % TT



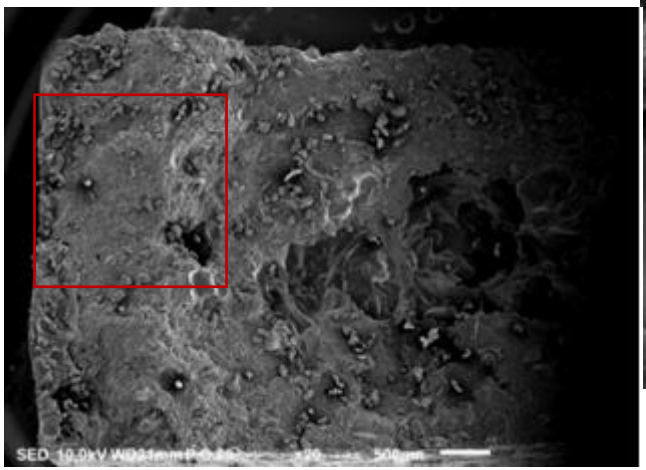


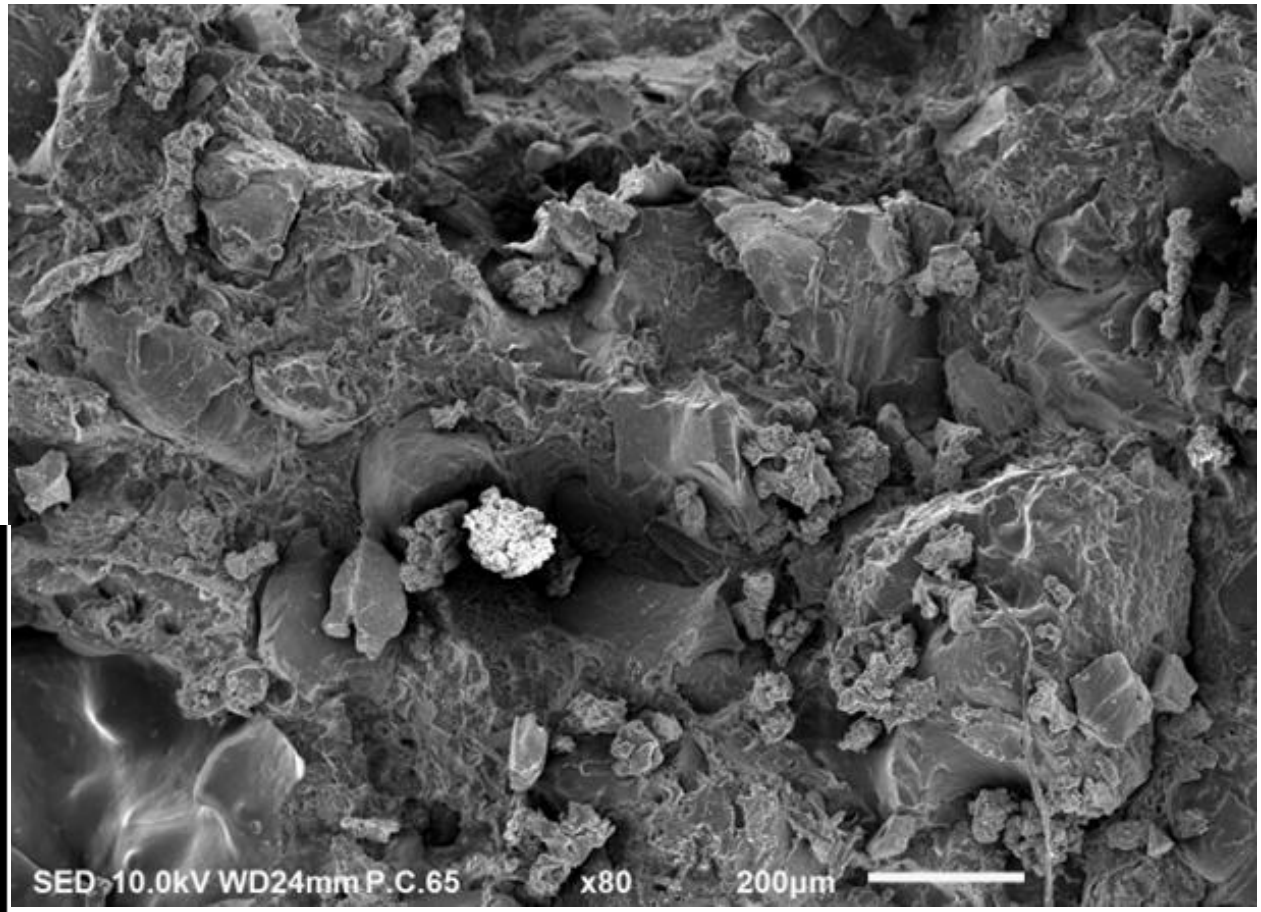
Morphology analysis using SEM of 40 % 30



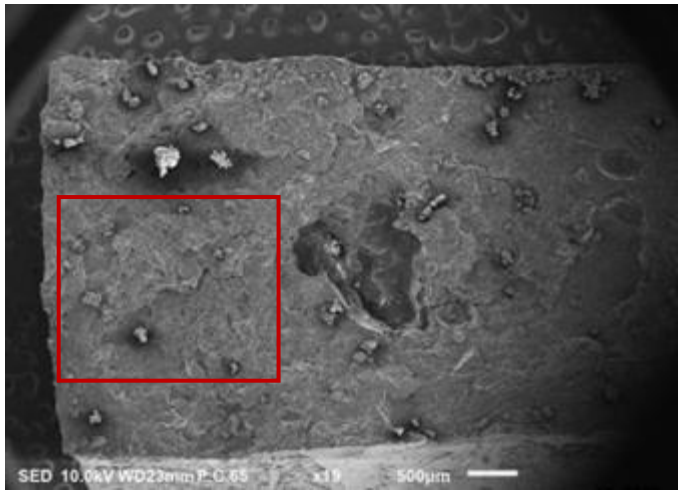


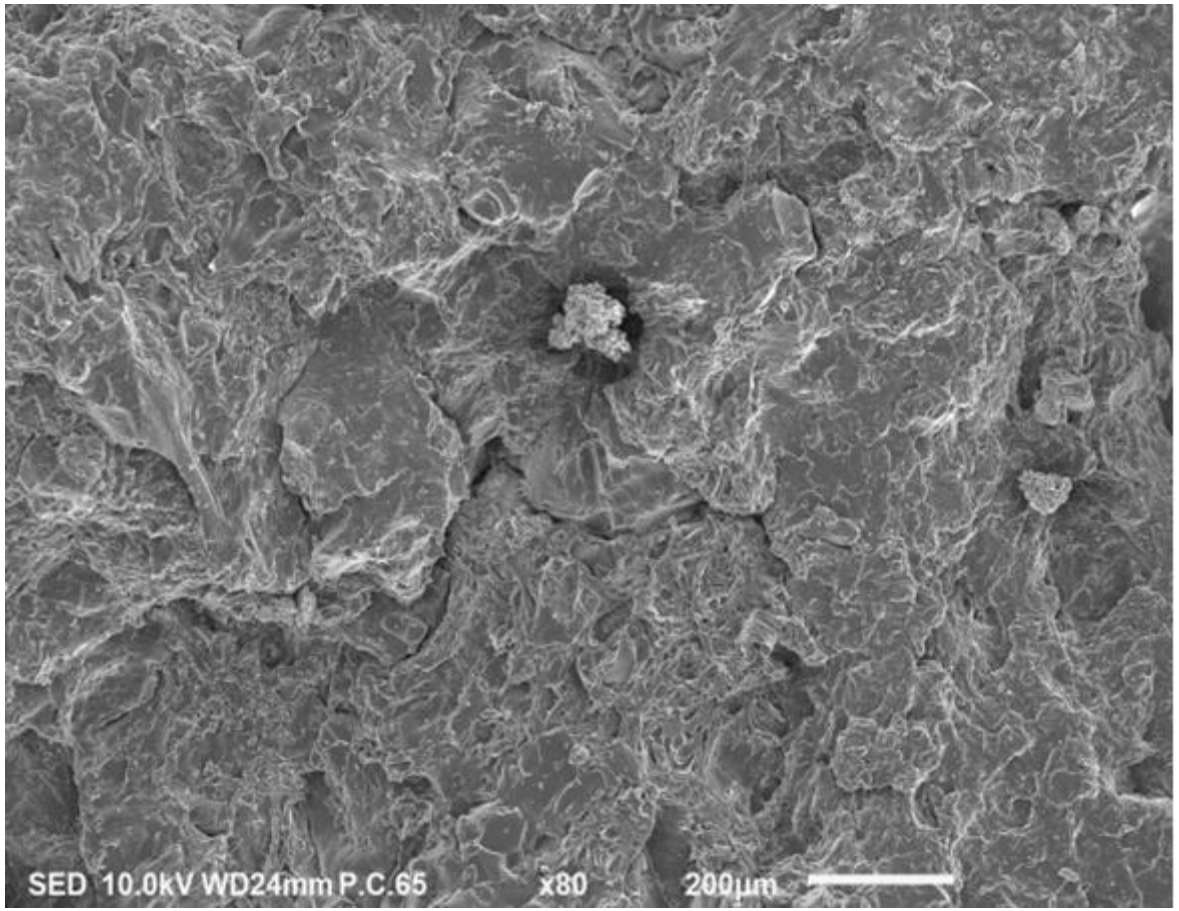
Morphology analysis using SEM of 40 % 40





Morphology analysis using SEM of 40 % 60 # cryogenic

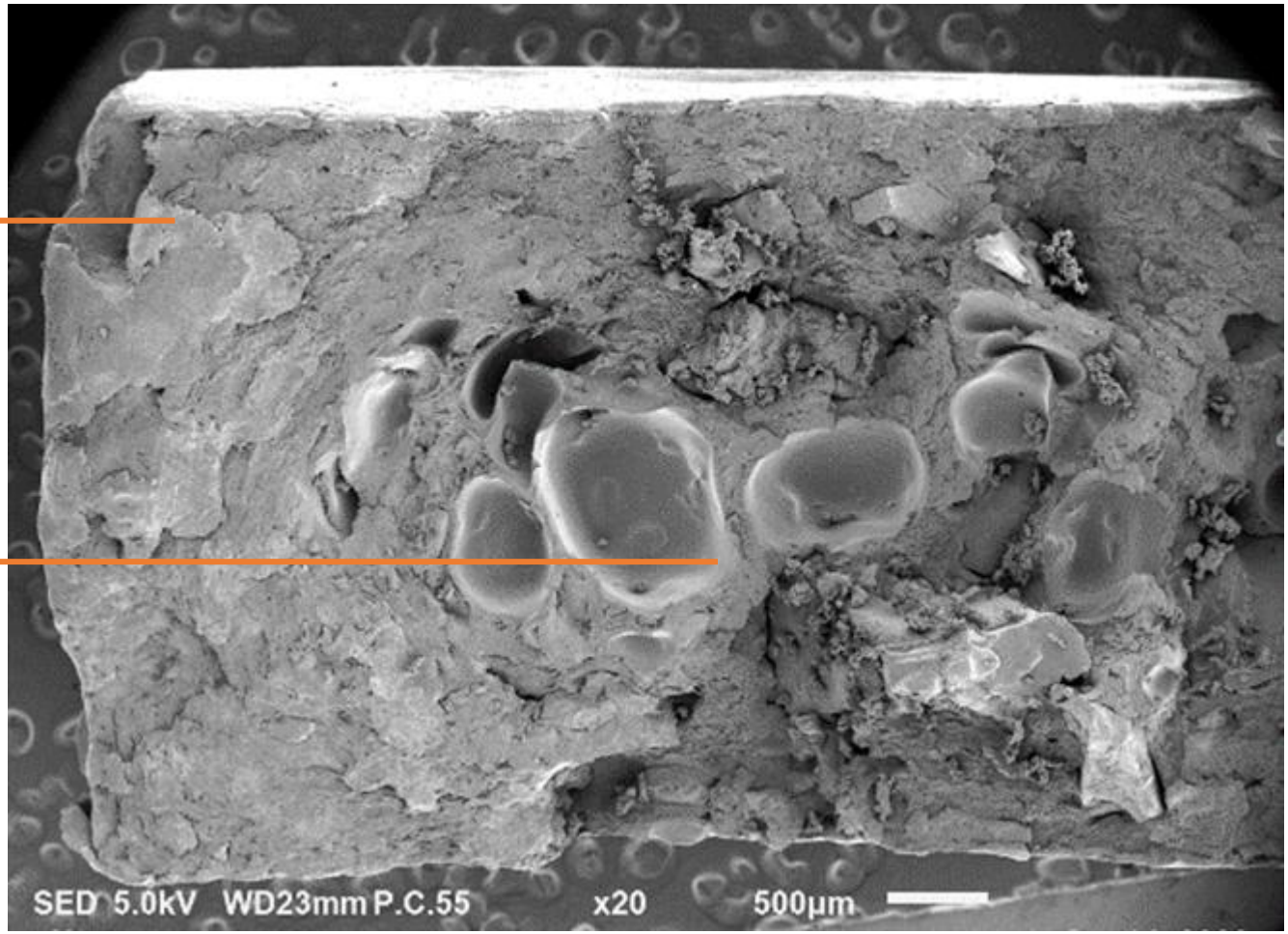




MORPHOLOGY ANALYSIS 20% SW

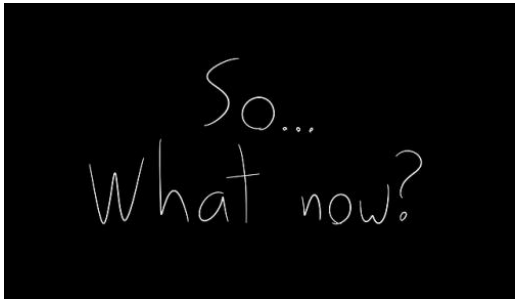
Plastic matrix

Elastomer



SUMMARY

Waste materials are not the same.

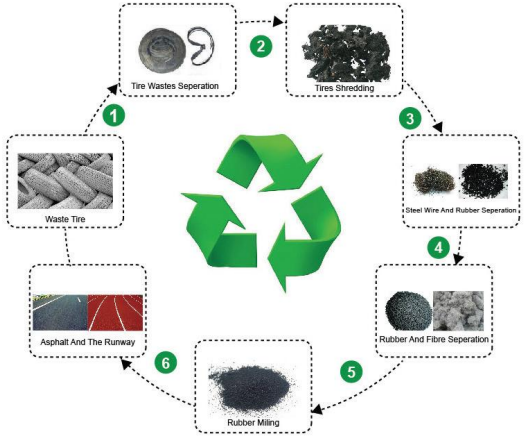


- They require proper **screening** and **evaluation**

Recycled plastic	GTR
Crystallinity	Size/shape
Morphology	Composition

Recommendations

- ***GPC >>>> MW, MWD, Mn,***
- ***Large Scale Moulding***
- ***Industrial Testing***
- ***Ageing***



Bretcor Plastics

Vistarus
Mission Station
To Restore the Broken Body, Mind and Soul.

CSIR
Touching lives through innovation

SAFARI TYRES
Est. 1973
Reliable Affordable Tyres

TrenTyre
SUPPORTED BY GOODYEAR

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Volkswagen

QPlas Automotive

TOYOTA