Assessment of Recycled Material Content in Recycled Products

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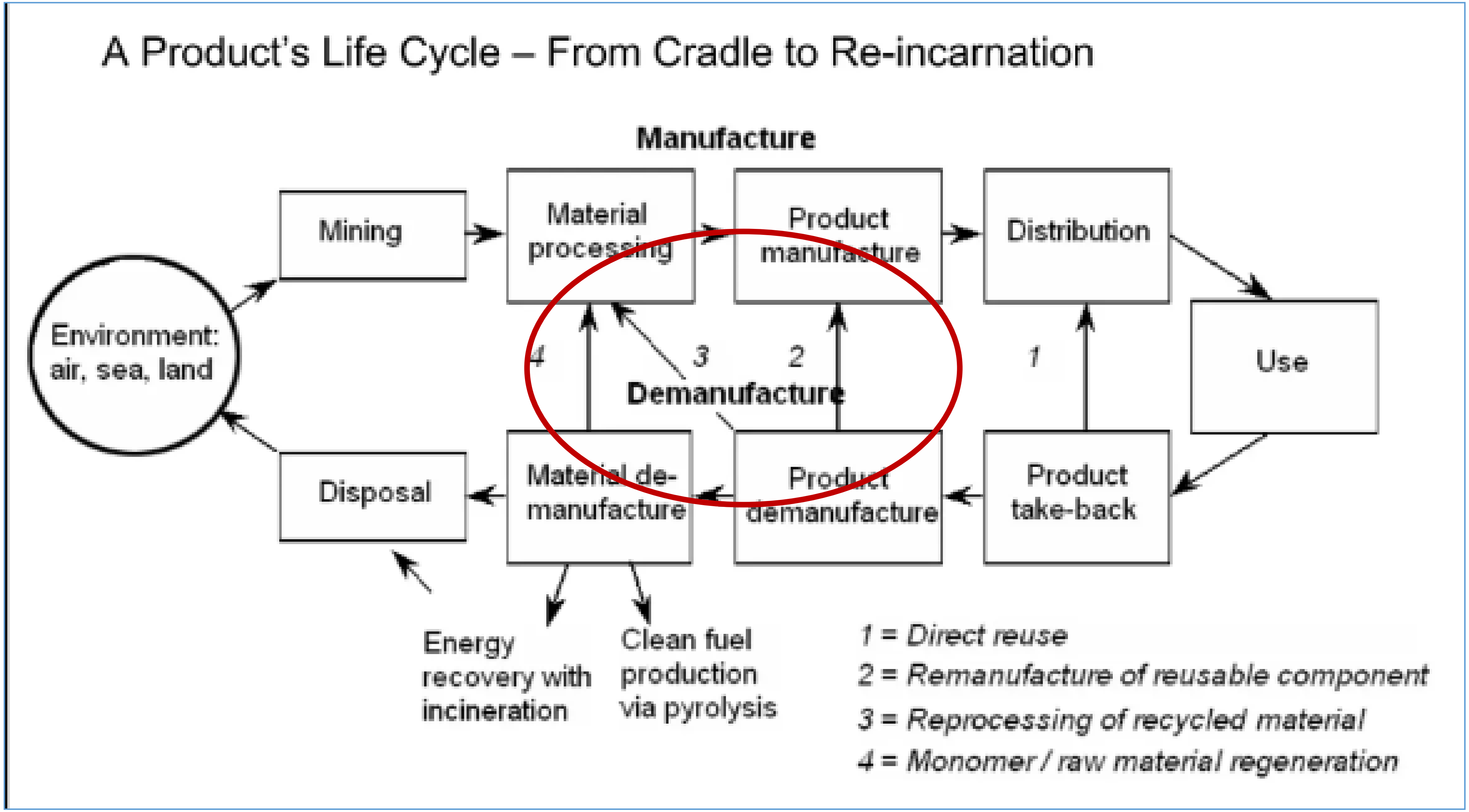
***Plastic Packaging Research and Development Centre* (PPRDC)**
Roundtable | | Sustainable Packaging & EPR Regulations
Date: 14th December 2022 (Wednesday)

Post Consumer Recyclate (PCR)

"THE USE OF POST-CONSUMER RECYCLED MATERIAL HELPS TO ELIMINATE THE NEED TO EXTRACT MORE FOSSIL FUELS FROM THE EARTH THAT ARE UTILIZED TO SHAPE NEW 'VIRGIN' PLASTICS."

Driving the Circular Economy thinking

Material Efficiency ⇄ **Carbon Footprint Mitigation**


A Product's Life Cycle – From Cradle to Re-incarnation
Manufacture
Mining
Material processing
Product manufacture
Distribution
Use
Environment: air, sea, land
Demanufacture
4
3
2
1
Disposal
Material de-manufacture
Product demanufacture
Product take-back
Energy recovery with incineration
Clean fuel production via pyrolysis
1 = Direct reuse
2 = Remanufacture of reusable component
3 = Reprocessing of recycled material
4 = Monomer / raw material regeneration

EPR- and PW-Related Rules

- The **Ministry of Environment, Forest, and Climate Change** announced the Plastic Waste Management (Amendment) Rules, 2022, which notified the instructions on *Extended Producer Responsibility* (EPR) for plastic packaging.

- **Plastic Waste Management Rules** 2016, 2018 has been amended to fast-track the elimination of single use plastics and promote alternatives.

- PET bottle scrap regulations in India are listed in the following guidelines and rules in India: **Plastic Waste Management (PWM) Rules**, 2016 , India. IS 14534: 1998

- The term **Extended Producer Responsibility** means the responsibility of a producer for the environmentally sound management of the product until the end of its life. With respect to plastic packaging, the EPR covers reuse, recycling, use of recycled plastic content and end of life disposal by producers, importers and brand-owners.

- Reuse of rigid plastic packaging material has been mandated in the guidelines to reduce the use of fresh plastic material for packaging.

Obligations under EPR

Mandated targets specified for :

Reuse of rigid packaging (Brand-owners) (2025 onwards)

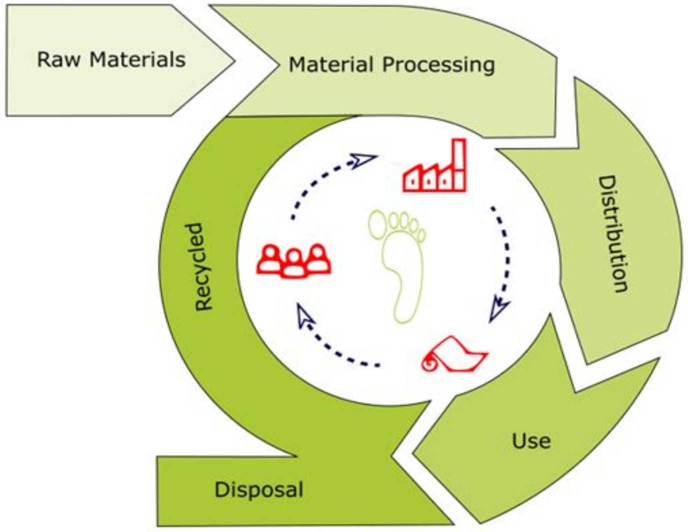
Use of recycled plastic (2025 onwards)

Fulfilling EPR obligations through recycling (2024 onwards)

Compostable plastics (2024 onwards)

- ✓ **Remaining EPR target to be fulfilled through End of Life Processing (Cement Kilns, Co-processing - Cement Kilns, Waste to energy and Waste to Oil.)**
- ✓ **70% EPR target : 2023-24; 100% EPR Target 2024 onwards**

• IMPACT OF PACKAGING FILM THICKNESS
• (MONOLAYER POLYETHYLENE)
• ON SUSTAINABILITY & CARBON FOOTPRINT



A STUDY

UNDER THE AEGIS OF

Aspirelabs | FITT, IIT Delhi | FICCI

CONDUCTED FOR THE PERIOD OCT'20 - AUG'21

Life Cycle Analysis - to preserve the value of plastics and to efficiently design the products for best possible post consumers usage ……………

PE Granules | **PE Film** | **PE bag** | **Post -consumer waste** | **Recycling** | **PCR granules**

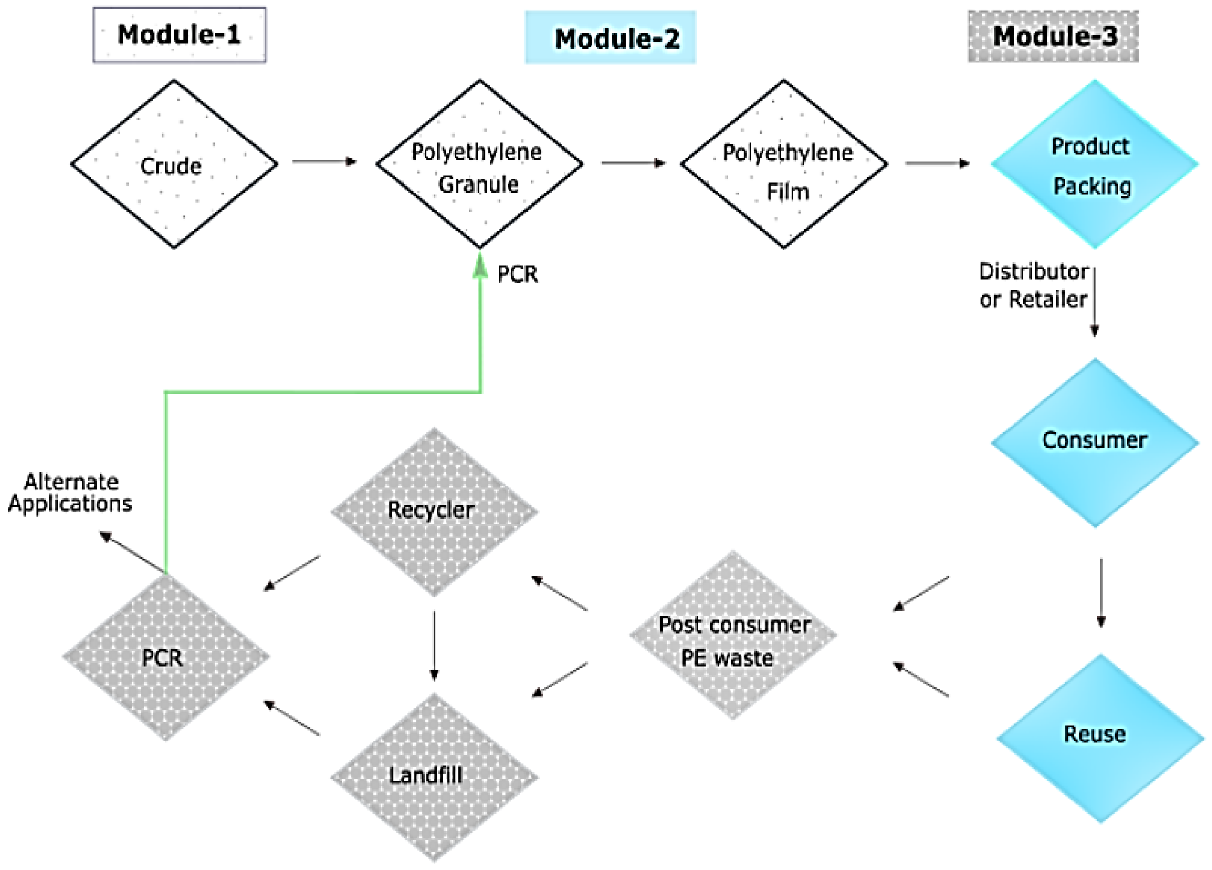
Figure-1: Schematic diagram – cradle to cradle
Source- Core team

"Consecutive and interlinked stages of a product or service system, from the extraction of natural resources to the final disposal."

- ISO 14040.2 Draft: Life Cycle Assessment - Principles and Guidelines

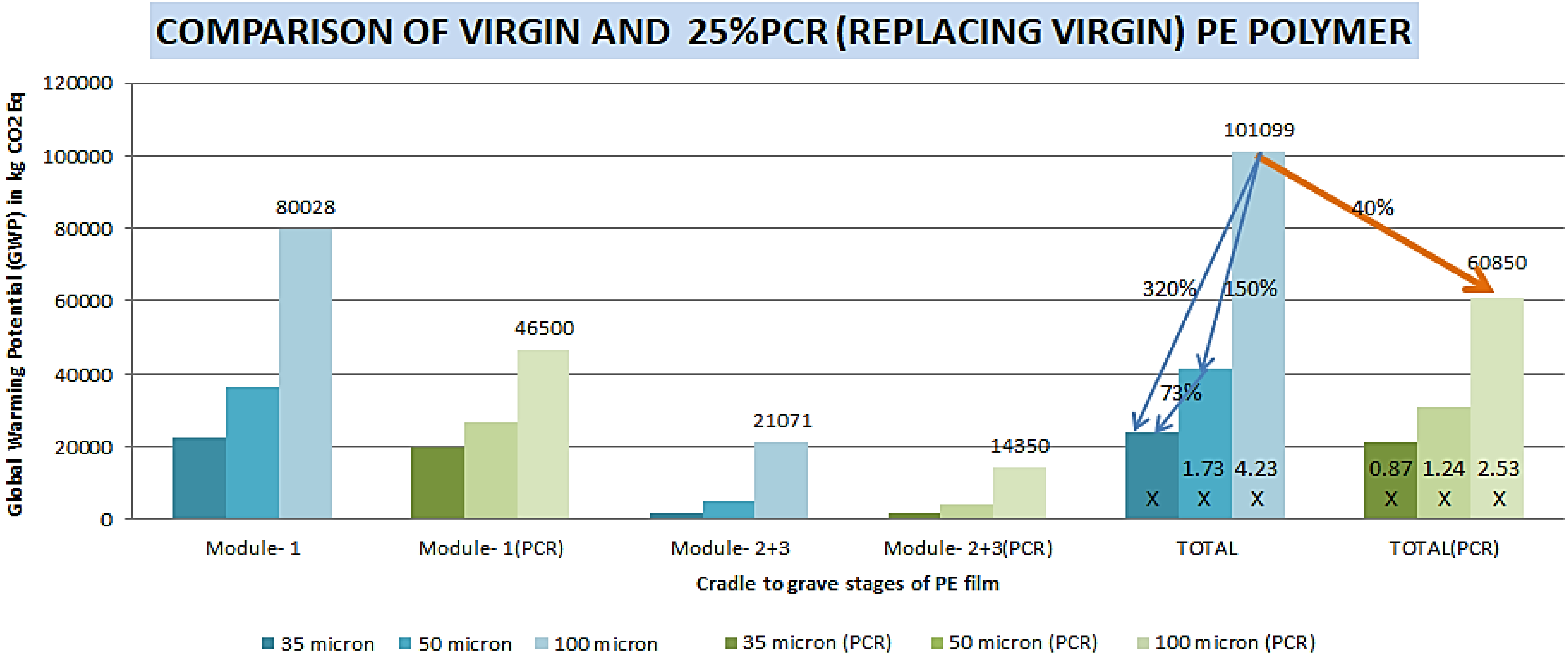
Project study steps

- Technical analysis of 35, 50 and 100 micron thickness packaging as per ISO 14040 standard and the LCA framework
- Data inputs on Module-1,2 and 3 from the stakeholders including survey on module-3 with Waste Plastic Recyclers
- Analysis with latest LCA software - GaBi Professional 2020



Material Flow Diagram

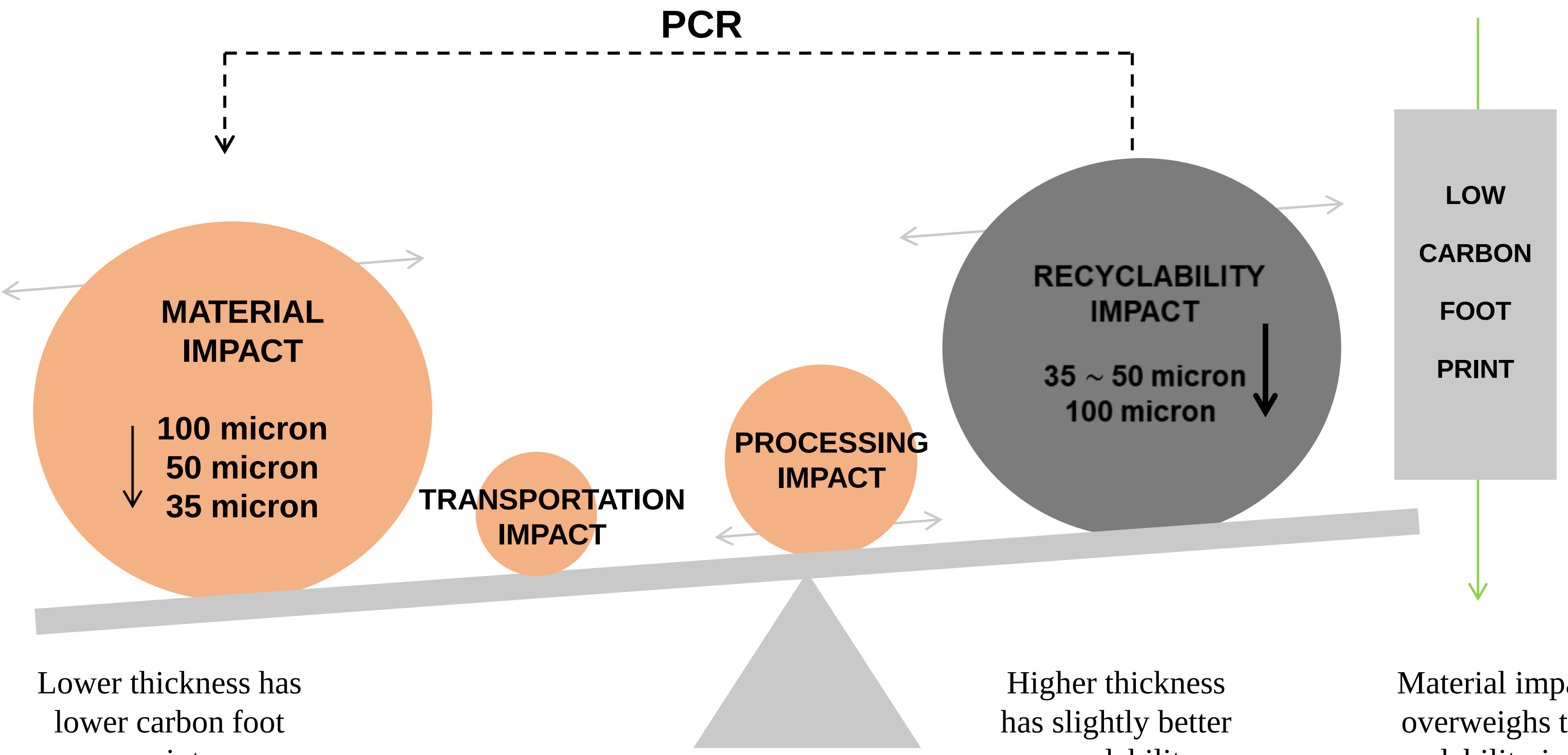
Findings



COMPARISON OF VIRGIN AND 25%PCR (REPLACING VIRGIN) PE POLYMER
Global Warming Potential (GWP) in kg CO2 Eq
120000
100000
80000
60000
40000
20000
0
80028
46500
21071
14350
101099
60850
40%
320%
150%
73%
1.73 X
4.23 X
0.87 X
1.24 X
2.53 X
Module- 1
Module- 1(PCR)
Module- 2+3
Module- 2+3(PCR)
TOTAL
TOTAL(PCR)
Cradle to grave stages of PE film
35 micron
50 micron
100 micron
35 micron (PCR)
50 micron (PCR)
100 micron (PCR)

Findings

Overall impact parameters can be shown figuratively as in a balance form as below



Material Burden			
Micron Thickness	35	50	100
GWP with No PCR	X	1.73X	4.23X

Recycling Gain			
Micron Thickness	35	50	100
GWP with 25% PCR	.87X	1.24X	2.53X

Lower thickness has lower carbon foot print

Higher thickness has slightly better recyclability

Material impact overweighs the recyclability impact

Global Warming Potential balance & Thickness variation

PPRDC – IIT Delhi – CIPET Project on

Testing Protocol and Standards for Estimation of PCR content in Product:

Characterization, Evaluation, Analysis and Standardisation

Carried out by

Central Institute of Petrochemicals Engineering & Technology (CIPET), Bhubaneswar
School for Advanced Research in Petrochemicals (SARP)-LARPM
(Dept. of Chemicals & Petrochemicals, Ministry of Chemicals & Fertilizer, Govt. of India)

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Dr. Smita Mohanty, CIPET, Bhubaneshwar

R&D Team, UFlex, NOIDA

Research Team

- **Dr Akshaya K Palai – QM**
- **Sri Pinaki Chatterjee - TM**
- **Sri Kali Prasad Sahoo - PA**
- **Sri Jeevan Jyoti -PA**

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Scope

This study aims to provide critical properties of PCR materials, underlying mechanisms and influencing material parameters with the intention to find correlations between these properties and parameters.

This is approached by studying a matrix of PCR-PET with

a) various levels of recycled content and
b) various qualities of PCR-PET from different collection systems and systematically studying these with regards to

- particle contamination,
- Intrinsic Viscosity/ Mol. Wt.
- CIELAB method
- Pyro-GC MS
- FTIR, DSC
- critical optical properties haze, colour and UV-VIS absorption, and
- mechanical property

OBJECTIVE

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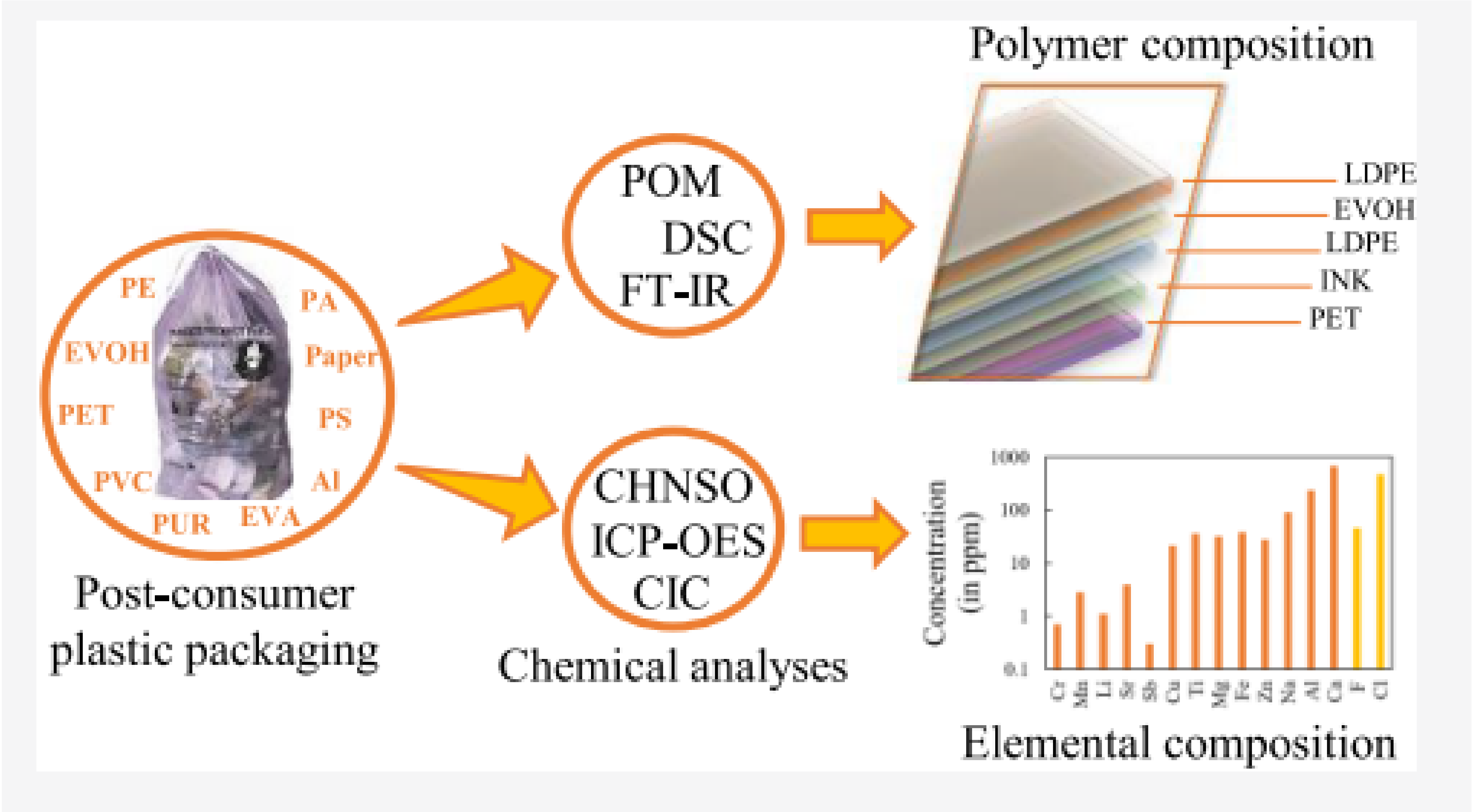
- To Increase the recycling capacity of post-consumer PET plastic by recovering its monomers for the synthesis of new materials.
- To check the quality performance of the polyethylene terephthalate(PET) application.
- Evaluation of material properties like Mechanical, thermal, Morphological and other properties.
- To identify the how much percentage (%) of PCR/ PET & impurities adding in Virgin PET material.
- Analyse the behaviour of material employing quantitative & qualitative experimental research.

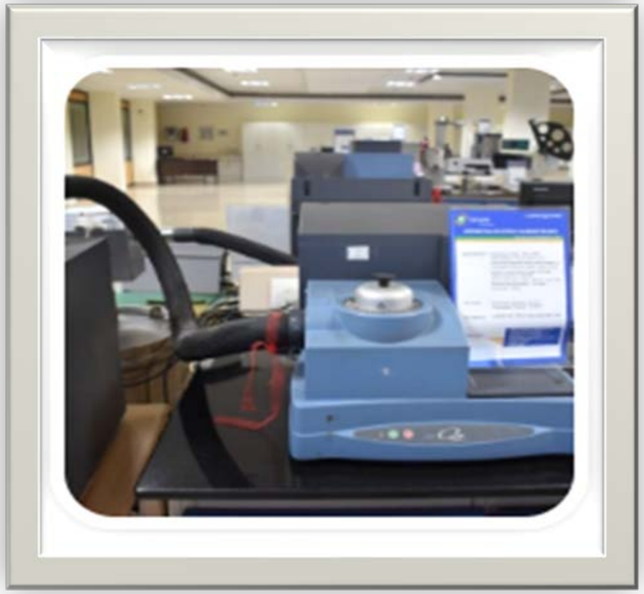
MATERIALS

- Neat PET
- PCR(post Consumer Recycle)
- PCR PET FILM WITH 90% PCR CHIP
- PCR PET FILM WITH 30% PCR CHIP
- PCR PET FILM WITH 20% PCR CHIP
- PCR PET FILM WITH 10% PCR CHIP



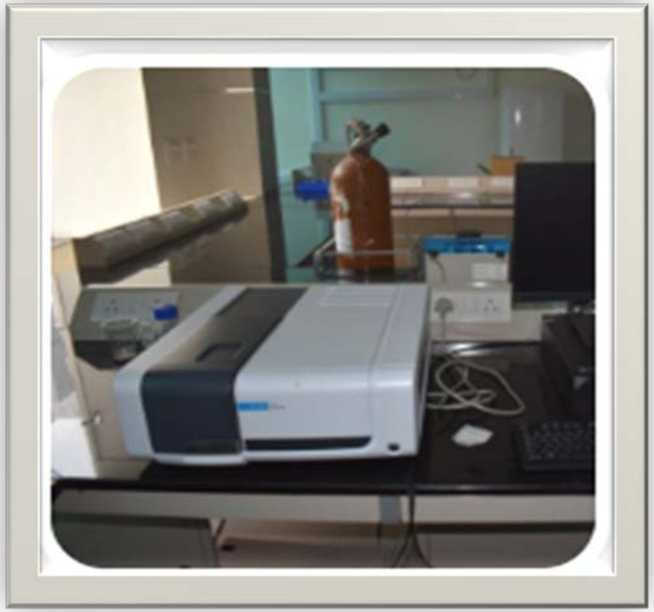
PE
PA
EVOH
Paper
PET
PS
PVC
Al
PUR
EVA
Post-consumer plastic packaging
POM
DSC
FT-IR
CHNSO
ICP-OES
CIC
Chemical analyses
Polymer composition
LDPE
EVOH
LDPE
INK
PET
Concentration (in ppm)
1000
100
10
1
0.1
Elemental composition

Characterization Techniques employed



Differential Scanning Calorimeter (DSC)

Thermogravimetric Analyzer (TGA)



UV- vis spectrophotometer

FTIR spectrometer

L&W Elrepho Spectrophotometer

(Source: L&W ABB)

DSC Thermograms

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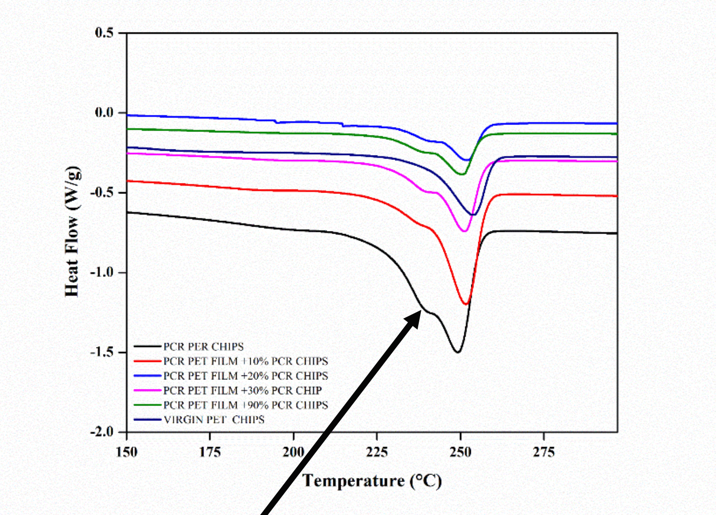
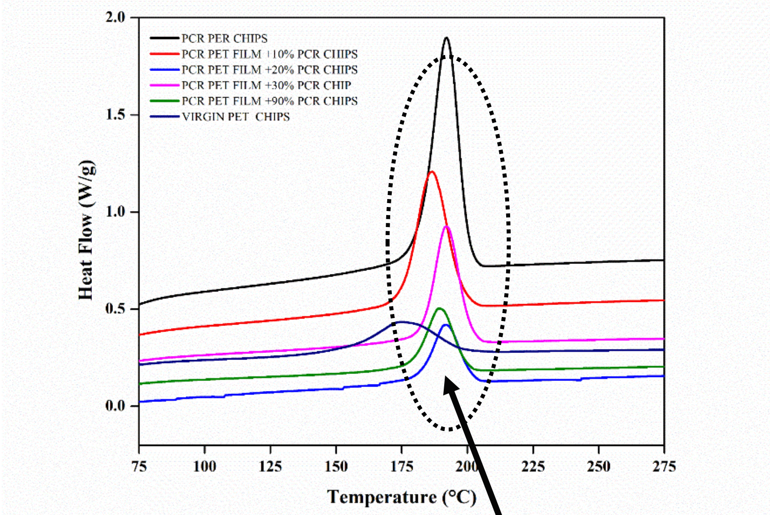


Broadening of Melting peak incase of PCR and PET with PCR



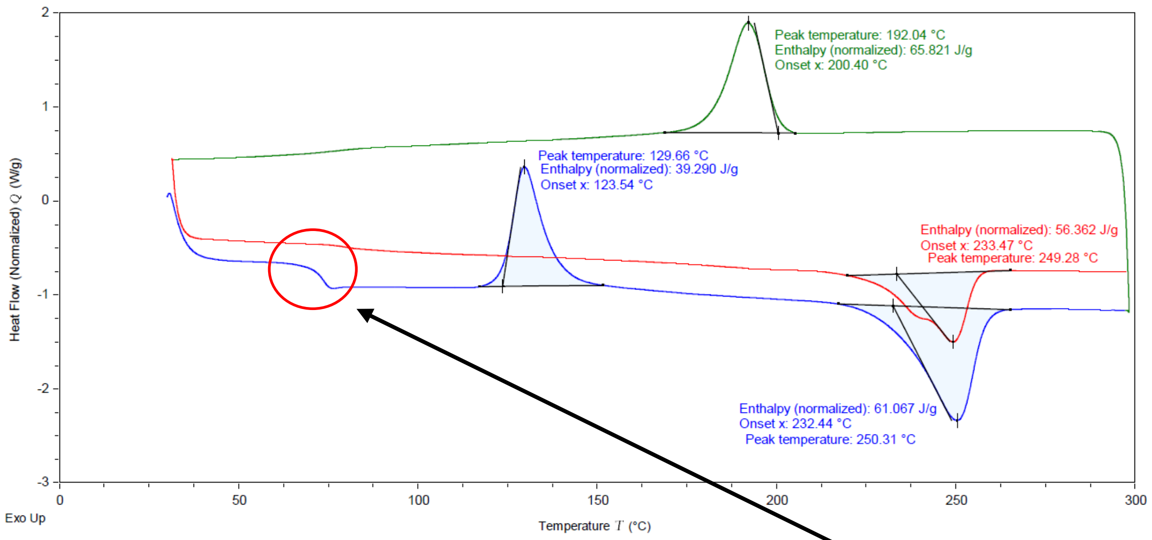
The Crystallization peak indicates sharp peak for PCR, whereas Virgin with PCR indicates wider peak intensity

Sample Type	T_g (°C)	T_c (°C)	T_m (°C)	
			$T_m(1)$	$T_m(2)$
Virgin PET	79	175.39		253.56
PCR 90% Chip	76	245.19	230.13	251.05
PCR 30% Chip	--	189.35	230.56	251.71
PCR 20% Chip	--	203.31	231.37	252.53
PCR 10% Chip	--	217.27	231.34	251.98
PCR Chip	80	231.23	232.02	

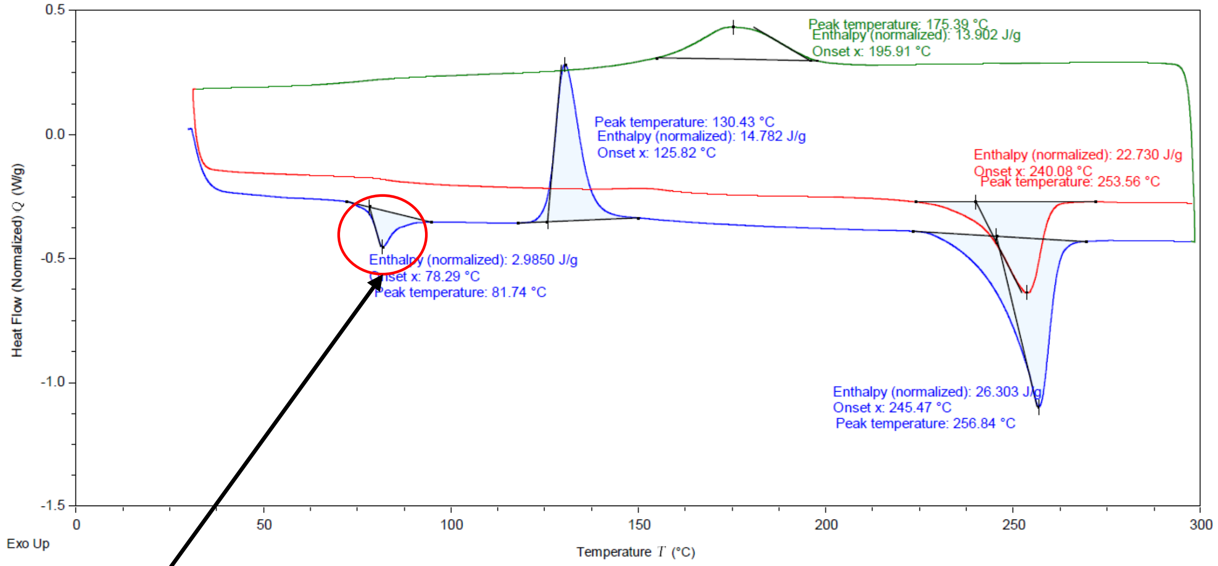
DSC Parameters of virgin PET and its blends with variable PCR content

DSC Thermograms

DSC thermogram for PCR

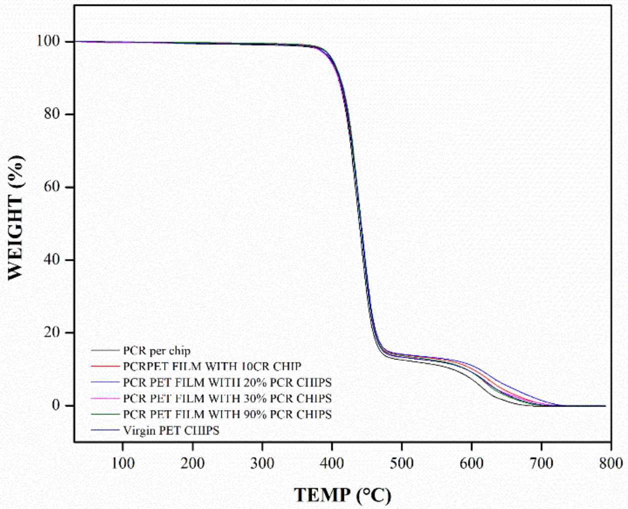


DSC thermogram for Virgin PET



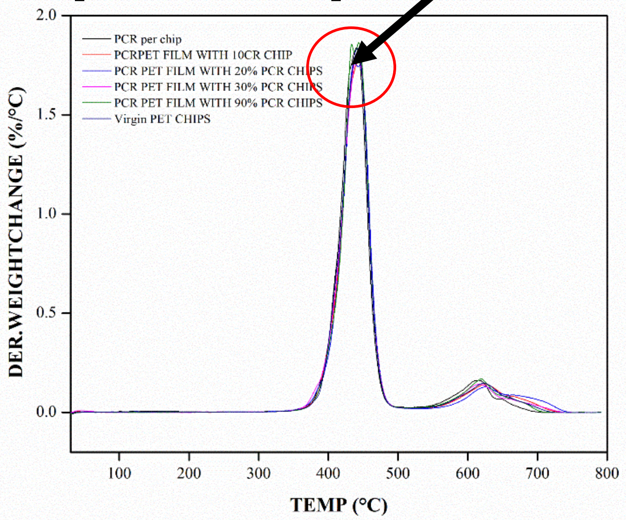
- ✓ Clear Tg was observed in case of PCR and Virgin PET around 76-79 °C.
- ✓ Addition of 10 wt% of PCR resulted in marginal increase in the Tg of PET.
- ✓ However, with the incorporation of PCR beyond 10 wt% there was a broadening of the Tg region and absence of any indicative peak.

TGA Thermograms



TGA thermogram shows no significant changes

Higher percentage of PCR in Virgin indicates multiple transition peaks



Sample Type	Initial Deg Temp °C	Maximum Deg Temp °C		Final Deg Temp °C
		Tmax(1)	Tmax(2)	
Virgin PET	357	442.06	--	723
PCR 90% Chip	358	433.01	443.88	714
PCR 30% Chip	354	442.33	445.21	731
PCR 20% Chip	348	435.34	444.66	742
PCR 10% Chip	361	433.79	445.44	728
PCR Chip	351	441.55	--	703

TGA parameters of virgin PET and its blends with variable PCR content:

- ✓ Higher percentage of PCR in Virgin PET indicated multiple transition peaks as observed from the DTG thermograms at maximum degradation range.
- ✓ This suggested the impurity/presence of multiple material in the PET matrix

Dynamic Mechanical Analysis

- **Temperature sweep from 280°C to 30°C on 4 samples were carried out.**
- **Temperature was ramped down from 280°C to 30°C at a rate of 2°C/min, normal force set to 0 N and strain was varied from 1% to 0.1% at a constant frequency of 1 Hz**

S.No.	Sample name	T_g (ºC)
1	PET Virgin	86.92
2	PCR-PET 100% recycled	143.72
3	50% PET Virgin and 50% PCR-PET	108.35
4	90% PET Virgin and 10% PCR-PET	96.21

- **All the tests were done in nitrogen atmosphere in CTD 600.**
- **The results obtained can be used to conclude that all these samples can be differentiated on the basis of their T_g.**

Recycled PET content

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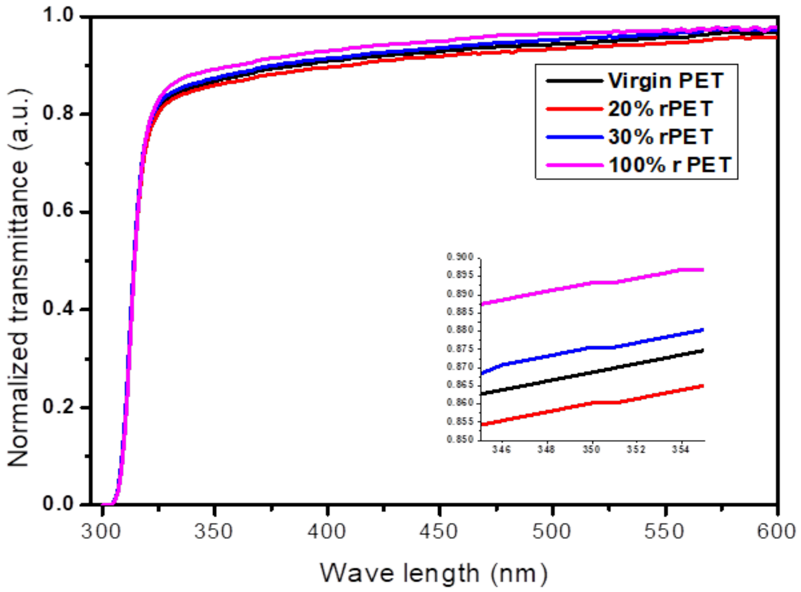
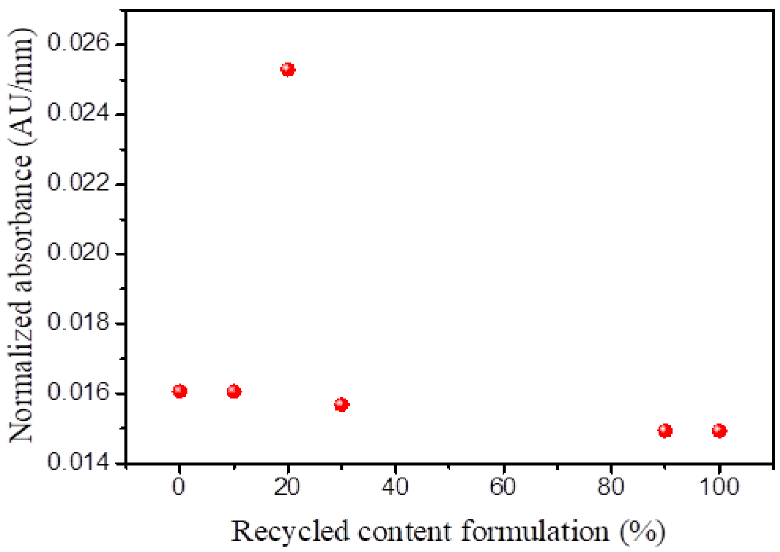


Light transmission at 300-600 nm of PET Sheets made from selected ratio of virgin and recycled PET



Normalised absorbance values at 350 nm at various recycled content levels

Light Transmission at 350 nm for PET sheets

Samples	Normalized UV transmittance (%)
Virgin PET	0.86867
20% recycled PET	0.86024
30% recycled PET	0.8756
100% recycled PET	0.89336

Thickness of PET sheets

Samples	Thickness (mm)
Virgin PET	0.01-0.11 (average 0.0105)
20% recycled PET	0.010
30% recycled PET	0.010
100% recycled PET	0.012-0.013 (average 0.0125)

Way-forward

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- **To encounter the challenges involved with the recycling processes, especially in separation, purification and processing steps.**
- **Incorporation of PCR content in the PET changes the thermal properties; UV-Vis spectra of the matrix – *recommended to provide films of variable thickness to generate calibration curve***
- **Studies i.e DSC/TGA; UV –Vis and FTIR shall be given more emphasis to determine the PCR content in unknown sample.**

THANK YOU!

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