सेन्ट्रल इंस्टिट्यूट ऑफ पेट्रोकेमिकल्स
इंजीनियरिंग & टेक्नॉलाजी (सिपेट)
(पूर्व सेन्ट्रल इंस्टिट्यूट ऑफ प्लास्टिक्स इंजीनियरिंग & टेक्नॉलाजी (सिपेट))
सेन्टर फॉर स्किलिंग & टेक्निकल सपोर्ट (सी एस टी एस)
रसायन एवं पेट्रोरसायन विभाग
रसायन एवं उर्वरक मंत्रालय, भारत सरकार
थिरुवादवूर, मधुरै - 625 110.
फोन : 0452-2424277
ई-मेल : atpdc.cipetmdu@gmail.com
वेब्सइट : www.cipet.gov.in
मुख्यालय : सिपेट, गिण्डी, चेन्नै - 600 032.

CIPET सि पे ट
probe • perform • practice • Plastics

CENTRAL INSTITUTE OF PETROCHEMICALS ENGINEERING & TECHNOLOGY (CIPET)
{Formerly Central Institute of Plastics Engineering & Technology (CIPET)}
CENTRE FOR SKILLING & TECHNICAL SUPPORT (CSTS)
Department of Chemicals & Petrochemicals
Ministry of Chemicals & Fertilizers, Govt. of India
Thiruvathavur, Madurai - 625 110
Phone : 0452-2424277
E-mail : atpdc.cipetmdu@gmail.com
Web : www.cipet.gov.in
Head office : CIPET, Guindy, Chennai - 600 032

CIPET: CSTS-MDU/PTL/GLEPL/2022-23 **13 January, 2023**

To
M/s. Greenline Eco Product Pvt. Ltd,
Vijayamangalam

Dear Sir,

Sub: Assessment and Certification of Paver Block & Roofing Sheet made from Plastics Waste –Reg

Ref: 1. Your Request Letter Dated: 19.12.2022
2. CIPET Proposal No: CIPET/Dir-Pro-Test/GEPL/Consul/2022 Dated: 20/12/2022
3. Your Conformation Email Dated: 20.12.2022
4. CIPET Technical team visit to your factory premise on 21.12.2022

With reference to the above subject, the samples of plastic film waste used in the manufacturing of paver blocks and the roofing sheet were collected from your factory premise and subjected to series of testing analysis as per various Standards at CIPET laboratory. Based on the results obtained through this analysis, CIPET Madurai hereby provide the following ***recommendations/ Certification***:

- As all aware, generation of plastic waste is huge in today scenario and waste recycling and reusing is an important aspects of safe disposal, collection and conversion of plastic waste into value added product
- The Paver Block & Roofing Sheet Product developed by M/s.Greenline Eco Product Pvt. Ltd, Vijayamangalam is substantially contributing in reduction and safe disposal of plastic waste, which in turn support green environment.
- Further, manufacturing process of paver block & Roofing Sheet from plastic waste is an established process which are already in practice in many countries; they do not release any hazardous elements/ matters to the environment which were confirmed through series of testing analysis (Report enclosed as Annexure- A&B) and hence it is recommended to permit the conversion (manufacturing) of plastic waste into paver block & Roofing Sheet towards safe disposal of plastic waste.
- This project may be recommended on Pan India basis to handle the plastic waste and kind of plastic waste generated by PCR (Post Consumer Recycled) and PIR (Post Industrial recycled)

The detailed testing analytical report of Paver block and Roofing Sheet is enclosed as Annexure- A (Paver Block) & B (Roofing sheet/ Plain Sheet) respectively.

Dr. Nalini R
Manager (T)

Dr. L.Sivasubramanian,
Manager (T)

Dr. K.Prakalathan
Director & Head

CONSULTANCY PROJECT REPORT

ON

ASSESSEMENT AND CERTIFICATION OF ROOFING SHEET/ PLAIN SHEET MADE FROM PLASTICS WASTE

Submitted to

M/s. Greenline Eco Product Pvt. Ltd, Vijayamangalam

Submitted by

CENTRAL INSTITUTE OF PETROCHEMICALS ENGINEERING & TECHNOLOGY

(Department of Chemicals & Petrochemicals, Ministry of Chemicals & Fertilizers, Govt. of India)

CIPET: Centre for Skilling and Technical Support (CSTS),

Near Samathuvapuram,

Thiruvathavur,

Madurai - 625110

CERTIFICATE OF ANALYSIS

The polymeric waste samples subjected to following analysis and the results obtained are summarized as given below:

Sample Details	Test Description	Test Details	Results Obtained
Roofing Sheet (As stated and submitted by the party)	Melting Point of the Polymers using DSC	ASTM D 3417	T_m – 127°C & 253°C T_m – 110°C, 122°C , 131°C & 257°C T_m – 162°C, & 256°C
	Material Identification by FTIR	ASTM D 1252	• Polyethylene Terephthalate (PET); • Linear Low Density Polyethylene (LLDPE)-PolyethyleneTerephthalate (PET); • Low Density Polyethylene (LDPE)-High Density Polyethylene (HDPE)-Ethylene Vinyl acetate (EVA)- Polyethylene Terephthalate (PET) Layers.
	Heavy Metal Analysis	CL. 4.3 IS 17899 T: 2022	With in Specific Limits - Table 1
	CHNSO Analysis	ASTM D5291	No Sulphur Detected– No impurities found
	Smoke Density	ASTM D 2843	Less than 400 (within limits)

Remarks :

- It is certified that the samples drawn (Plastic Waste) from the factory site during the manufacturing of roofing sheet is found as LLDPE/PET/LDPE& HDPE without any other chemical substance. Incorporation of these plastic waste resulted with no leaching of Hazardous substance. Further, the smoke density of the plastic has also found to be within the limits.
- Detailed technical analysis on the above results are enclosed as Annexure-A

CIPET : CSTS ★ THIRUVATHAVUR, MADURAI ★ (Govt. of India)

ANNEXURE-A

DETAILE ANALYTICAL TEST REPORT NO: GEP-01 **Date: 13.01.2023**

Assessment Report of Roofing Sheet/ Plain Sheet Manufactured Using Plastic Waste

1. Introduction

M/s. Greenline Eco Product Pvt. Ltd, Vijayamangalam is currently in the process of manufacturing Roofing Sheet using about plastic film wastes. The innovative **Roofing Sheet is being manufactured by M/s. Greenline Eco Product Pvt. Ltd** using Multilayer Plastic (MLP) Waste and Other Polyethylene Terephthalate (PET) films wastes. The Multilayer Plastic (MLP) Waste of roofing sheet are made out of various polymers such as Polyethylene Terephthalate (PET), Low density Polyethylene, Aluminium Foil, Ethylene Vinyl Alcohol, High Density Polyethylene, Polypropylene, Polyamide, Ethylene Vinyl Acetate (EVA) etc. MLP is a preferred material in the food industry, as it protects the food products and hence giving it a longer shelf life. India has a diverse climate and the nature of MLP allows protection of food in climates like hot and humid. Hence, it is preferred on a large scale across India. This makes recycling of MLP economically unviable and is mostly destined to end up in landfill. However few technological interventions (includes the manufacturing of roofing sheet) have made it possible to manage this waste. The common laminated/ multilayer film structure along with the application is shown below.

Table 1: Multilayer Films used in different applications

Sl. No	Polymeric Material		Applications
1.	LLDPE/HMW-HDPE/LLDPE	:	Grocery Bags
2.	HDPE/LLDPE/HDPE/EVA	:	Cereal Liners
3.	Paper-LDPE-Al-LDPE	:	Liquid/Paste Packaging (Juice, Milk Cartons)
4.	PET/EVOH/LDPE/Al/LDPE	:	
5.	LLDPE-EVOH-LLDPE	:	Fresh Meat
6.	LLDPE-EVOH-PA-EVOH-LLDPE	:	Processed Meat
7.	LLDPE- Ethylene-vinyl acetate (EVA) -PA-EVOH-PA- Ethylene-vinyl acetate (EVA) -LLDPE	:	Fresh Meat
8.	LLDPE-HDPE- EVOH-HDPE-LLDPE		Processed Meat

CIPET : CSTS (Govt. of India) THIRUVATHAVUR, MADURAI

2. Manufacturing Process

In case of manufacturing of roofing sheet 100% Multilayer Plastics (MLP) Films are being used. Laminated films are used in a wide range of flexible packaging applications such as food pharma, personal care products, etc. and then disposed off with no values. These non-recyclable wastes are used in propitiatory technology to convert them into sheet form as a building material.

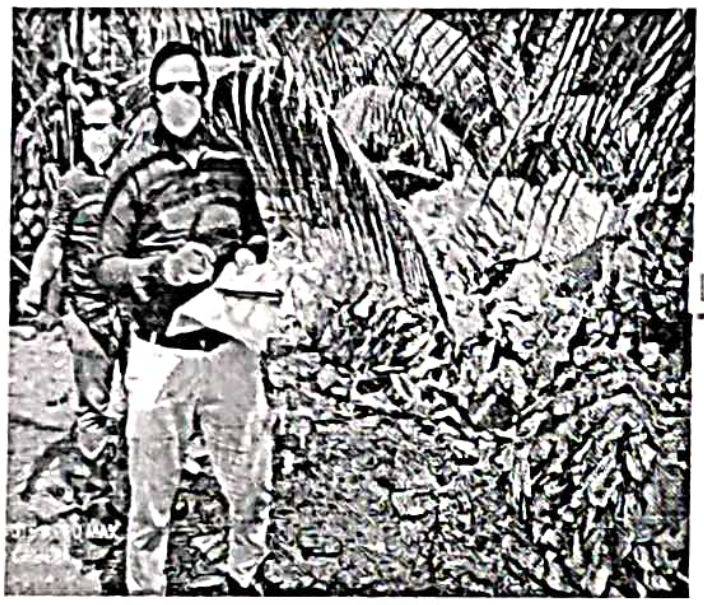

Figure 1: Multilayer Plastic Waste

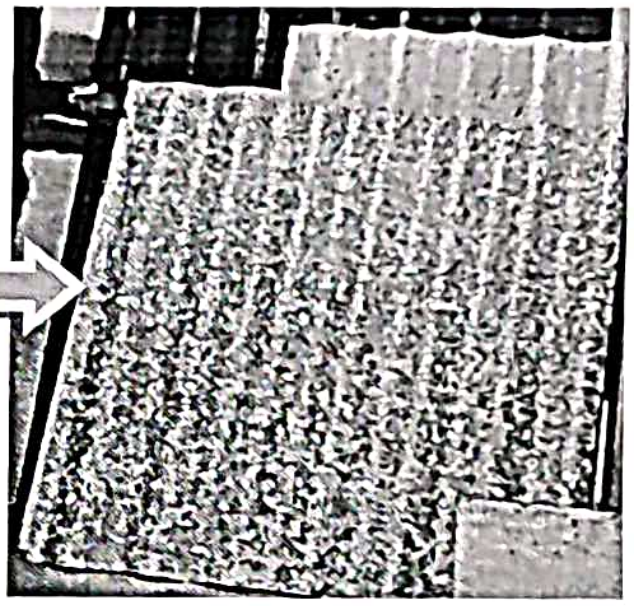

Figure 2: Roofing Sheet

Initially the PET cum the Multilayer films as shown in Figure 1 are shredded using the scrap grinder in order to obtain fine pieces of plastics. Then the shredded films are then converted to roofing sheet using extrusion process. Initially the shredded films are feed into the extrusion hopper, then feed materials get melted and homogenized at a temperature of 180°C-250°C; the homogenized melt is then pumped through the die in order to form sheet as shown in Figure 2. The Thick Plate Extrusion plate upto 25 mm are manufactured using the MLP Waste materials. These sheet plates/ roofing sheet have the features of nontoxic, smooth surface, erosion resistance. The extruded plate is the engineering plastic which can be used in the as partition walls, cabinets cum doors. The plates have good impact, heat resistance, flexibility, and smooth surface. M/s. **Greenline Eco Product Pvt. Ltd** has the Extrusion Machine, (Make Sinter Machines; Model: SM 400, Capacity: 600 Kgs/ Hr), as shown in Figure 3.

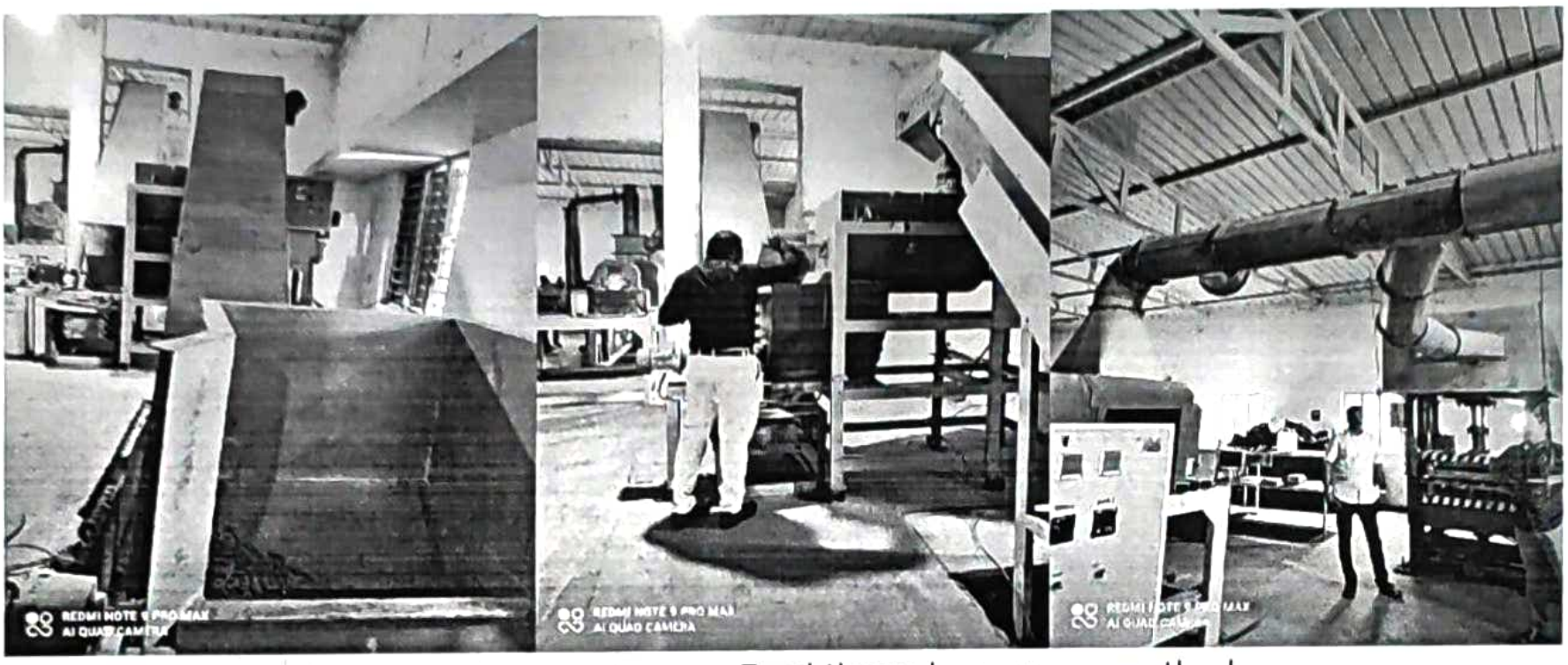

Figure 3: Extrusion Process, Feed through conveyor method

Analysis of Plastic Waste used in Roofing Blocks Manufacturing

The following testing were identified for analyzing the impact of hazardous constituents present in the waste and characterization was performed using the samples of waste

a. Characterization : (1) Differential Scanning Calorimetry (DSC)
   (2) Fourier Transform Spectroscopy (FTIR)
b. Heavy Metal Analysis : (1) Arsenic (As); (2) Copper (Cu); (3) Nickel (Ni) ; (4) Zinc(Zn)
   (5) Chromium (Cr); (6) Mercury (Hg); (7) Cadmium (Cd) ;
   (8) Lead (Pb)
c. CHNSO Analysis : Presence of –Carbon; Hydrogen; Nitrogen; Sulfur & Oxygen
d. Smoke Density : Emission of smoke during formation of Lumps

3.1 Differential Scanning Calorimetry (DSC)

The sample was subjected to differential scanning Calorimetry (DSC). Figure x, shows the thermograms samples used in the manufacturing of Roofing sheets. The characteristics of plastics waste used in the roofing were analyzed and reported. The samples were collected from the factory site are analyzed by using Differential Scanning Calorimeter (DSC) make of Perkin Elmer. The samples are tested as per ASTM D 3417; the temperature rise of 20° C/ min with the supply of nitrogen is maintained. DSC assists in determining the melting point of each polymeric material present in the plastic waste. The analysis confirms the presence of LDPE-LLDPE; PET-EVOH-LDPE-Al-LDPE; LDPE-Al-LDPE in the submitted. The results obtained are

depicted In Figure -4A, B & C

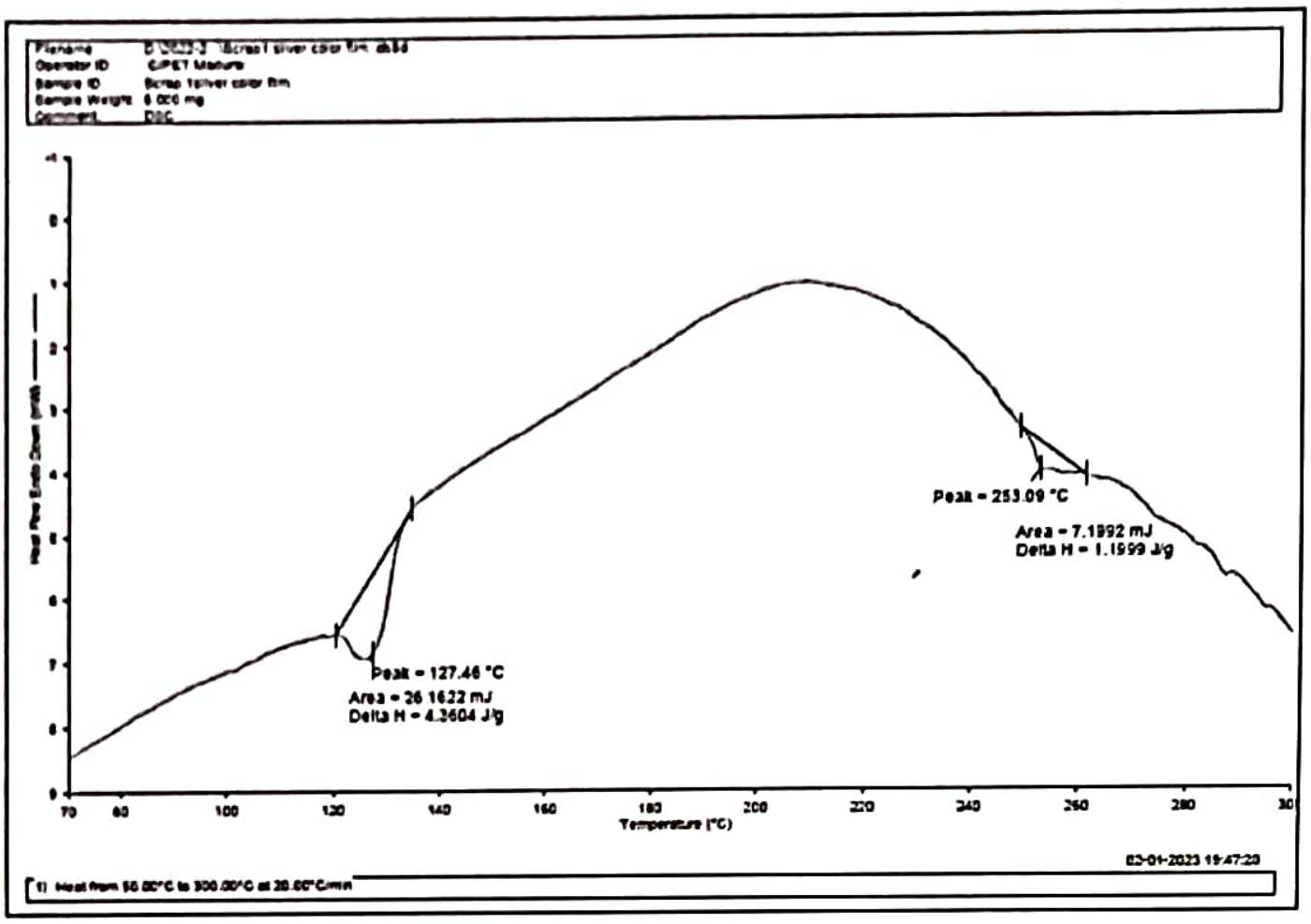

Figure 4A: DSC Analysis of Multilayer film 1- Linear Low Density Polyethylene (LLDPE)/ Polyethylene Terephthalate (PET)

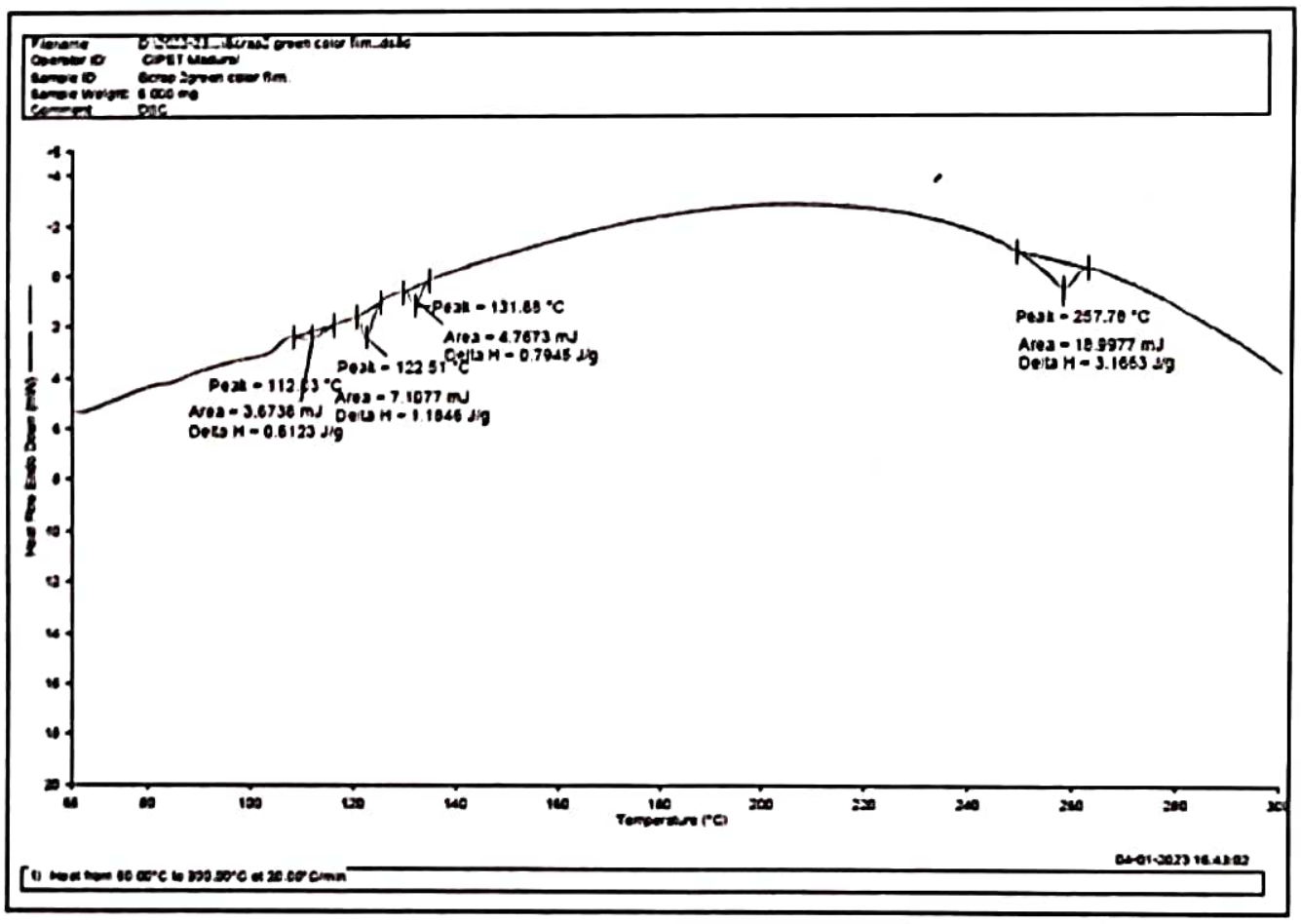

Figure 4B: DSC Analysis of Multilayer film 2- Low Density Polyethylene (LDPE)/ High Density Polyethylene (HDPE)/ Polyethylene Terephthalate (PET)

CIPET : CSTS
(Govt. of India)
THIRUVATHAVUR, MADURAI

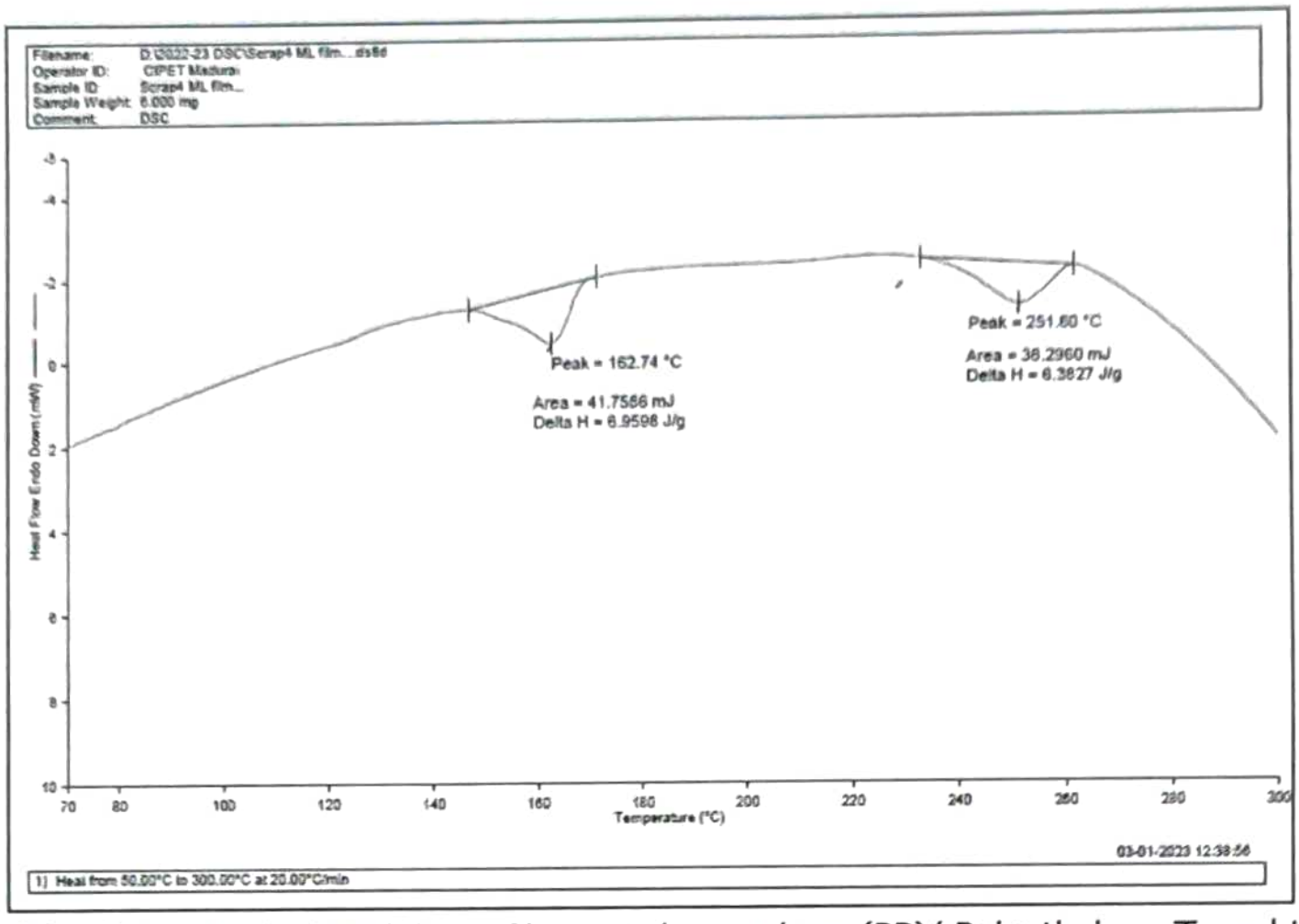

Figure 4C: DSC Analysis of Multilayer film 3- Polypropylene (PP)/ Polyethylene Terephthalate

3.2 Fourier Transform Spectroscopy (FTIR)

FTIR spectroscopy is an established technique to identify and characterize unknown materials (e.g., films, solids, powders, or liquids). If any contamination on or in a material (e.g., particles, fibers, powders, or liquids) could also be determined. The test is performed as per ASTM E 1252; a change in the characteristic pattern of absorption bands clearly indicates a change in the composition of the material or the presence of contamination. If problems with the product are identified by visual inspection, the origin is typically determined by FTIR microanalysis. This technique is useful for analyzing the chemical composition of smaller particles, typically 10 -50 microns, as well as larger areas on the surface.

In this study the plastic waste and the roofing sheet are collected from the factory site and analysis. The spectrum of plastic waste used in roofing sheet are identified and depicted in (Figure -5A & B)

On analysis of the spectra,it is understood that the PET due to the sharp C=O group at around 1700 cm^{-1} & C-O group at 1100 cm^{-1} as shown in figure 5A-2 & 5B-2 and PE due to the prominent peaks of stretching vibrations of CH_2 group at around 2900 cm^{-1} and 2800 cm^{-1} as

shown in figure 5A-1 & 5B-1.

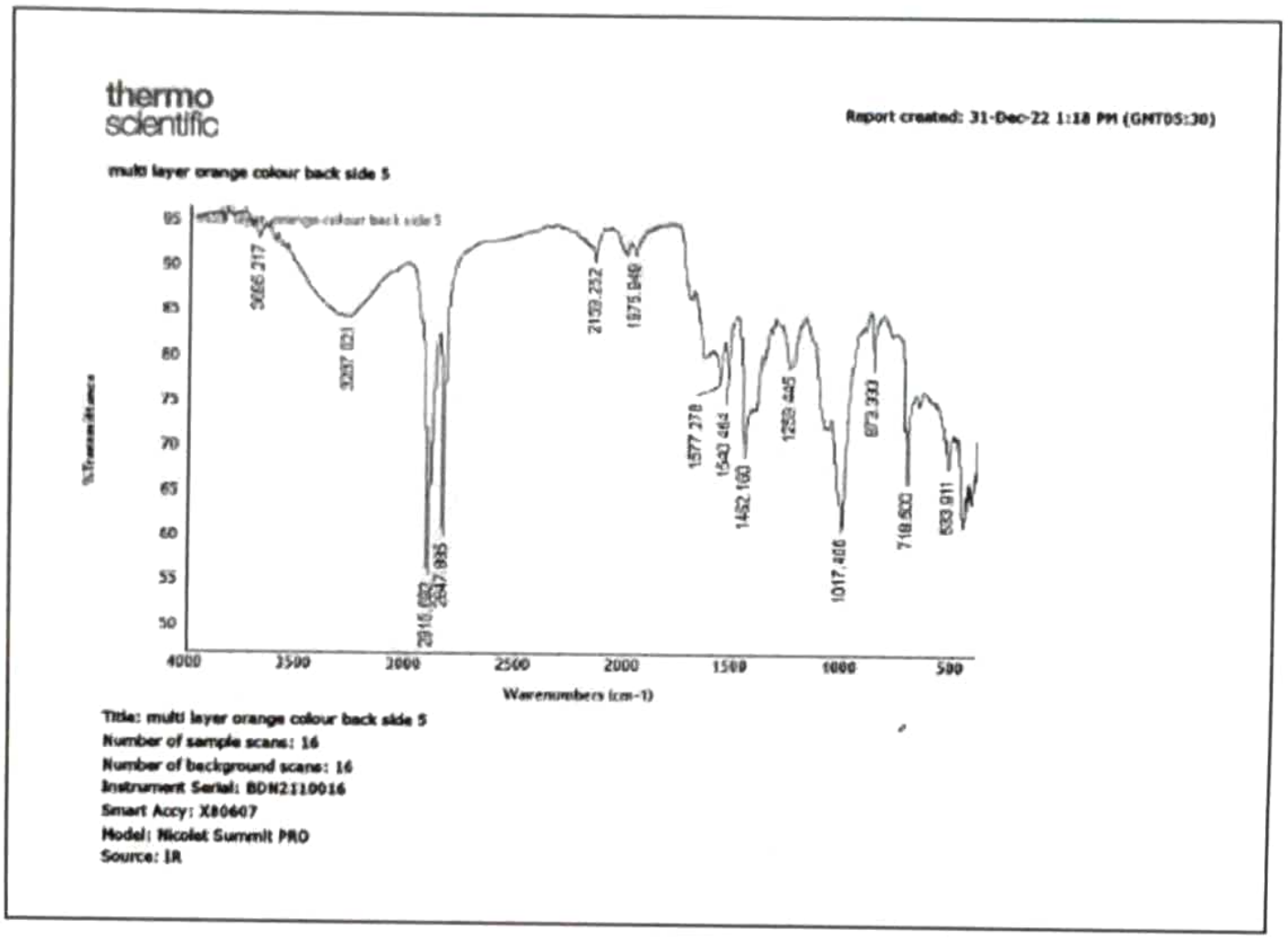

Figure 5A-1: FTIR Analysis of Multilayer Film -1- Linear Low Density Polyethylene (LDPE)

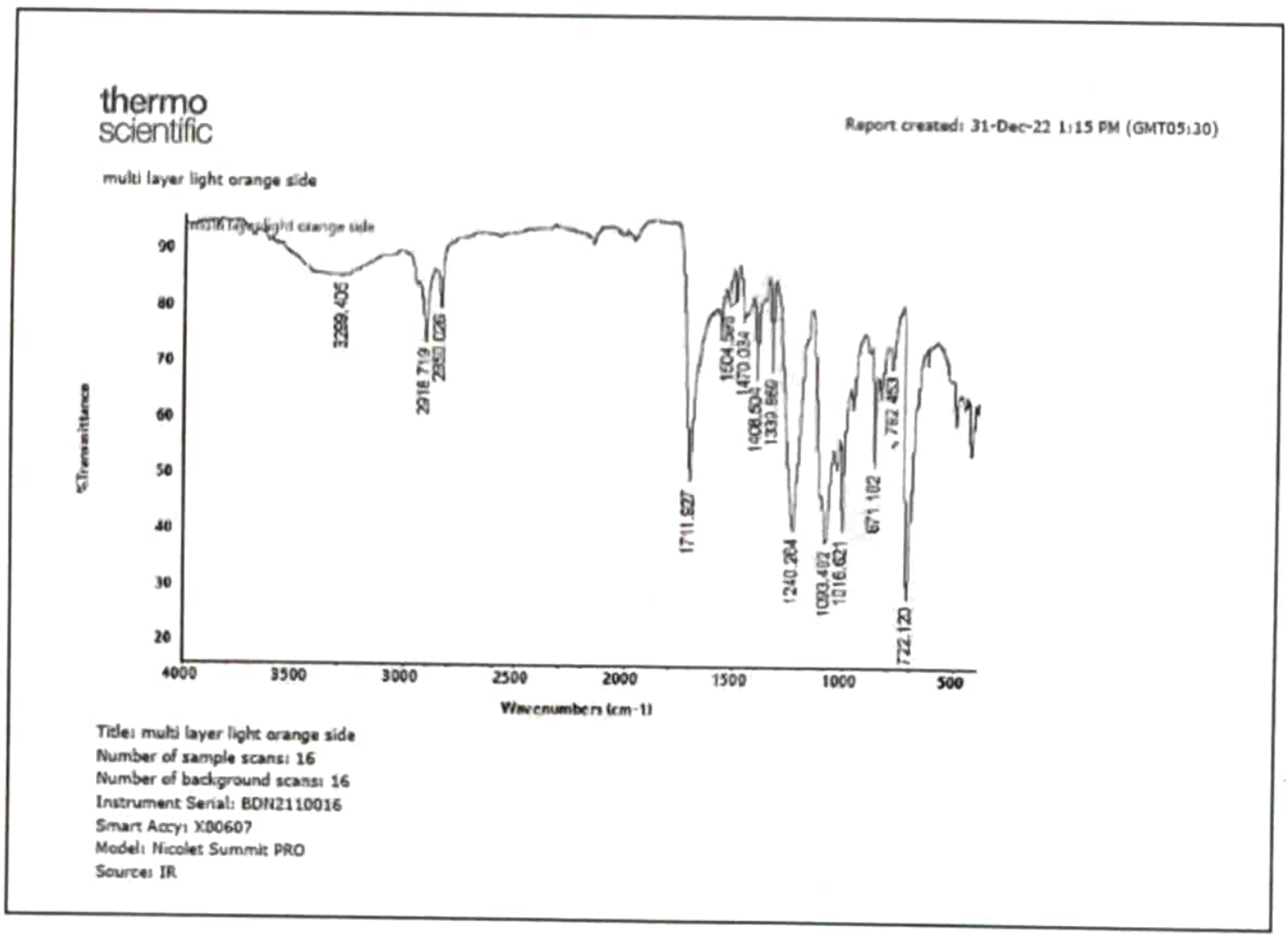

Figure 5A-2: FTIR Analysis of Multilayer Film -1- Polyethylene Terephthalate (PET)

3.3 Heavy Metal Analysis

Leaching is the process by which contaminants are transferred from a stabilized matrix to liquid medium, such as water or other solutions. However, the influence of acid rain on the leaching behavior of heavy metals and transformation of their speciation into the soil is investigated and detailed in Table 2.

Table 2: Heavy Metal analysis of Multilayer Plastics based Polymeric Waste

Sl No	Tests	Test Method/Standard	Unit	Specified Requirements (Max)	Result Obtained
	Heavy Metal Analysis				
1.	Arsenic (As)	C. 4.3 IS 17899 T: 2022	%	10	0.0003
2.	Copper (Cu)			300	0.0041
3.	Nickel (Ni)			50	0.0647
4.	Zinc (Zn)			1000	0.0003
5.	Chromium (Cr)			50	0.0005
6.	Mercury (Hg)			0.15	0.0002
7.	Cadmium (Cd)			5	0.0001
8.	Lead (Pb)			100	0.0005

The results obtained reveals that the heavy metals found to be having very minimal concentration of Leachate from the plastic waste used in the manufacturing of Roofing sheet. From the results, it is revealed that the used of waste materials in the Roofing sheet do not produce any harmful toxic elements to the soil/ ground water/ Surface water or any other associated matter.

3.4 CHNSO Analysis

CHNSO (CHNSO) elemental analyzer determined the Total nitrogen, carbon, nitrogen, sulfur and oxygen present in the compound as per ASTM D5291. Elemental analysis is a process where a sample of some material, mineral or chemical compound is analyzed for its elemental composition. CHNS analysis gives the percentage composition of each element in a sample. Impurities can easily be identified. Data produced by CHNSO elemental analysis helps to determine the chemical composition and structure of an organic compound. Table 3, shows the results of CHNSO analysis of multilayer plastic waste used in manufacturing of roofing sheet, the results reveals that zero percentage of elemental sulphur. Therefore it is concluded that the plastic samples used in Roofing sheet do not have any impurities.

Table 3: CHNSO analysis of Polyolefin-based Polymeric Waste

CHNSO ANALYSIS					
Sl. No	**Test –Analysis**	**Unit**	**Results Obtained**		
			Sample A	**Sample B**	**Sample C**
1.	Carbon	%	49.42	47.67	50.73
2.	Hydrogen	%	5.122	0.0	5.13
3.	Nitrogen	%	0.0	0.0	11.78
4.	Sulphur	%	0.0	0.0	0.0
5.	Oxygen	%	26.55	28.96	11.16

3.5 Smoke Density

This test measures the amount of smoke given off by a material that is burning or smoldering. The test is performed as per ASTM D 2843. The material is tested when it begins to smolder and again when a flame source is added. The smoke density is between 0 (no smoke generated) and 800. An exposure condition in the test simulates important and typical parameters experienced in a real fire. For example, the amount and rate of smoke generation for most materials depends on whether the specimen is exposed to flame or just radiant heating.

Table 4 shows the maximum specific optical density of plastic waste materials under flaming and non-flaming exposure conditions. The smoke must not exceed a maximum smoke optical density value which differs based on the test specification used.

Table 4: Smoke Density analysis of multilayer polymeric film

Smoke Density of plastic waste materials			
Sl. No	**Test –Analysed**	**Unit**	**Results Obtained**
1.	Smoke Density	%	43

From the results, it is found that the smoke generated during combustion is within the permissible limits.

3. Conclusion

From the entire analysis, the following conclusions are drawn in regards to the MLP's used in the manufacturing of roofing sheet / Plain Sheet

- The multilayer films/ films used in roofing sheet consist of Polyethylene Terephthalate (PET); Linear Low Density Polyethylene (LLDPE)-Polyethylene Terephthalate (PET); Low Density Polyethylene (LDPE)-High Density Polyethylene (HDPE)-Ethylene Vinyl acetate (EVA)- Polyethylene Terephthalate (PET) Layers.

- The Heavy Metal analysis revealed that the used of waste materials in the roofing sheet do not produce any hazardous elements to the soil/ ground water/ Surface water

- CHNSO elemental analysis helps to determine the chemical composition and structure of an organic compound, which shows the no impurities in the compounds of roofing sheet

- The smoke density analysis revealed that the plastic waste used during the manufacturing of Roofing sheet has not exceeded a maximum smoke optical density value, which may not harm the environment

4. Recommendations

- As all aware, generation of plastic waste is huge in today scenario and waste recycling and reusing is an important aspects of safe disposal, collection and conversion of plastic waste into value added product
- The Roofing Sheet/ plain sheet Product developed by M/s.Greenline Eco Product Pvt. Ltd, Vijayamangalam is substantially contributing in reduction and safe disposal of plastic waste, which in turn support green environment
- Further, manufacturing process of roofing sheet from plastic waste is an established process which are already in practice in many countries; they do not release any hazardous elements/ matters to the environment which were confirmed through series of testing as stated in this report of analysis and hence it is recommended to permit the conversion (manufacturing) of plastic waste into roofing sheet towards safe disposal of plastic waste.
- The roofing / plain sheet may be a good replacement for wood. Hence, this project may be recommended on Pan India basis to handle the plastic waste and kind of plastic waste generated by PCR (Post Consumer Recycled) and PIR (Post Industrial recycled)

CIPET : CSTS ★ THIRUVATHAVUR, MADURAI ★ (Govt. of India)

Reference :

- Garg, S.K., A Support Manual for Municipal Solid Wastes, Environmental Engineering, Central Pollution Control Board, Vol.II, (July 2003).
- Ministry of Road Transport and High Ways, Manual for construction and supervision of Bituminous works, New Delhi, November 2001.
- Nabil Mustafa, Plastics Waste Management, Canadian Plastics Institute, Toronto, Ontario, Canada, Marcel Dekker, Inc (1993).
- Sri Ram Institute for Industrial Research, Plastics Processing and Environmental Aspects, New Delhi – 7
- Vasudevan, R., Utilization of waste plastics for flexible pavement, Indian High Ways (Indian Road Congress), Vol. 34, No.7. (July 2006).
- R. Vasudevan, S.K. Nigam, R. Velkennedy, A. Ramalinga Chandra Sekar and B. Sundarakanna Utilization of Waste Polymers for Flexible Pavement and Easy Disposal of Waste Polymers, Proceedings of the International Conference on Sustainable Solid Waste Management, 5 - 7 September 2007, Chennai, India. pp.105-111

Dr. Nalini R
Manager (T)

Dr. L.Sivasubramanian,
Manager (T)

Dr. K.Prakalathan
Director & Head

CIPET : CSTS
(Govt. of India)
THIRUVATHAVUR, MADURAI