

CREATING IMPACTFUL INNOVATIONS

Speciality Polymers



Founded in 1994, Pluss Advanced Technologies started with R&D and manufacturing of specialized polymers. In 2007 Pluss commenced development in the field of Phase Change Materials (PCMs) technology. In 2012, the company raised equity funds from Tata Capital Innovations Funds and expanded R&D, developed and commercialized first of its kind temperature control solutions using proprietary materials, addressed unmet need of temperature control across refrigeration, cold storage, cold-chain logistics, HVAC, and healthcare sectors. The company today has a global presence with its own subsidiary in Netherlands. Pluss has received several awards and recognitions, including the CII Innovation award twice, in 2014 and 2017. It has also received the Massachusetts Institute of Technology's Innovators under 35 awards, in 2016 and 2017. Since 2021, Pluss is a subsidiary of Carborundum Universal Limited (CUMI), which is a Murugappa Group company.



PLUSSTAINABLE

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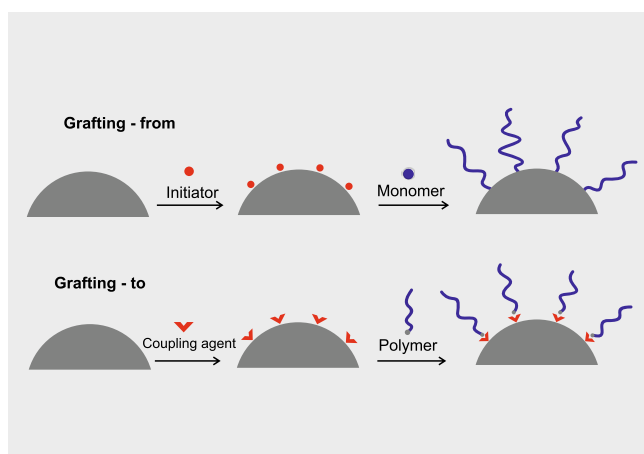
able to maintain the optimal rate or level to meet the needs of the present without compromising the needs of future generations, the **PLUSS way**.

Sustainability drives all that we do. From the business that we are in, the ideas we generate, the products we develop to the processes we undertake. Our unwavering commitment to a sustainable way of living and working, drives us towards PLUSStainability at all times.



Our Technology

Starting with research and development on Functionalised Polymers in 1994, Pluss entered commercial production in 2001. In 2003, Pluss was awarded the Technology Day award by the then Vice President of India for development of Maleic Anhydride functionalised polymers for the first time in India. Subsequently, the company has received recognition at various platforms for its home-grown technology for creating functionalised polymers.



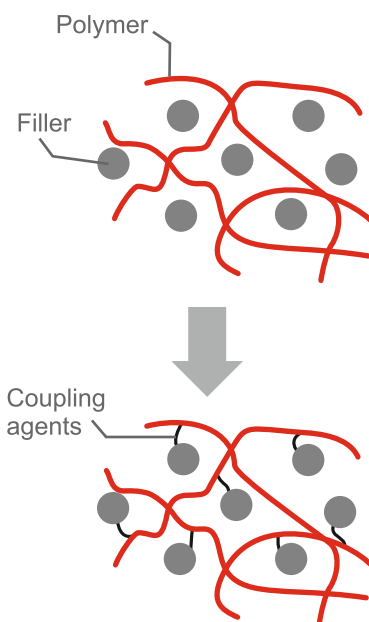
Our Technology

Driving through Sustainability

PLUSS has been a constant trendsetter in the field of functionalized polymers which serve to enhance the mechanical properties and processing conditions of polymer compounds, blends, and alloys.

Speciality polymers are chemically modified polymers used as coupling agents, compatibilizers, impact modifiers, tie-layer adhesive resins, metal adhesion promoters, flow modifiers and chain extenders for polymer compounds, blends, and alloys. These are produced by chemical grafting of reactive monomers like maleic anhydride, glycidyl methacrylate and other similar materials on the base polyolefins. They possess superior properties than the simple polyolefins in terms of polarity, adhesion to different substrates, and compatibility with reinforcements and fillers.

PLUSS produces and markets these speciality polymers under the brand names OPTIM[®], BindEX, reCoup[®], NOVIS, ADNYL[™], OPTIPET[™]. These enhance properties of polymer compounds thus enabling their increased adoption in automotive, wire & cable, wood plastics composites, flexible packaging, white goods, and recycling industries besides several others.



Key Features



Extensive portfolio

Coupling agents, compatibilizers, impact modifiers, flow promoters, scrap upgraders, tie-layer adhesive, metal adhesion promoter & chain extender.



Production facilities

State-of-the-art machines equipped with German and American technology at the production site in Bawal, located on the Delhi Mumbai Industrial Corridor, Haryana.



Indigenous technology

Being the first in India to indigenize the technology on commercial scale. Hence economical.



Just in time

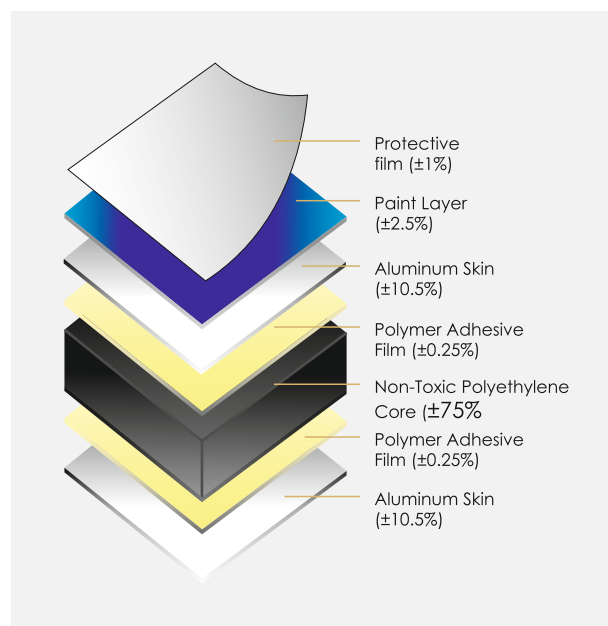
Well-established network of associates in India and across the globe for ensuring JIT delivery.

Buildings

Aluminium Composite Panels

Aluminum composite (ACP) panels are laminates made of LDP core layer sandwiched between two sheets of aluminum, jointed with the help of adhesive Layer polymer. This adhesive layer of polymer can be applied by direct extrusion coating process or in the form of films.

BindEX E-165 adhesive resin bonds polymer core with aluminum sheets in ACP. It can be processed on normal extruders used for polyethylene. BindEX E-165 has suitable pendant functional groups to bond to aluminum metal on one side, while its polyethylene backbone has natural affinity with the non-polar polyolefinic layer on the other side in the aluminum panel structure. OPTIM E-119 coupling agent is also used for filled PE based HFFR ACP compound.



Advantages

- Strong Adhesion - BindEX E-165 bonds strongly to metals such as aluminium and steel under heat and pressure. It has natural affinity with PE due to its polyolefinic nature
- Easy processability – It is available in pellet form and can be processed on all conventional extrusion equipment suitable for polyolefin processing

| Segment | Grade | Applications |
|---------|---------------|--|
| ACP | OPTIM® E-119 | Coupling agent for PE based ACP with high filler content |
| | OPTIM® MB-80 | Low temperature adhesive film for ACP |
| | BINDEX® E-165 | Adhesive film for ACP to bond polymer core with aluminum sheets in aluminum composite panels |

Wires and Cables

PLUSS manufactures coupling agents for Halogen Free Flame Retardant (HFFR) Wire & Cable Compounds based on polyethylene, with the addition of special mineral fillers to impart flame retardant properties. They are finding increasing use as replacement for PVC for applications where low smoke and no acid gas evolution are required during a fire situation.

ATH and Magnesium Hydroxide are the most widely used non-halogenated flame-retardant

fillers used in wire & cable industry. These are incompatible with PE matrix. In order to keep excellent mechanical performance at a very high mineral loading,

OPTIM® coupling agents can be effectively used as coupling agents between polyolefin polymers and flame retardants. Typical addition levels of OPTIM® are in the range of 2-5 weight % based on the total compound weight.

Buildings

| Segment | Grade | Applications |
|---------------|--------------------------|---|
| wire & cables | OPTIM [®] E-119 | Coupling agent for HFFR fillers in wire & cable compounds |
| | OPTIM [®] E-131 | |
| | OPTIM [®] E-118 | |

Advantages

- Stable melt flow characteristics
- Higher extrusion speeds with improved surface appearance
- Less stress whitening in cable insulation layer
- Higher filler acceptability
- No limitation in colouring

Wood Plastic Composite

Wood plastic composites (WPCs) are mixtures of thermoplastic polymers, typically polypropylene and polyethylene, and small wood particles. The wood and thermoplastics are usually compounded above the melting temperature of the thermoplastic polymers and then further processed to make various WPC products, such as windows, door frames, interior panels in cars, railings, fences, landscaping timbers, cladding and siding, park benches, moulding and furniture.

The performance of WPC strongly depends upon the interfacial bonding between the wood and the plastic. This is because wood contains abundant hydroxyl and phenolic hydroxyl groups, making it highly polar;

however, thermoplastics are nonpolar or weakly polar materials. The low compatibility between wood and plastic significantly impacts the interfacial bonding, leading to the low mechanical properties in the resulting composites. Hence OPTIM series of coupling agents play an important role in improving the compatibility and adhesion between polar wood particles and non-polar polymeric matrices.



| Segment | Product Name | Applications |
|----------------|--------------------------|--|
| PP Compounding | OPTIM [®] P-408 | Coupling agent for CaCo ₃ , taic, mica or glass filled PP |
| | OPTIM [®] P-425 | Coupling agent for PP based WPC compounds |
| | OPTIM [®] R-658 | Impact modifier for filled/ Un- filled PP compounds |
| PE Compounding | OPTIM [®] E-119 | Coupling agent for CaCo ₃ , talc, or mica filled PE |
| | OPTIM [®] E-156 | Coupling agent for HDPE based WPC compound |

Advantages

- Coupling agent for polyethylene compounds with glass, wood, and other natural fibres
- Improves mechanical properties: stiffness
- tensile and flexural properties, impact strength etc
- Reduces water absorption in natural fibre filled composites

Automotives and white goods

Polymer compounds for automotives and white goods

Polymer compounds used in automotive and white goods are high and mechanical properties and are typically blends of different polymers and fillers.

OPTIM[®] polymer resins act as a compatibilizer or coupling agent between multiple polymers and fillers. These are based on functionalized elastomeric and polyolefin polymers and are produced through reactive extrusion. They enable higher filler loadings.

These are polymeric materials, which have a functional unit grafted onto the backbone of the polymer. This allows fillers such as talc, calcium carbonate, nano clays, and glass to be chemically bonded to the polymer. It also enables dissimilar polymers, such as polypropylene and polyamides, to become compatible with each other.



| Segment | Product Name | Applications |
|-----------------|---------------------------|--|
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| | OPTIM [®] P-425 | Coupling agent for PP based WPC compounds |
| | OPTIM [®] R-658 | Impact modifier for filled/ un-filled PP compounds |
| PE Compounding | OPTIM [®] E-119 | Coupling agent for CaCo ₃ , talc or mica filled PE |
| | OPTIM [®] E-156 | Coupling agent for HDPE based WPC compound |
| | OPTIM [®] E-152 | Coupling agent for EVA based masterbatches |
| PA Compounding | OPTIM [®] E-126 | Impact modifier for Pa6, PA66 for ambient conditions |
| | OPTIM [®] E-131 | Impact modifier for Pa6, Pa66 for sub-zero conditions |
| PBT Compounding | OPTIM [®] GE-344 | Impact modifier for filled PBT compounds |
| | OPTIM [®] GE-340 | |
| ABS Compounding | OPTIM [®] R-642 | Coupling agent for ABS |

Advantages

- Coupling agent offers optimized blend morphology for typically used polymer blend formulations
- Improves mechanical properties: stiffness tensile and flexural properties, impact strength etc

Packaging

Metal Adhesion Promoter

Polyester and PP films are the most commonly used substrates for producing high barrier packaging films- Metallized Films. Cast PP film is fast catching up as the substrate of choice for metallization by packaging industry. Vacuum metallized cast PP film is known as VMCPP or simply MCPP in the trade. Areas of applications include food packaging, cosmetic packaging, tobacco & liquor packaging, besides numerous decorative applications.

Too much of high voltage electric discharge tends to cause a drop in mechanical properties, degradation of the surface polymer and possibly undesirable treatment on the reverse side of the film.

Metal adhesion can be uniformly and decisively enhanced by using BindEx E-183 in the surface layer of PP film that has inherently high polarity and suitable physical characteristics for this purpose. This renders the target film surface better receptive to the metal vapours hitting and adhering to it.

Advantages

- Reduces performance uncertainty due to natural decay of these physical treatments
- Better adhesion of subsequent aluminium vapours deposited in high OD metallized films
- Very low density polyolefin adhesive resin,

Lamitubes Adhesive Resin

One of the most important components in Lamitubes is tie layer adhesive resin. This is used to bond the dissimilar materials together and thus combines the properties of different materials, such as gas barrier resins and moisture barrier resins. The use of this adhesive resin in packaging structures restricts the passage of oxygen, flavor and odour permeation.

Plus Advanced Technologies. Its physical characteristics allow the approaching metal vapours to embed strongly into the film surface layer. The polar groups contained in it provide the chemical affinity towards the metal particles, making a strong bond. Its uniform distribution in the film surface layer imparts an equally uniform polarity to the film surface. This in turn, ensures consistent metal bond values across the metallized area.



having excellent compatibility with polyethylenes, polypropylenes and copolymers

BindEX E-186 is a maleic anhydride modified linear low density polyethylene adhesive resin. It is used as a tie layer adhesive resin for bonding dissimilar resins together in increasingly polar multilayer barrier packaging structures called Multilayer Lamitubes. With advanced grafting technology, this grade creates super adhesion to metal, EVOH, PE and PA while maintaining excellent processability.

Packaging



Advantages

- Suitable for varied flexible film packaging industry requirements
- Imparts excellent thickness accuracy
- Enhances barrier properties ensuring best shelf life
- Ensures better surface finish with crystal clear graphics
- Ensures puncture resistant in the films since it as an olefin-based adhesive

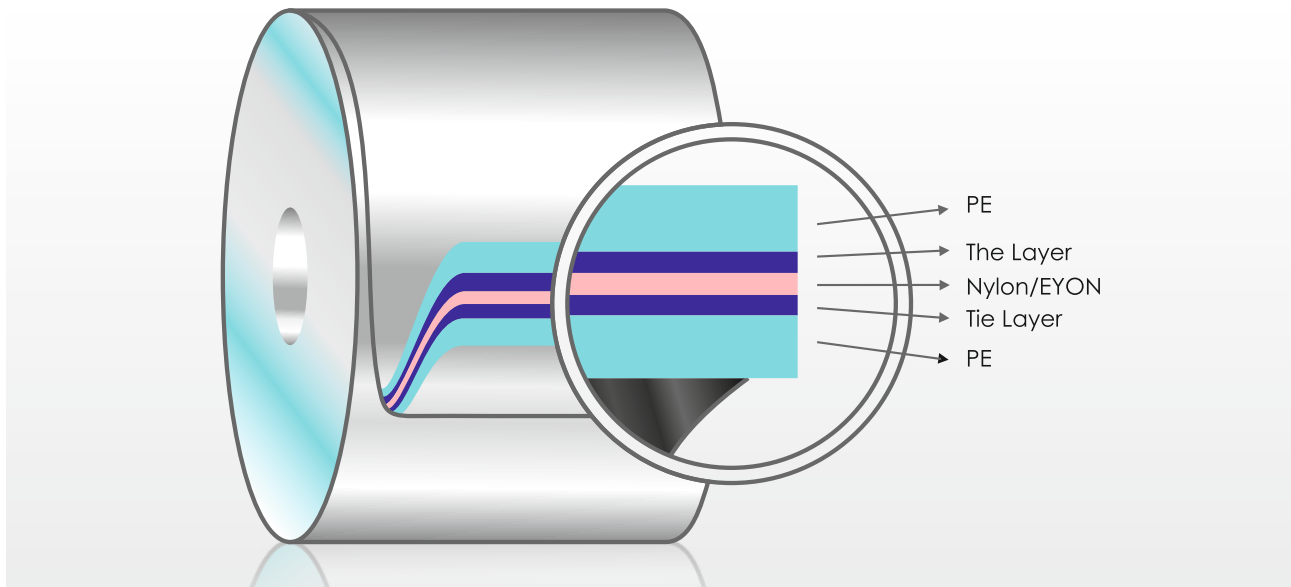
Tie-Layer Adhesive Resin

Multilayer film structures made by lamination of the different substrates, using solvent-based or solvent-less adhesives, is a well-established practice in trade. However, co-extrusion of multiple polymers into a multilayer film in a single operation has revolutionized flexible packaging application. To be able to combine chemically different materials in all the mentioned structures during co-extrusion process, we need to use a tie layer in-between.

BindEX series including BindEX E-188, E-187, E-189, P-187 are maleic anhydride grafted polyethylene adhesive resins. These are the

recommended tie layer material for making multilayer films in conventional cast co-extrusion equipment. It has suitable pendant functional groups to bond to polar polymer layer on one side, while its polyethylene backbone has natural affinity with the non-polar polyolefinic layer on its other side in the multilayer structure. BindEX E-188 is used to combine Nylon 6, Nylon 66, and EVOH for gas barrier properties with variety of HDPE, LLDPE, LDPE & PP grades for different functions like sealability, moisture barrier and providing bulk to the structure. It is recommended to be used in its pure (undiluted) form.

Packaging



Advantages

- Designed to give improved adhesion
- Imparts high clarity
- Ensures better surface finish with crystal clear graphics

Recycling of Multilayer Coextruded Films

Presence of plastics with different chemistries and processability in the same structure poses a challenge in reprocessing. Coextruded multilayer barrier films comprising of nylon and polymers of olefin family are not as easy to reprocess as those of a single polymer type like polyethylene or polypropylenes. Not only do the diverse materials have different melting temperatures, but they are also inherently incompatible in melt and solid states.

ReCoupp[®] tie layer resins for coextruded films render the multi-layered structure recyclable. Plus ReCoupp[®] E-832 provides excellent interlayer adhesion between nylon and PE or PP layers in a coextruded multilayer structure. It contains adequate reactive groups to homogenize nylon with PE or PP in melt state and stabilise the alloy in solid state. This polymer alloy behaves as a single uniform material in further processing and use. This

material can further be blown into films or moulded into various products using conventional injection or extrusion moulding.



Advantages

- Improves the compatibility of immiscible polymers in a multi-layer film
- Enhances blending morphology and related mechanical properties of the materials

Recycling

Recycling of Polyamides, Polyolefins, Polycarbonates and Polybutylene terephthalate

Recycled Nylons, Polyethylene, Polypropylene, Polybutylene terephthalate undergo reduction in impact strength due to thermal degradation. Pluss has developed grafted polymers used as coupling agents to make up the loss in mechanical properties and prevent brittleness in recycled polymers. These additive particles are dispersed uniformly in engineering polymer matrix and improve the toughness, heat resistance, and help in improving physical properties such as impact strength by absorbing the energy during an impact.



| Segment | Product Name | Applications |
|--------------------|---------------|--|
| PA Recycling | OPTIM® E-119 | Compatibilizer for Nylon (Fiber, film or moulding waste) |
| | OPTIM® E-126 | Impact Modefier & coupling agent in Pa6, Pa66 for use at ambient conditions. |
| | OPTIM® E-131 | Impact modifier & coupling agent in Pa6, Pa66 for Sub-zero temperature applications. |
| | ADNYL® E-177 | In-situ toughening agent for PA-6,/PA-66 in injection moulding process |
| PC & PBT Recycling | OPTIM® R-658 | Impact modifier for recycled PP (Articles & film scrap) |
| | OPTIM® GE-344 | Impact modifier in PC and PBT recycling |
| | OPTIM® GE-340 | In situ toughening agent for PC recyvlcd injection moulding process |
| | OPTIM® B-025 | |

Advantages

- Improves production or subsequent melt-processing efficiency by optimizing melt flow
- Reduces compound melt viscosity for improved mould filling
- Ensures better surface appearance of the glass-filled moulded parts
- Retains original mechanical properties such as tensile strength, modulus, and heat deformation temperature (HDT)

Recycling

Chain Extenders for Polyethylene Terephthalate

Poly(ethylene terephthalate) (PET) is a polymer highly susceptible to the hydrolytic reactions that occur during applications and mainly in thermomechanical processing. These reactions lead to the decrease of molecular weight of the polymer, limiting the recycling number of the material. The reactive extrusion of the PET in presence of chain extenders is an alternative to recover mechanical and rheological

properties that were depreciated by the polymer degradation.

OPTIPET® chain extenders have two or more reactive sites in molecule, which can react with terminal groups of polymeric chains, bonding each other and increasing molecular weight of the polymer.



| Segment | Product Name | Applications |
|---------------|---------------|------------------------------|
| PET Recycling | OPTIPET® 213M | Chain extender for PET scrap |
| | OPTIPET® 213P | |

Advantages

- Increases intrinsic viscosity
- “Recouples” depolymerized polycondensation chains
- Preserves physical properties
- Improves melt strength and viscosity
- Improves tensile strength of recycled PET straps
- Solves the splitting problem of recycled PET straps

Members



National Centre of Cold Chain Development
NCCD is an autonomous body established by the Government of India with an agenda to positively impact and promote the development of the cold-chain sector in the country.



India Energy Storage Alliance,
IESA was launched in 2012 to help technology and system integration companies involved in energy storage and microgrids to understand and capture the opportunities in the growing markets.





Clean Energy Access Network,
is an all India representative organization launched in 2014 with a clear mandate to support, unify and grow the decentralized clean energy sector in India.



Reichs-Ausschuss für Lieferbedingungen (RAL),
Several active PCM enterprises formed the Quality Association PCM in 2004 to develop proper quality assurance procedures.

SUSTAINABLE DEVELOPMENT GOALS

ACHIEVED USING THIS TECHNOLOGY

| | |
|--|---|
| 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE  | Industry, innovation and infrastructure |
| 12 RESPONSIBLE CONSUMPTION AND PRODUCTION  | Responsible consumption and production |

Recognition for PLUS[®]



GITA- Global Innovation & Technology Alliance - 2022



FICCI- DST Lockheed Martin Award - 2015



WWF- Climate & Energy - 2021



TCL- Supply Chain Innovation Award for Pharmaceuticals - 2018



DST, GI- Department of Science & Technology, Government of India - 2020 & 2017



BIRAC- Sparsh Grant - 2022



UNIDO- FLCTD Innovation Challenge - 2018 & 2022



MIT- Innovators under 35 India Award - 2016 & 2017



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PLUS[®]
TECHNOLOGY FOR A BETTER WORLD

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