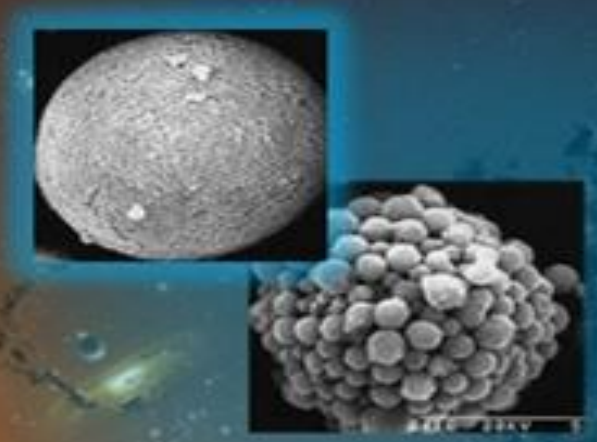
Graft Polymer planned Pipeline products 2018-19.



Graft Polymer Business Units

GRAFT POLYMER
COMBINE INCOMPATIBLE

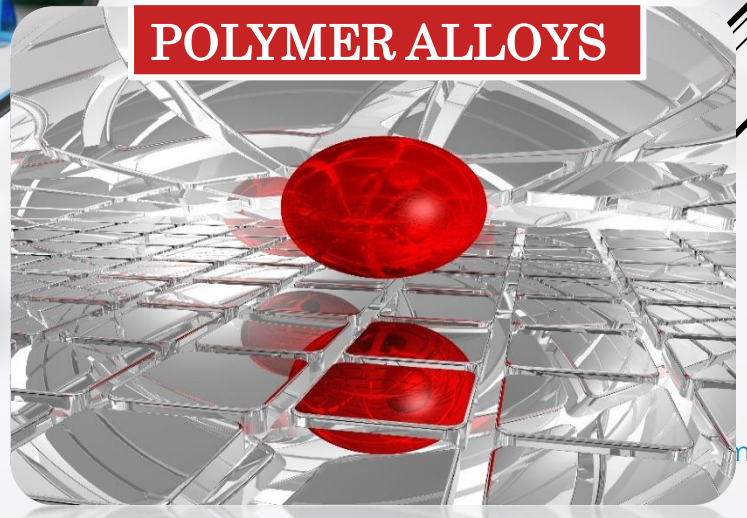
POLYMER MODIFIERS

MASTERBATCHES

R&D

FUNCTIONAL POWDERS

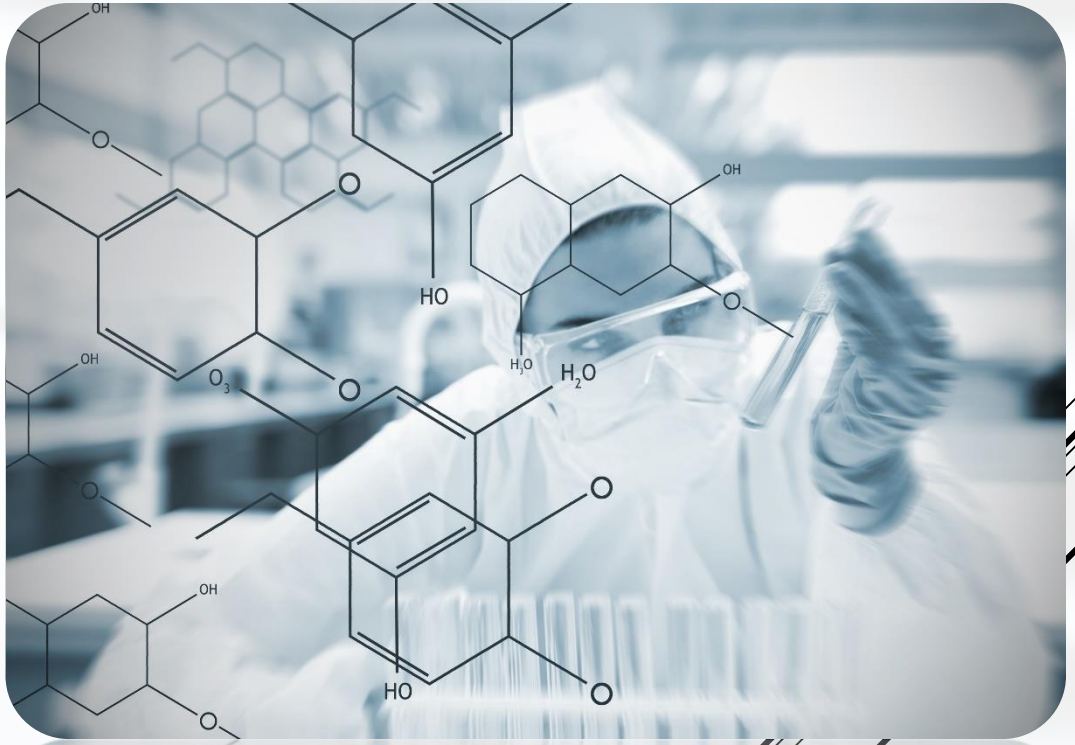
POLYMER ALLOYS



GRAFT POLYMER
COMBINE INCOMPATIBLE

Polymer Modification is a key for composite materials` developments

- **Synergy** of properties
- **Fine-tuning** (setting) properties
- **Designing** of a material for a specific application



Market challenges in the field of composite materials

- **Weight** reduction of the product.
- Lowering the **Cost** of the product.
- **Synergy** of the best properties of composite components.
- Technological **Safety** of the composite production process.
- **Ecological purity** of the production process and the composite material itself.
- Industrial **Scalability** of modification technologies

Spectrum of Graft Polymer innovative modification technologies

GRAFT POLYMER
COMBINE INCOMPATIBLE

Grafting technologies:

- “Peroxide free” grafting technique
- Nitroxide mediated grafting
- Solid phase grafting

Masterbatch technologies:

- MB on polymer carriers
- MB on porous polymers

Crosslinking technologies:

- Thermoreversible Crosslinking
- Novel Irreversible Crosslinking (PEX)
- Interpenetrating Polymer Networks (IPN)

Grafted Polymer Powders:

- Hot Ozonolysis-Plasma Surface Modification
- Particle Hybridization

Polymer Alloying:

- Co-continues Nano Structures
- Flow induced crystallization (“shish-kebab”)
- Self-reinforced polymer alloys
- Self-healing polymer compounds
- Polymer alloys with Nano Fillers (Nano diamond, Aerogels, POSS)

Graft Polymer Products Pipeline

GRAFT POLYMER
COMBINE INCOMPATIBLE

Graft Co-Polymers:

- GRAFTABOND™ SBC
- GRAFTABOND™ WPC
- GRAFTABOND™ PF
- GRAFTABOND™ NMP
- GRAFTABOND™ ECO
- GRAFTABOND™ PVC

Crosslinked Polymers:

- GRAFTALEN™ TRC
- GRAFTALEN™ PEX
- GRAFTABOND™ RPC

Masterbatches:

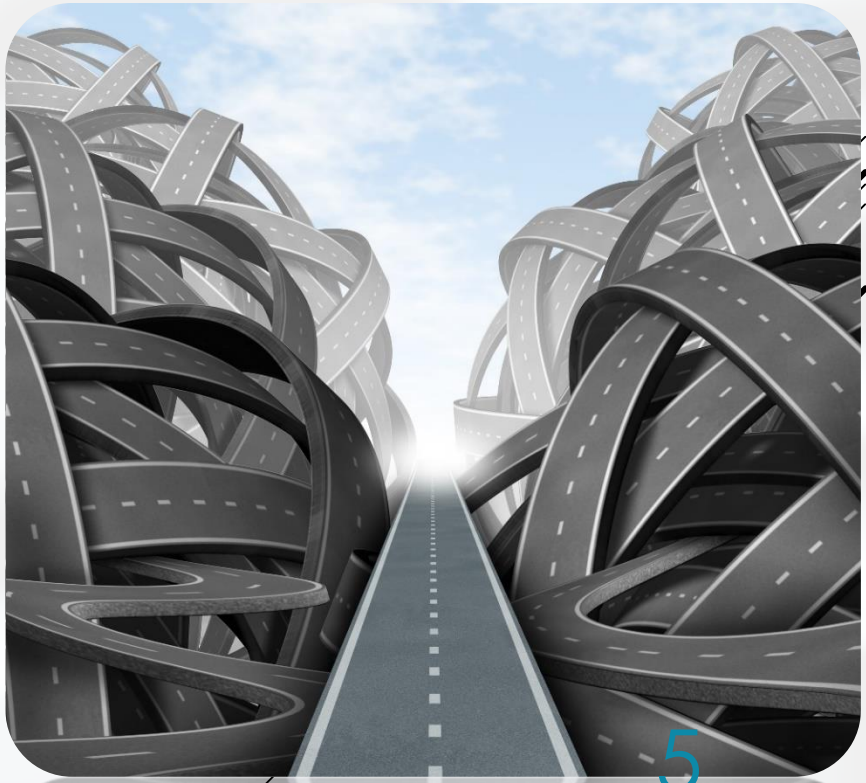
- GRAFTALEN™ MB –EMA
- GRAFTALEN™ MB –HMSPP
- GRAFTALEN™ MB -SIlAN
- GRAFTALEN™ MB –PER

Grafted Polymer Powders:

- GRAFTABOND™ P -UH

Polymer Alloying:

- GRAFTALEN™ MP -UHMWPE
- GRAFTALEN™ MP -PVA
- GRAFTAMID™
- GRAFTALEN™ AERO
- GRAFTALEN™ ND
- GRAFTALEN™ POSS
- GRAFTALEN™ SR – FIBER
- GRAFTALEN™ PDMS



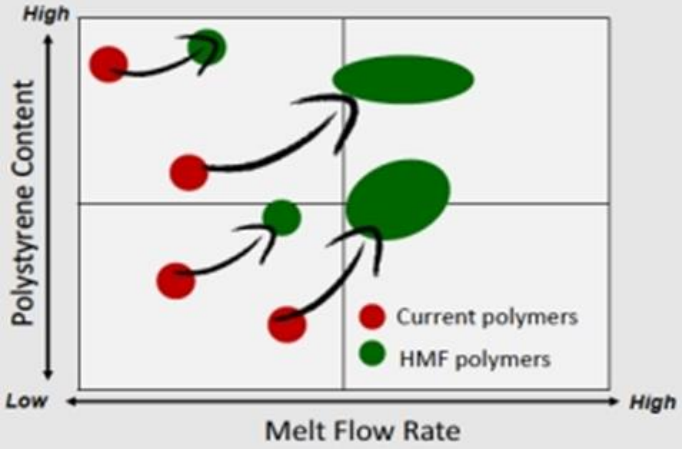
GRAFTABOND™ SBC (Styrene Block Copolymers) SIS,SBS,SEBS,SEPS

GRAFT POLYMER
COMBINE INCOMPATIBLE

Market Demands

- High Melt Flow Styrene Block Copolymers
- High Grafted Styrene Block Copolymers with various spectrum of monomers (MAH, GMA, HEMA, MMA, AAc etc)
- Granulated Melt Processable Styrene Block Copolymers

Technology Overview:



- High Melt Flow allows us to extend a group of polymers into low viscosity HSBC applications

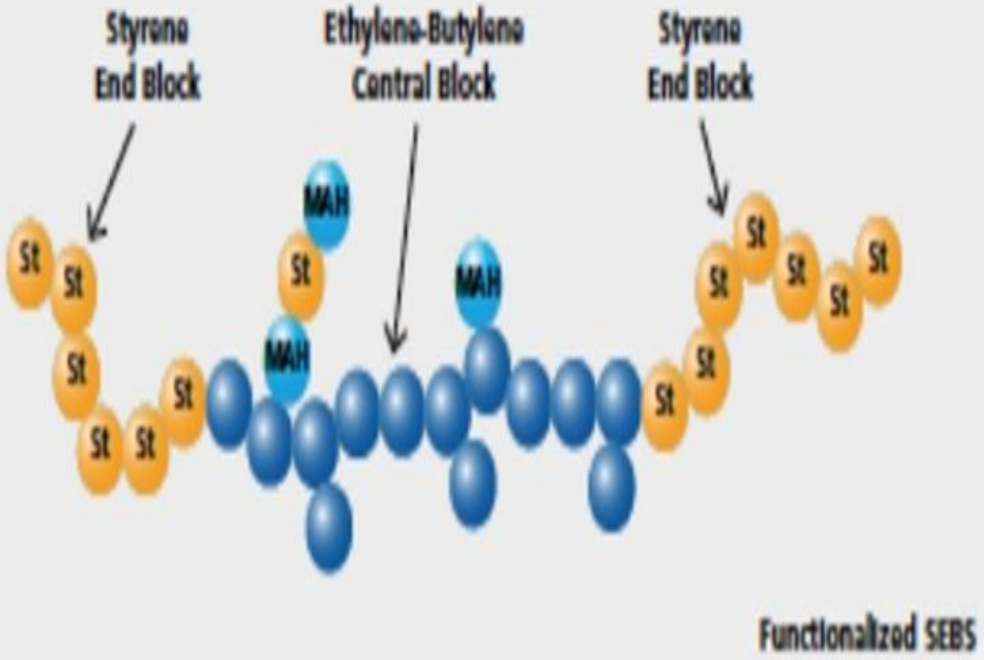
Commercial Opportunity:

- Low viscosity allows SBCs to compete with other material types in existing processes that were previously inaccessible

- Automotive (dashboards & interiors)

- Specialty Polymers - coated fabrics for contract furnishings

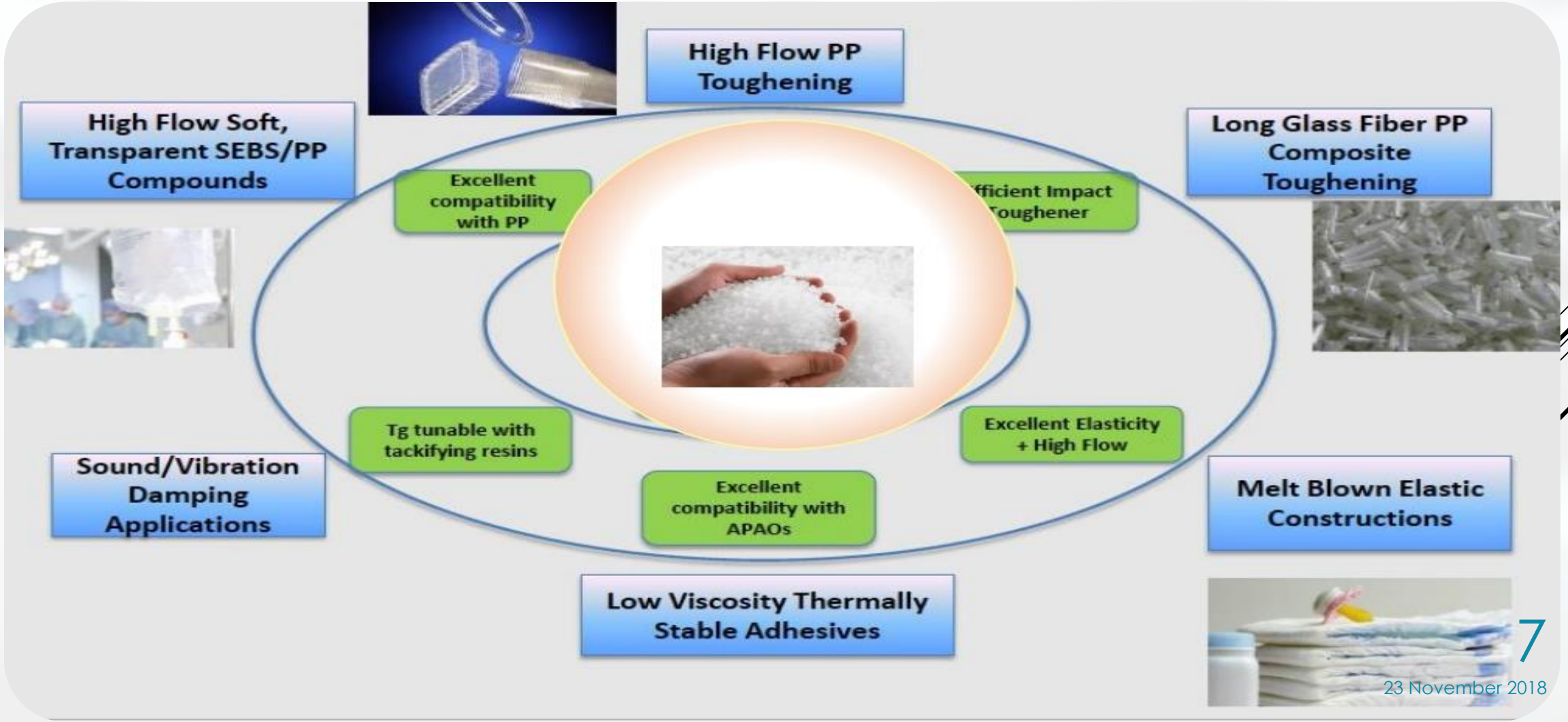
- Hot melt adhesives



GRAFTABOND™ SBC (Styrene Block Copolymers) SIS,SBS,SEBS,SEPS

GRAFT POLYMER
COMBINE INCOMPATIBLE

Main Applications



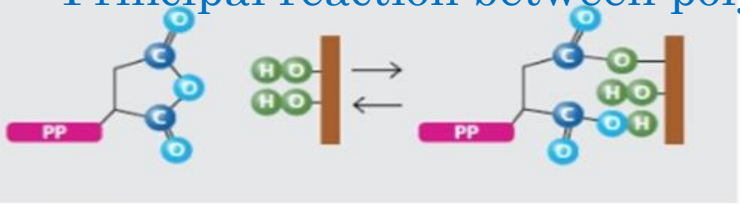
GRAFTABOND™ WPC (wood plastic composite modifier)

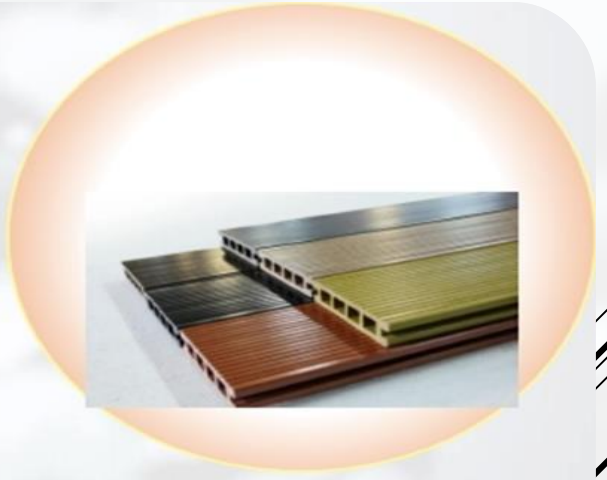
GRAFT POLYMER
COMBINE INCOMPATIBLE

Market Demands

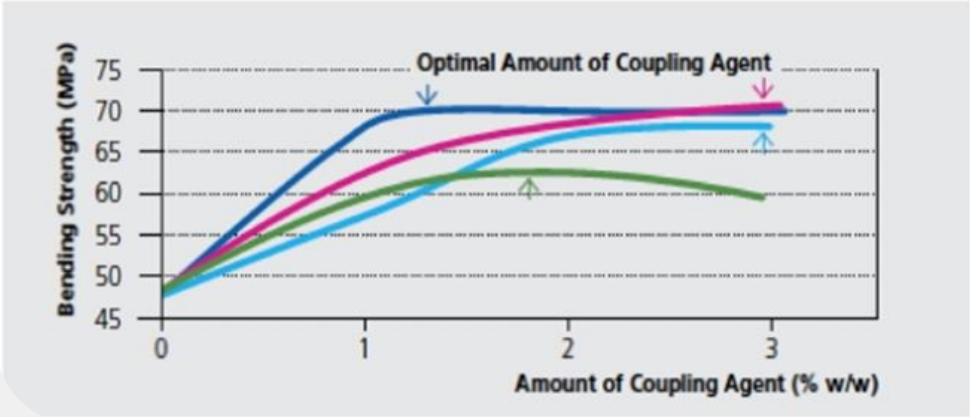
- High grafting level - not less than 1,5% to overcome an antagonist effect of lubricants, mixed plastic and fiber moisture
- High melt flow - in order to wetting 60% and more % of natural fibers
- Introduction of effective desiccant in graft-copolymer to solve drying problems with fibers moisture

Principal reaction between polymer graft and fibers





Effect of MAH Content



Recommendation of Graft Polymer in WPC compositions PE or PP based

Base Polymer	Grafting	MFR (190 °C, 2.16 kg)	MAH Content
PP	Solid-phase	> 80 g/10 min.	1.4 %

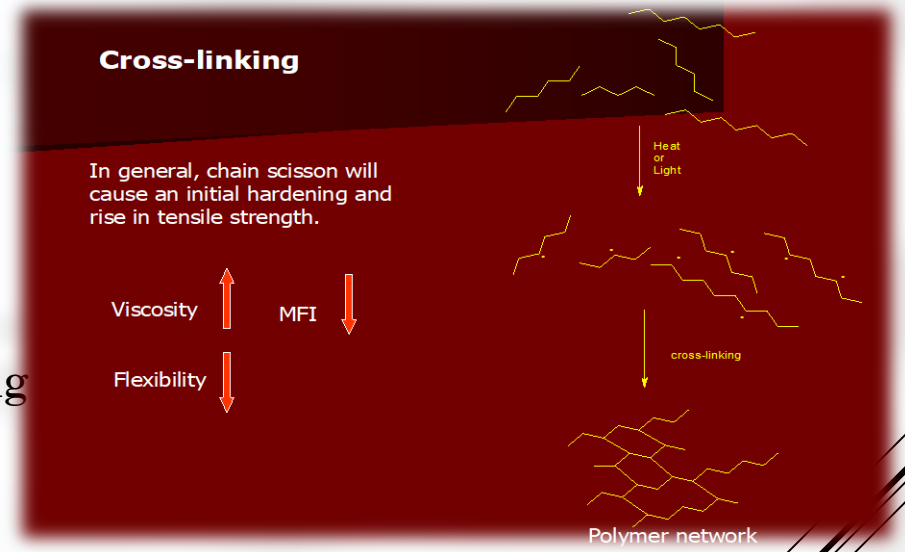
Base Polymer	Grafting	MFR (190 °C, 5 kg)	MAH Content
LLDPE	Solid Phase + Melt	> 5 g/10 min.	2 %
HDPE	Solid Phase + Melt	> 5 g/10 min.	1.7 %

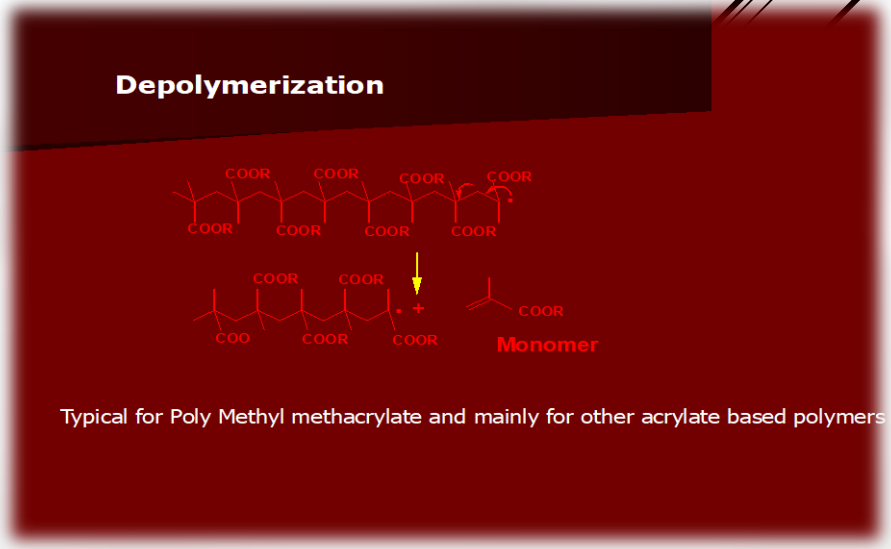
GRAFTABOND™ PF (“peroxide free” graft polymer)

GRAFT POLYMER
COMBINE INCOMPATIBLE

4 Main Problems in Grafting

- **Crosslinking** for ETHYLENE polymers (Melt Flow Rate of Ethylene polymers usually reduced considerably)
  - For melt grafting up to 10 times
  - For Solid Phase Grafting up to 2-3 times
- **Betta-Scission** (de-polymerization) for PROPYLENE polymers
- Peroxides usually have very **harmful post-residues** :
  - Free unreacted peroxides and radicals lead to polymer aging and degradation in time
  - Treat-Butyl Alcohol (TBA) residues restricted in certain application up to 20ppm
  - High Yellowness Index (YI)
- **Gel** availability exist and influence on:
  - Mechanical Strength and Elongation of final product
  - Film transparency
  - Scotch effects in film and cable processing



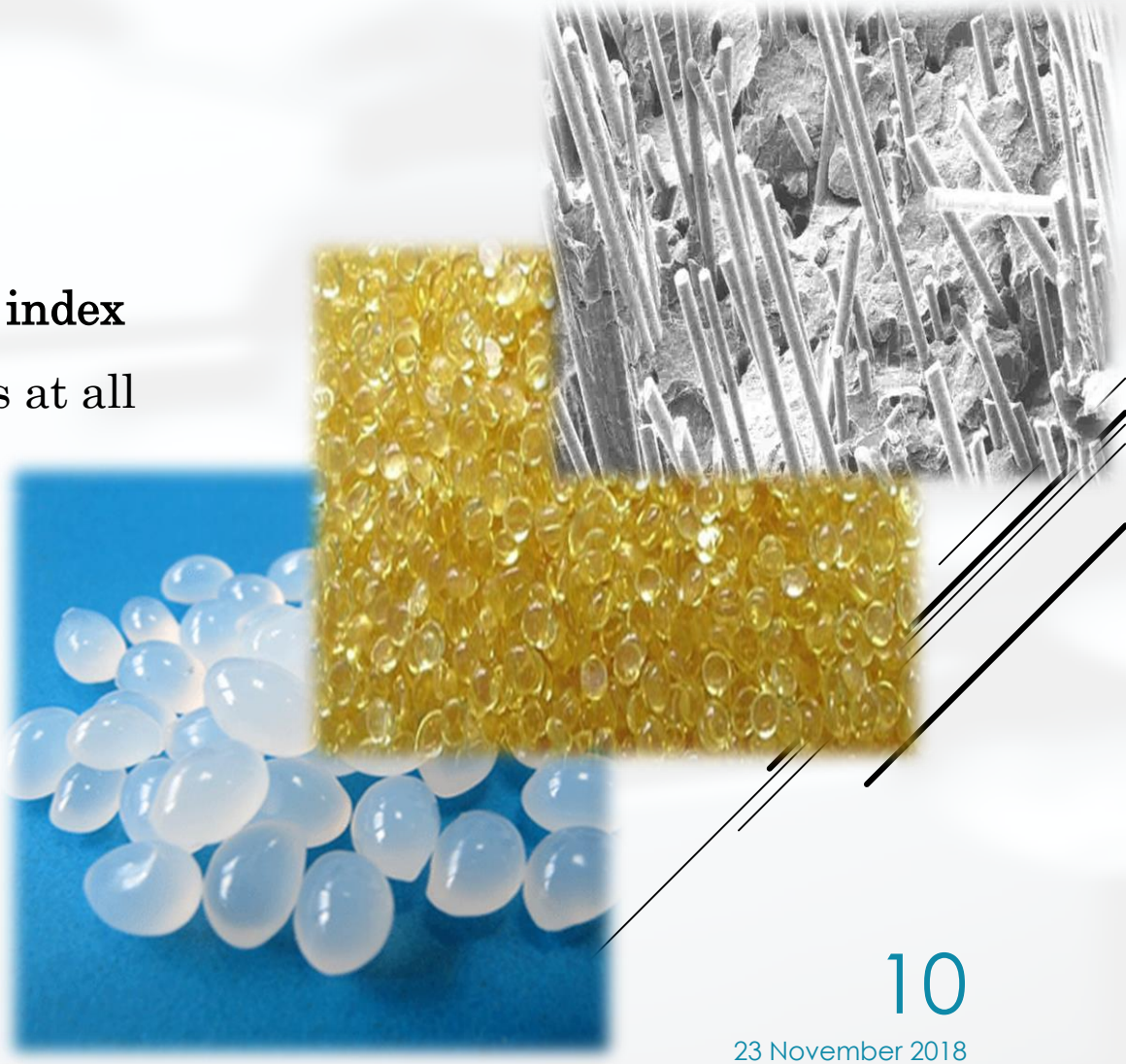


GRAFTABOND™ PF ("peroxide free" graft polymer)

GRAFT POLYMER
COMBINE INCOMPATIBLE

Solution by Graft Polymer

A novel process for producing ethylene and propylene homopolymers, interpolymers, and functional ethylene copolymers made by **PF ("Peroxide Free" grafting)** with **regulated and controlled molecular weight and melt flow index** without uncontrolled crosslinking or betta scission effects at all and harmful peroxides residues



Main Applications

- Compatibilizer based on PP-g-MAH with High MFI for PP glass fiber reinforced compositions
- Graft Polymer EVA based Hot Melt
- Thermoplastic Concentrated Adhesive for Packaging

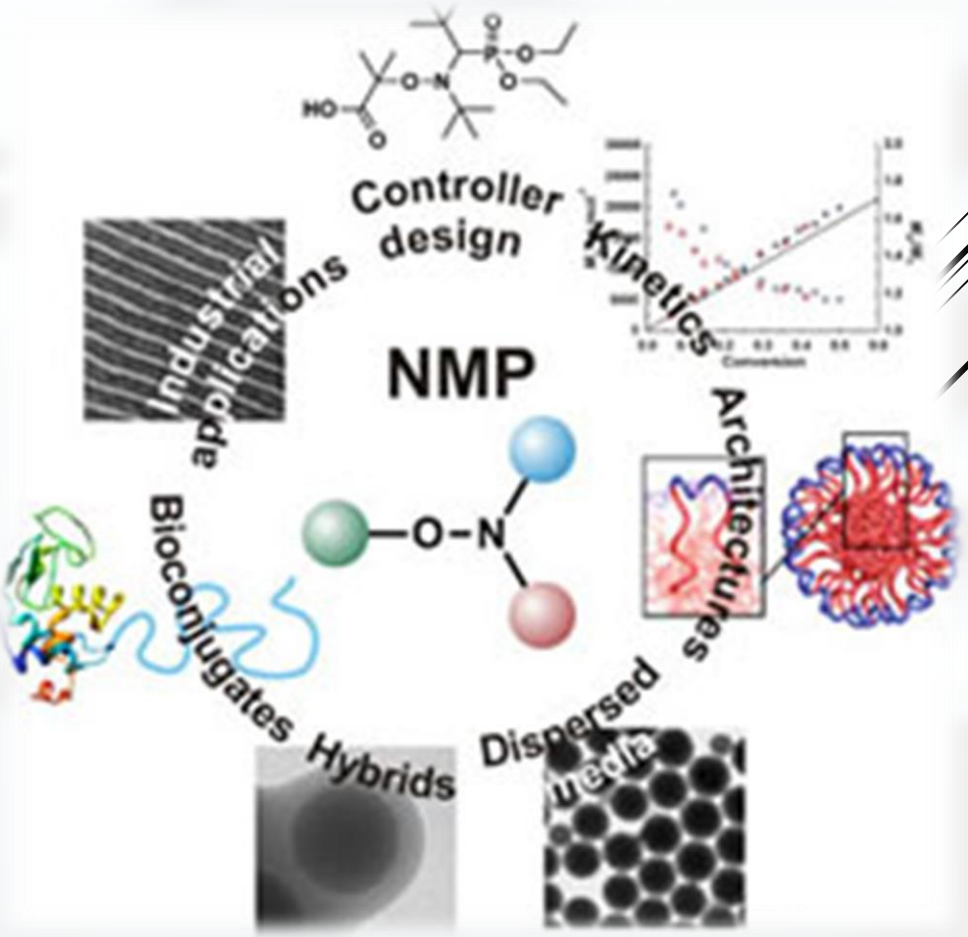
GRAFTABOND™ NMP (Nitroxide Mediated Polymerization)

Grafted Olefin Elastomers (POE,POP,EVA,EBA,EPDM APAO,APP, PE-PP wax)

GRAFT POLYMER
COMBINE INCOMPATIBLE

Market Demands

- ❑ Efficient grafting of **thermosensitive** polyolefin elastomers
  - ✓ Polyethylene Olefin Elastomers (POE)
  - ✓ Polyethylene Olefin Plastomers (POP)
  - ✓ Ethylene Vinyl Acetate Copolymers (EVA)
  - ✓ Ethylene Butyl Acrylate Copolymers (EBA)
  - ✓ Ethylene-Propylene Elastomer (EPDM)
  - ✓ Amorphous Poly-Alfa Olefins (APAO)
  - ✓ Atactic Polypropylene (APP)
  - ✓ Polyolefin Waxes
- ❑ **High Degree** of Grafting (usually above 1%)
- ❑ **Free from unreacted** monomers (“clean grafting”)
- ❑ Low **Yellowness** Index (YI)



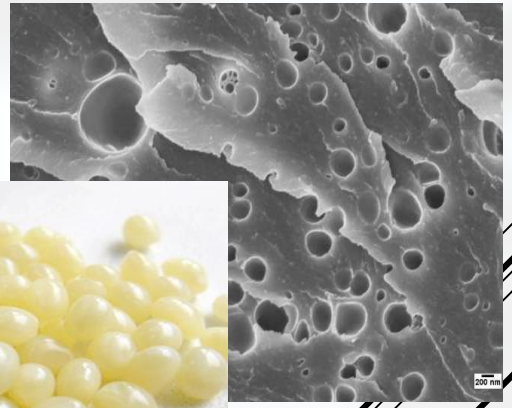
GRAFTABOND™ NMP (Nitroxide Mediated Polymerization)

Grafted Olefin Elastomers (POE,POP,EVA,EBA,EPDM APAO,APP, PE-PP wax)

GRAFT POLYMER
COMBINE INCOMPATIBLE

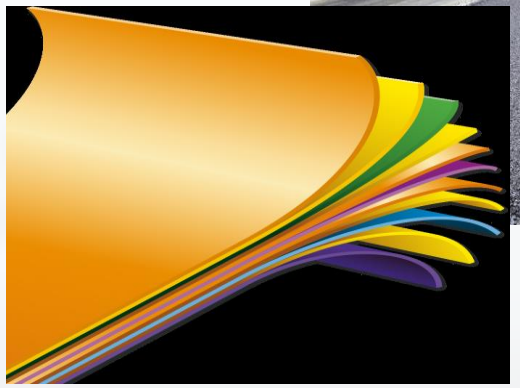
Solution by Graft Polymer

NMP (Nitroxide Mediated Polymerization) Grafting in Solid Phase is a **novel** process for producing high grafted degree thermosensitive polyolefin elastomers with high rate of grafted monomer conversion



Main Applications

- ❑ Toughening of Polymer Blends (PO,PA, PET, PBT, ABS, PS,PC,SAN)
- ❑ Hot Melt Adhesives Applications
- ❑ Bitumen Modification
- ❑ Packaging Tie-Layers



GRAFTABOND™ ECO (compatibilizers for recycled plastics)

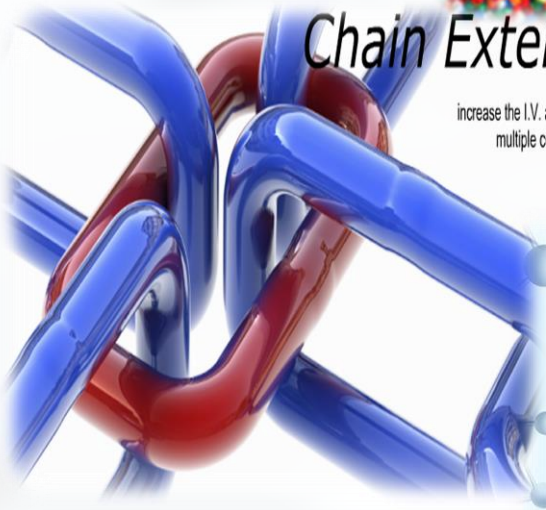
GRAFT POLYMER
COMBINE INCOMPATIBLE

Market Demands

- ❑ Efficient compatibilizers for mixed recycled plastic scrap
  PE-PP, PO-PA, PO-PET, PS-PO
- ❑ Chain Extender Modifiers for condensation polymers
  PA, PET, PBT
- ❑ Stabilization of Scrap Blends against thermo and UV oxidation

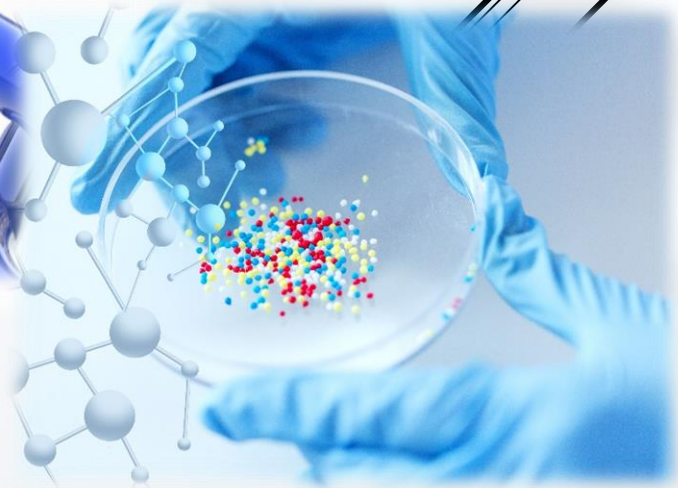
Solution by Graft Polymer

- ➢ Use custom-made Compatibilizers (in accordance with scrap mixture)
- ➢ Use Proprietary Chain Extenders
- ➢ Use Antioxidants bound Compatibilizers



Compatibilizers and Chain Extenders

- Blend (PE-g-GMA with EPDM-g-Amine)
- PO-g-PA
- PO-g-PET
- SEBS-g- SMA
- SEBS-g-GMA
- PO-g- TMI-g-Amine



Main Applications

- ❑ Mixed Scrap Recycling(PO,PA, PET, PBT, ABS, PS,PC,SAN)
- ❑ Increasing of condensation Polymers Molecular Weight
- ❑ Stabilization of Post Recycled Blends

GRAFTABOND™ PVC (modifiers for PVC)

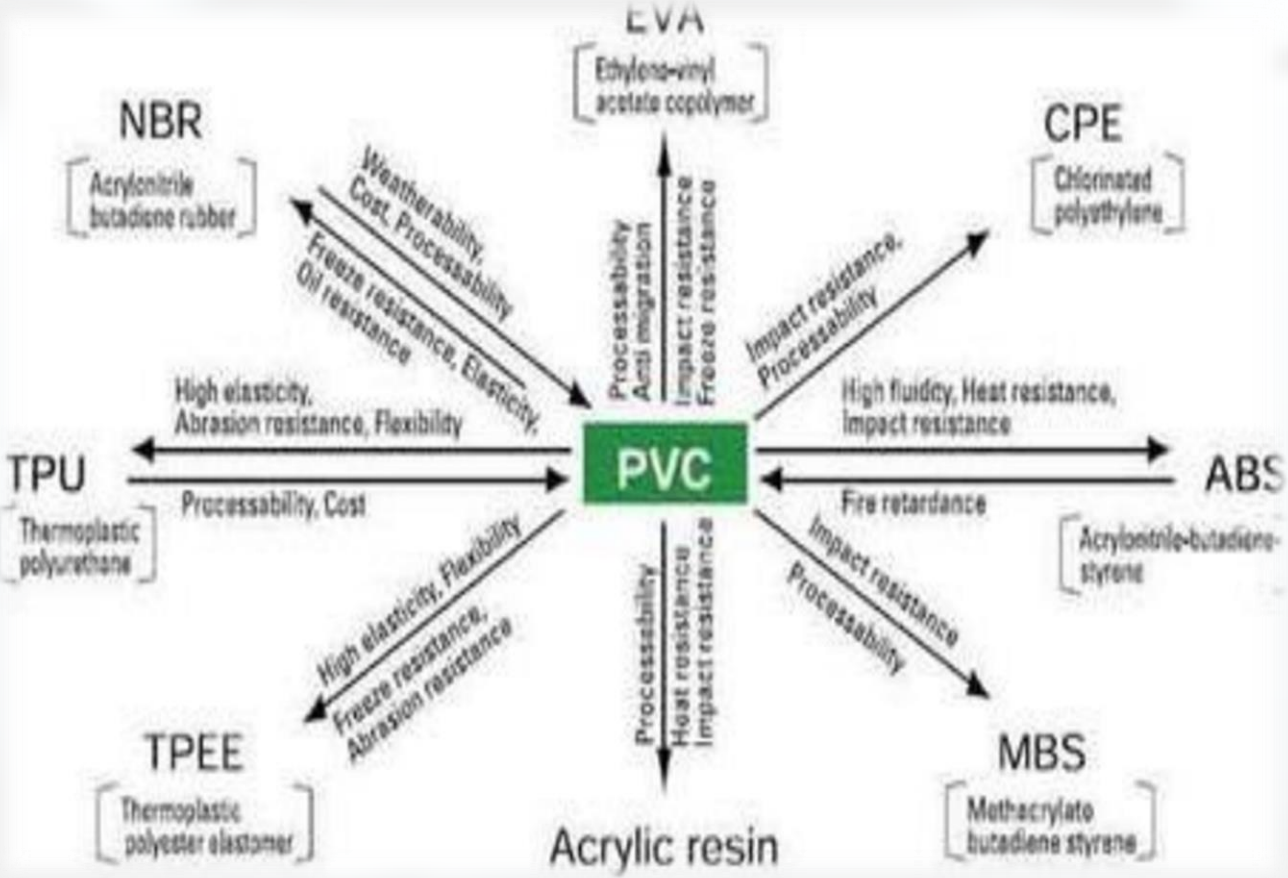
GRAFT POLYMER
COMBINE INCOMPATIBLE

Market demands and Applications

Property modification of PVC products by Polymer Modifiers

Since PVC has a high polarity and high compatibility with a variety of other high-performance plastics, it is possible to mix these easily to form polymer alloys. By polymer alloying techniques some of the shortcomings of rigid PVC products can be modified.

Fig shows the outline of property modification through polymer alloying



Modifiers for PVC:

- EVA-g-MMA/GMA
- CPE-g-GMA
- MBS-g-GMA
- ABS-g-GMA
- SEBS-g-GMA

GRAFTABOND™ PVC (modifiers for PVC)

GRAFT POLYMER
COMBINE INCOMPATIBLE

Market demands and Applications

Impact Resistance

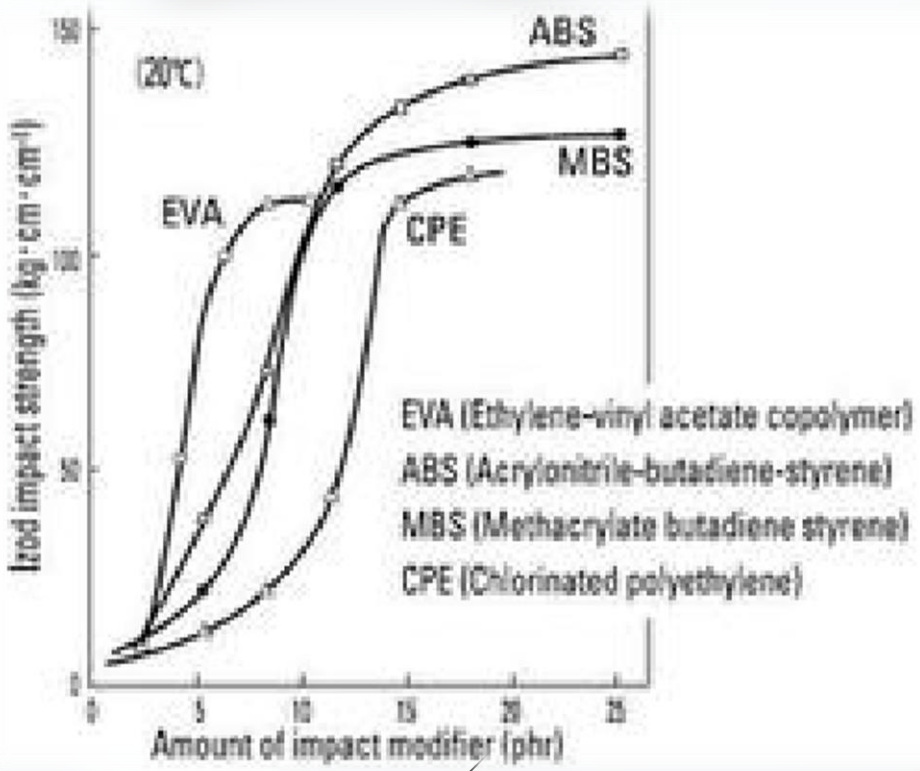
Impact modifiers (toughening agents) which have rubber-like properties such as ABS, MBS, acrylic rubber, chlorinated polyethylene or EVA, are mixed with PVC. Sufficient impact resistance for practical use can be obtained by blending 5~20 weight parts of these impact modifiers to 100 weight parts of PVC.

Heat distortion temperature (softening temperature)

PVC with enhanced heat resistance is used for heat resistant rigid PVC pipes, such as hot water supply pipes or electric cable protecting tubes, and instrument panels of vehicles. On the other hand, soft PVC products with modified heat resistance can be manufactured by blending with a high-polymer plasticizer. Such products are used for heat resistant cable covering and other applications.

Prevention of plasticizer bleed and volatilization

plasticizer free flexible PVC products are manufactured as in the case of graft polymerized EVA (ethylene vinyl-acetate copolymer) and PVC
PVC including plasticizers which do not migrate or bleed at high temperatures is used for electric/electronic parts and heat resistant cables. Some of the non-migrating type plasticizers are used for medical bags/tubes or industrial hoses



GRAFTALEN™ MB –EMA
(olefin/maleic anhydride copolymer)

GRAFT POLYMER
COMBINE INCOMPATIBLE

Market demands

- Improve the uniformity of incorporation of additives in the final composition
- The additives should not phase separate from CARRIER resin
- The carrier resin should not phase separate with a polymer being formulated
- The carrier resin should remain thermally stable at the processing conditions
- The presence of a carrier resin in the polymer formulation should not adversely affect the performance of the formulated composition

Main Applications

- Surface coating of Glass Fibers in sizing emulsion
- Can be used in PA compounding to increase melt viscosity and reduce melt flow at low loading levels
- Increase tensile strength and other mechanical properties
- To improve resistance to anti-freeze
- Upgrade recycling PA(Nylon)
- Crosslink nylon during compounding at high loading levels

Carrier resins

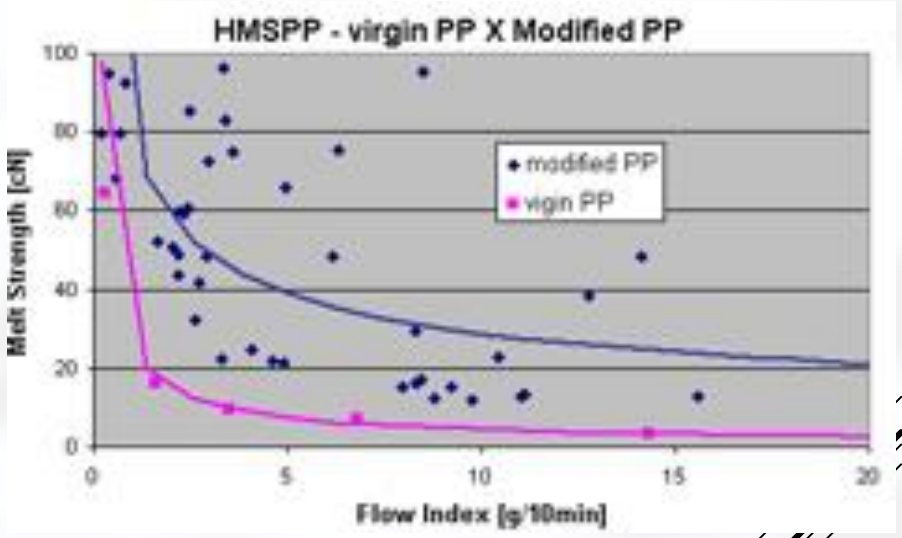
PA, PET,PBT,PC, ABS,PCL,PLA, TPU

GRAFTALEN™ MB -HMSPP
(High Melt Strength Polypropylene)

GRAFT POLYMER
COMBINE INCOMPATIBLE

Market demands

- ❑ PP melt strength is generally increased by the addition of long-chain branches to the polymer structure. On the other hand, long chain branches bonded within the polymer structure can make the polymer too rigid, compromising the polymer's thermoplastic character.
- ❑ Thus, methods of making high melt strength polypropylene (HMS-PP) are needed to promote long chain branching without sacrificing the thermoplastic character.
- ❑ The HMS-PP can also be useful to use as a master batch for enhancing the melt strength of conventional polypropylene resins.



Solution by Graft Polymer

- ✓ Preparation of Grafted PP in the first stage
- ✓ Preparation of PP Ionomer in the second stage
- ✓ Cooling of PP ionomer to room temperature
  Masterbatch is a super-concentrate of chemical monomers based on polyolefin carrier. PP carrier is usually in POWDER form (300-700 mic)
- ✓ Granulation the resulted MB HMS-PP in the Melt reactive extrusion

Main Applications

- Sheet extrusion thermoforming
- Extrusion blow molding
- Extrusion coating
- Fiber, film, molding, and the like

GRAFTALEN™ MB -Silane *
(Silane Masterbatch on Polymer Carrier)

GRAFT POLYMER
COMBINE INCOMPATIBLE

Market demands

- To improve the uniformity of incorporation of additives in the final composition
- The additives should not phase separate from CARRIER resin
- The carrier resin should not phase separate with a polymer being formulated
- The carrier resin should remain thermally stable at the processing conditions
- The presence of a carrier resin in the polymer formulation should not adversely affect the performance of the formulated composition

Silane* (examples)

VTMS (vinyltrimethoxysilane)
VTES (vinyltrimethoxysilane)
AMEO (aminotrimethoxysilane)
GLYMO (glycydoxypropyltrimethoxysilan)
MEMO (acryloxypropyltrimethoxysilane)

Carrier resins

EVA (ethylenevynilacetate)
EBA (ethylene butyl acrylate)
POE (polyolefin elastomers)
PE (polyethylene)
PP (polypropylene)

GRAFTALEN™ MB -Silane *
(Silane Masterbatch on Polymer Carrier)

GRAFT POLYMER
COMBINE INCOMPATIBLE

Solution by Graft Polymer

A Silanol Masterbatch is prepared in Solid Phase proprietary reactor " GRAFT POLYMER"
Resulting MB are usually in the form of POLYMER POWDERS or GRANULES (free flowing ,without dust, no smell)
Usual concentration of reagent in MB = 20%-40% micro-granules (powder) or standard granules covered with thin wax layer (PE or PP) to prevent migration of reagent contact with air and moisture and smell.

The advantages of silanol masterbatches are that they can be prepared fairly readily, the silane is in a fairly stable form, and they are relatively safe and easy to store, ship and handle, particularly since masterbatches typically are formed into pellets or powders for ease of blending with the host polymer or resin to be treated. Furthermore, the masterbatches are formulated by using a polymer in the masterbatch which is identical to or very compatible with the host polymer or resin to be treated to assure good blending and compatibility.

Main Applications

- Production of silan crosslinking PE (PEX-b) cables
- Production of silan crosslinking (PEX-b) pipes
- Adhesion promoter in polymer compositions

GRAFTALEN™ MB -PER
(Peroxide Masterbatches on Polymer Carrier)

GRAFT POLYMER
COMBINE INCOMPATIBLE

Market demands

- To improve the uniformity of incorporation of additives in the final composition
- The additives should not phase separate from CARRIER resin
- The carrier resin should not phase separate with a polymer being formulated
- The carrier resin should remain thermally stable at the processing conditions
- The presence of a carrier resin in the polymer formulation should not adversely affect the performance of the formulated composition

Carrier resins

EVA (ethylenevynilacetate)

EBA (ethylene butyl acrylate)

POE (polyolefin elastomers)

PCL (polycaprolactone)

Wax PE-PP (waxes of PE or PP)

GRAFTALEN™ MB -PER
(Peroxide Masterbatches on Polymer Carrier)

GRAFT POLYMER
COMBINE INCOMPATIBLE

Solution by Graft Polymer

A Peroxide Masterbatch is prepared in Solid Phase proprietary reactor " GRAFT POLYMER"
Resulting MB are usually in the form of POLYMER POWDERS or GRANULES (free flowing , without dust, no smell).
Usual concentration of reagent in MB = 10%-25% micro-granules (powder) or standard granules covered with thin wax layer (PE or PP) to prevent migration of reagent contact with air and moisture and smell

The advantages of peroxide masterbatches are that they can be prepared fairly readily, the peroxide is in a fairly stable form, and they are relatively safe and easy to store, ship and handle, particularly since masterbatches typically are formed into pellets or powders for ease of blending with the host polymer or resin to be treated. Furthermore, the masterbatches are formulated by using a polymer in the masterbatch which is identical to or very compatible with the host polymer or resin to be treated to assure good blending and compatibility.

Main Applications

- Basic Polymer Organic Synthesis Plants (PE,PP)
- Production of peroxide crosslinking PE (PEX-a) cables
- Production of peroxide crosslinking (PEX-a) pipes

GRAFTABOND™ P –UH (Grafted UHMWPE powders)

GRAFT POLYMER
COMBINE INCOMPATIBLE

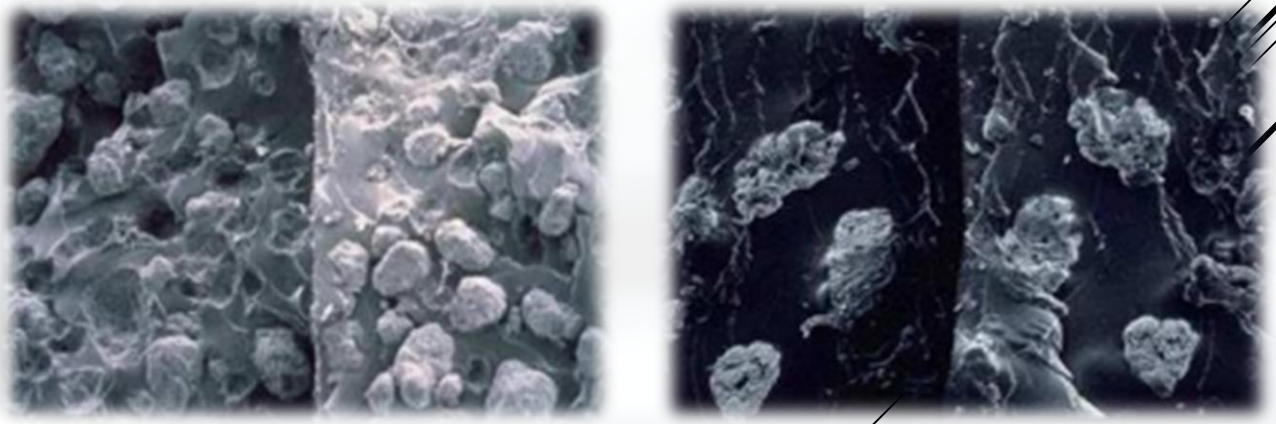
Market demands

- To improve abrasion resistance of engineering plastics (Epoxy, PU, PPS, PSU,PEEK,PI)
- To increase impact resistance of engineering plastics, epoxy, polyurethane, paints and coatings
- To increase adhesion of engineering plastics to various substrates (Steel. Glass, Aluminum , Copper etc)
- To low coefficient of friction in plastic goods
- To increase scratch, mar , gloss in pains and coatings
- To enhance barrier properties of composite materials

Wetting and Dispersion

non-treated UHMW PE(left) and surface-modified UHMW PE (right) in water .

Bonding of particles



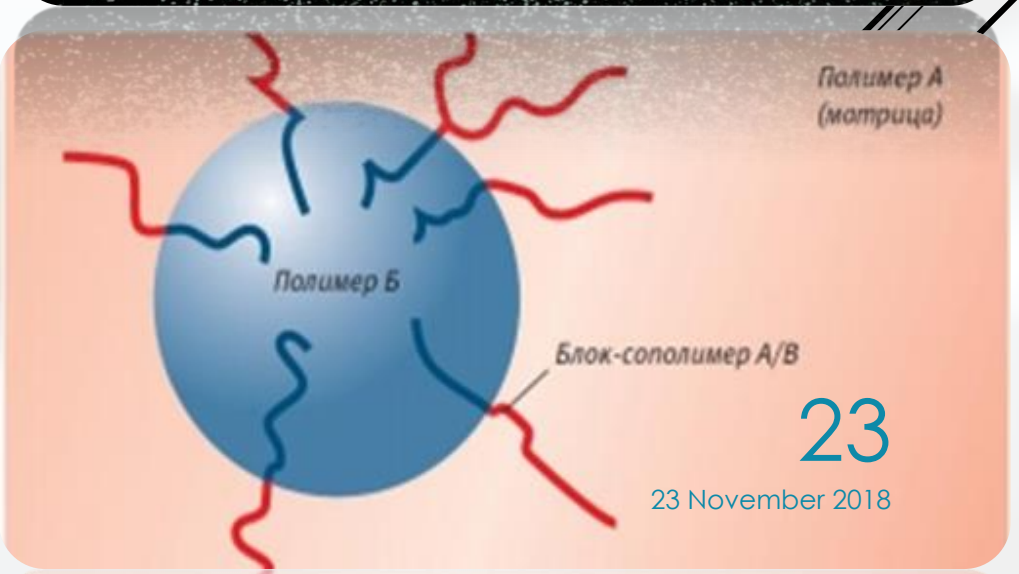
Non-treated (left) and surface-modified (right) UHMW PE particles in a polyurethane matrix clearly illustrate.

GRAFTABOND™ P –UH (Grafted UHMWPE powders)

GRAFT POLYMER
COMBINE INCOMPATIBLE

Advantages of Graft Polymer Solution

- UHMWPE graft copolymers having enhanced thermal stability and excellent nucleating efficiency.
- UHMWPE graft copolymers having improved rheological properties.
- The process for preparing UHMWPE graft copolymers by using solid state graft co-polymerization process.
- The economical and environmentally safe process for preparing UHMWPE graft copolymers wherein the use of costly and hazardous solvents, and high temperature conditions are completely obviated.



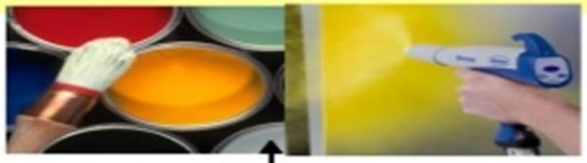
GRAFTABOND™ P –UH (Grafted UHMWPE powders)

GRAFT POLYMER
COMBINE INCOMPATIBLE

Main Applications

Pains & Coating

To increaseт: abrasive resistance (Mar, Scrab, Rub, Scratch), gloss, toughness, adhesion to meatl, glass, concrete etc.



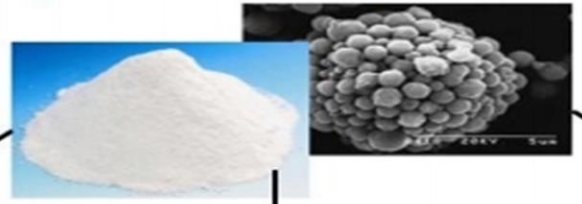
Adhesives & Sealants

To change module – increase or decrease , increase adhesion

Heavy duty goods

Coefficient of friction (increase or decrea to increase abrasion resistance

Nanomodified polymer powders & compostes



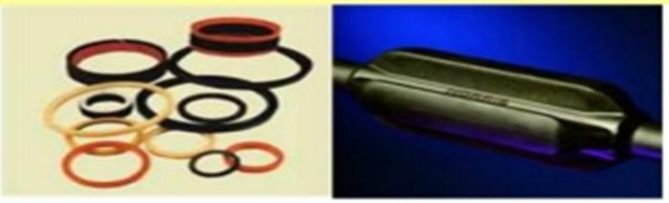
Cast Polyurethane ,Epoxy, Polyether Abrasion resistance,flexibility,adhesion

Thermoplastic & Thermosets

Abrasion resistance, creep resistance, solvent resistance, adhesion and compatibilization.

Rubber Goods

Increase abrasive resistance, coefficient of friction , adhesion



GRAFTALEN™ TRC
(Thermo-Reversible Crosslinking Alloys)

GRAFT POLYMER
COMBINE INCOMPATIBLE

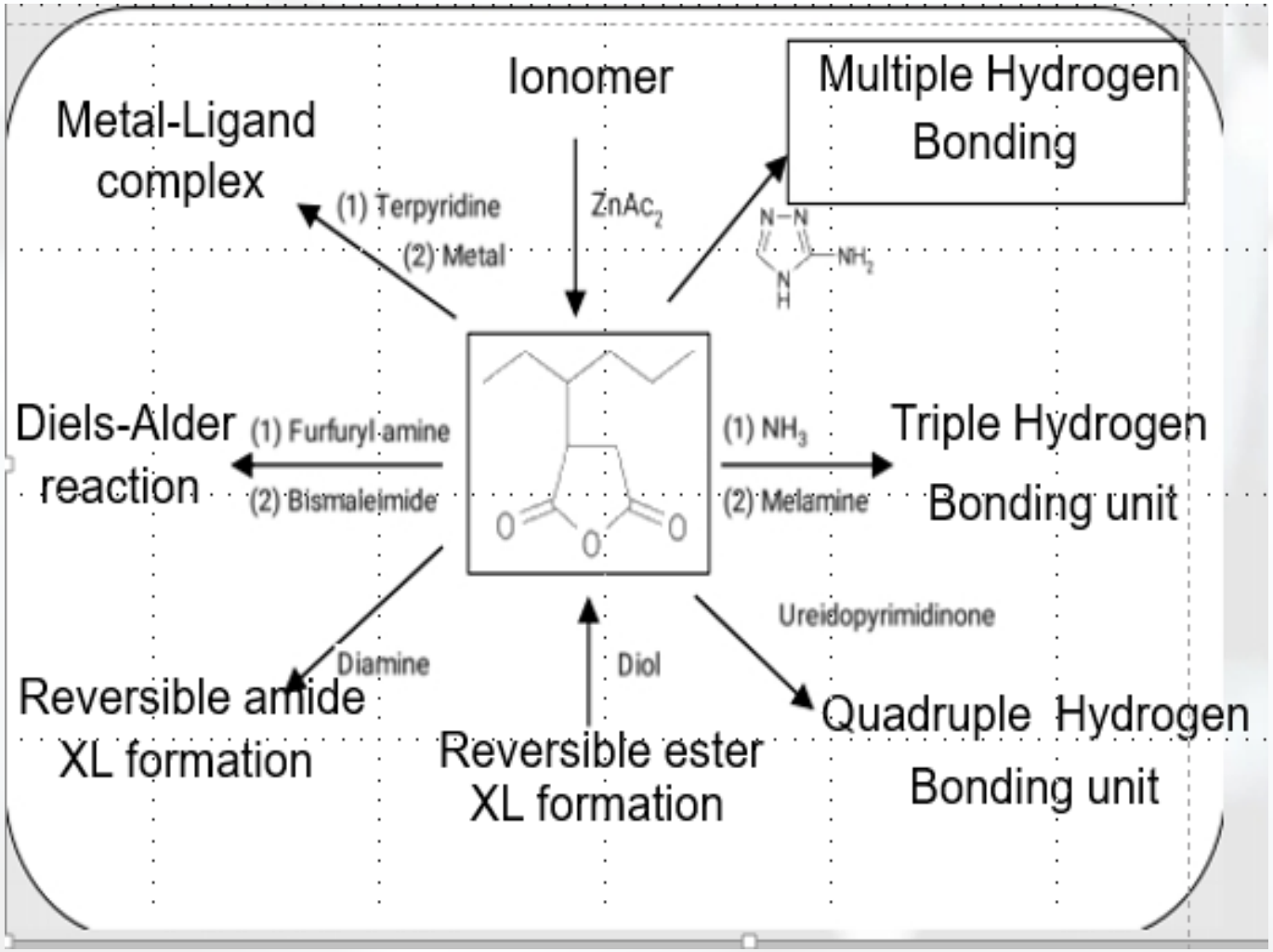
Market existing problem / challenge

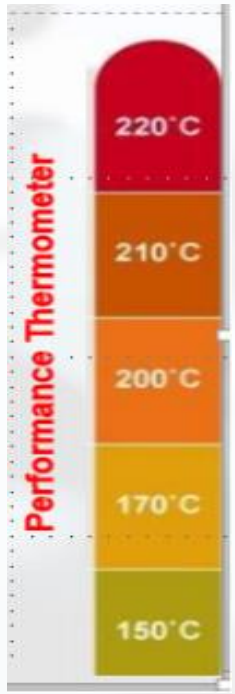
A key disadvantage of peroxide-based crosslinking (as well as other conventional crosslinking chemistries, including silane and radiation technologies) is that the materials become thermoset, and cannot be processed as thermoplastics after manufacture.
Therefore, it would be advantageous to identify and develop a strategy that enables polymer crosslinking in a **reversible manner** wherein the subsequent application of a chemical or physical stimulus permits controlled reversion of the thermoset back to its antecedent thermoplastic form.
This strategy may take advantage of a variety of chemistries, for instance, by incorporating a reactive group into the polymer architecture through grafting or copolymerization of a functional co-monomer and subsequently coupling with di-functional crosslinking agents that react in a reversible manner.
For the case of thermo-reversible crosslinking , reversion to the non-crosslinked thermoplastic state may be achieved by the application of high temperatures wherein Thermoreversible the entropic gains of crosslinking de-crosslinking overcome the enthalpy driving force of crosslinking.

GRAFTALEN™ TRC
(Thermo-Reversible Crosslinking Alloys)

GRAFT POLYMER
COMBINE INCOMPATIBLE

Thermoreversible crosslinking techniques





Graft Polymer TRC products

PO-g-MAH - Hydroxylamine

PO-g-MAH - Diol

PO-g-TEMPO - Isocyanate

PO-g-TEMPO- Peroxide

PO-g-Furan - Bismaleimide

GRAFTABOND™ RPC (Reactive Polymer Coating)

GRAFT POLYMER
COMBINE INCOMPATIBLE

GRAFTABOND™ RPC100 is a novel composite polymeric coating based on FBE epoxy coat and an outer layer of reinforced polyolefin

Market demands

- Price competitive with existing 3LPO systems
- Enhance FJ (field joint) systems interfacial strength and performance – key to increasing pipeline overall reliability factor
- Improve operating temperature envelope – target 100 ° C
- Mechanical properties to exceed 3LPO systems in all environments as specified by ISO 21809 sec1 or CSA Z245-20/21
- Improved mechanical properties of polymeric based coatings such as penetration and impact resistance at elevated temperature

1. Fusion Bonded Epoxy
2. SureBond™ 100 (Reinforced Polymeric Coating)

GRAFTABOND™ RPC (Reactive Polymer Coating)

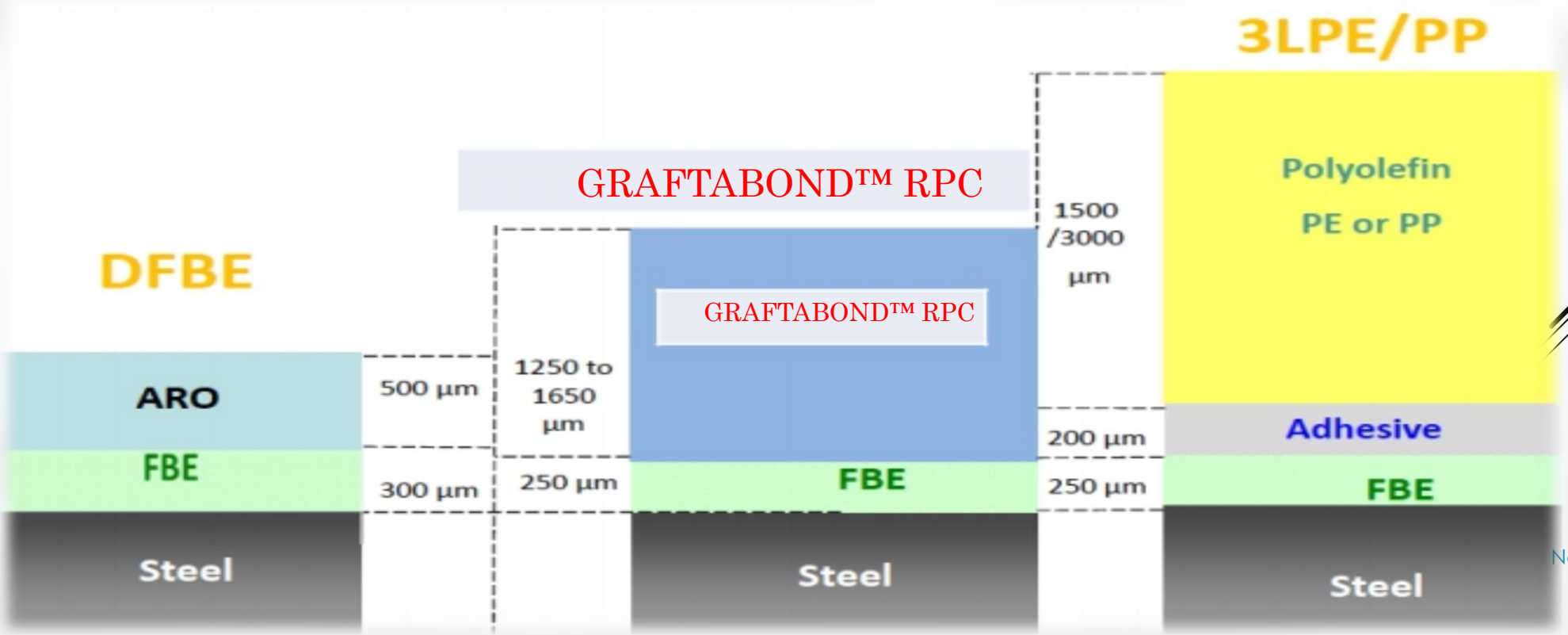
GRAFT POLYMER
COMBINE INCOMPATIBLE

Our Advantages:

GRAFTABOND™ RPC **eliminates** the adhesive layer which maybe the weak point

GRAFTABOND™ RPC **minimizes** component thermal mismatch and hence residual stress which contributes to some 3LPE issues.

Reduce shrinkage from melt to solid phase



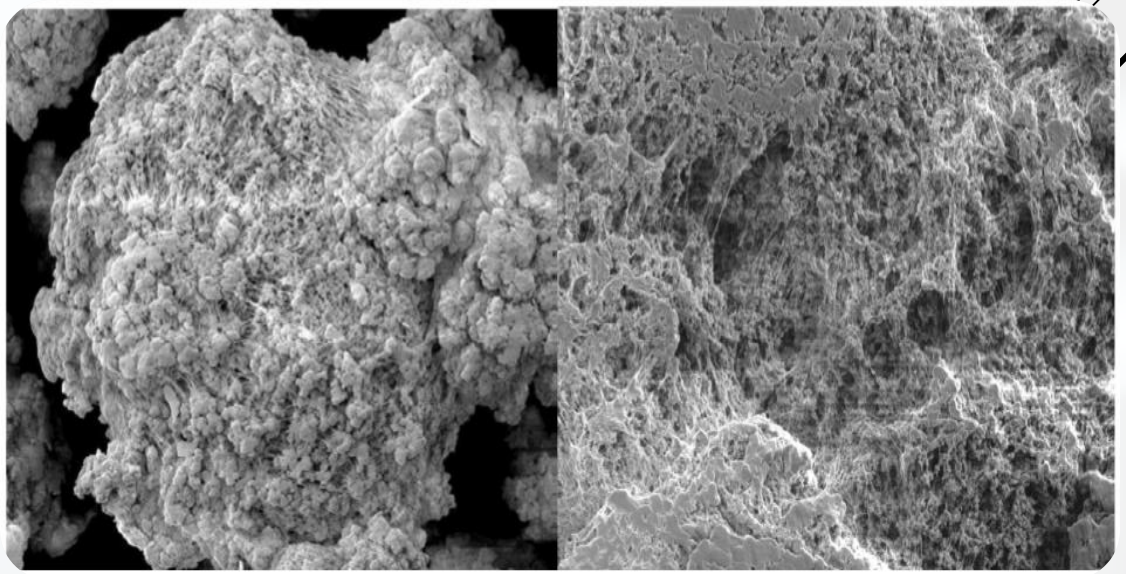
GRAFTALEN™ MP –UHMWPE (melt-processible)

GRAFT POLYMER
COMBINE INCOMPATIBLE

Melt-Processable **Ultra High Molecular Weight Polyethylene** is a novel unique product

The flexibility of the technology allows to produce concentrated blends based on MP UHMWPE (thermo plastic urethanes, rubber, titanium nitride etc.) with outstanding features and applications:

- Extrusion standard nomenclature sheets of standard equipment
- Ability to produce thin sheets (less than 1 cm).
- Master batches UHMWPE at different polymeric bases-- PE, PP, PS,ABS, PC, POM, PA, PPEK (70% loading).
- Cable application
- Pipe application as an additive (master batch) for multimodal PE 125 new generation
- The use of polymer coatings to metal pipes



Morphology of standard UHMWPE (left) particle and UHMWPE of new generation (right). The grain-structure (left) and sponge-structure (right) are clearly visible.

GRAFTALEN™ MP –UHMWPE (melt-processible)

GRAFT POLYMER
COMBINE INCOMPATIBLE

Main Properties of MP-UHMWPE

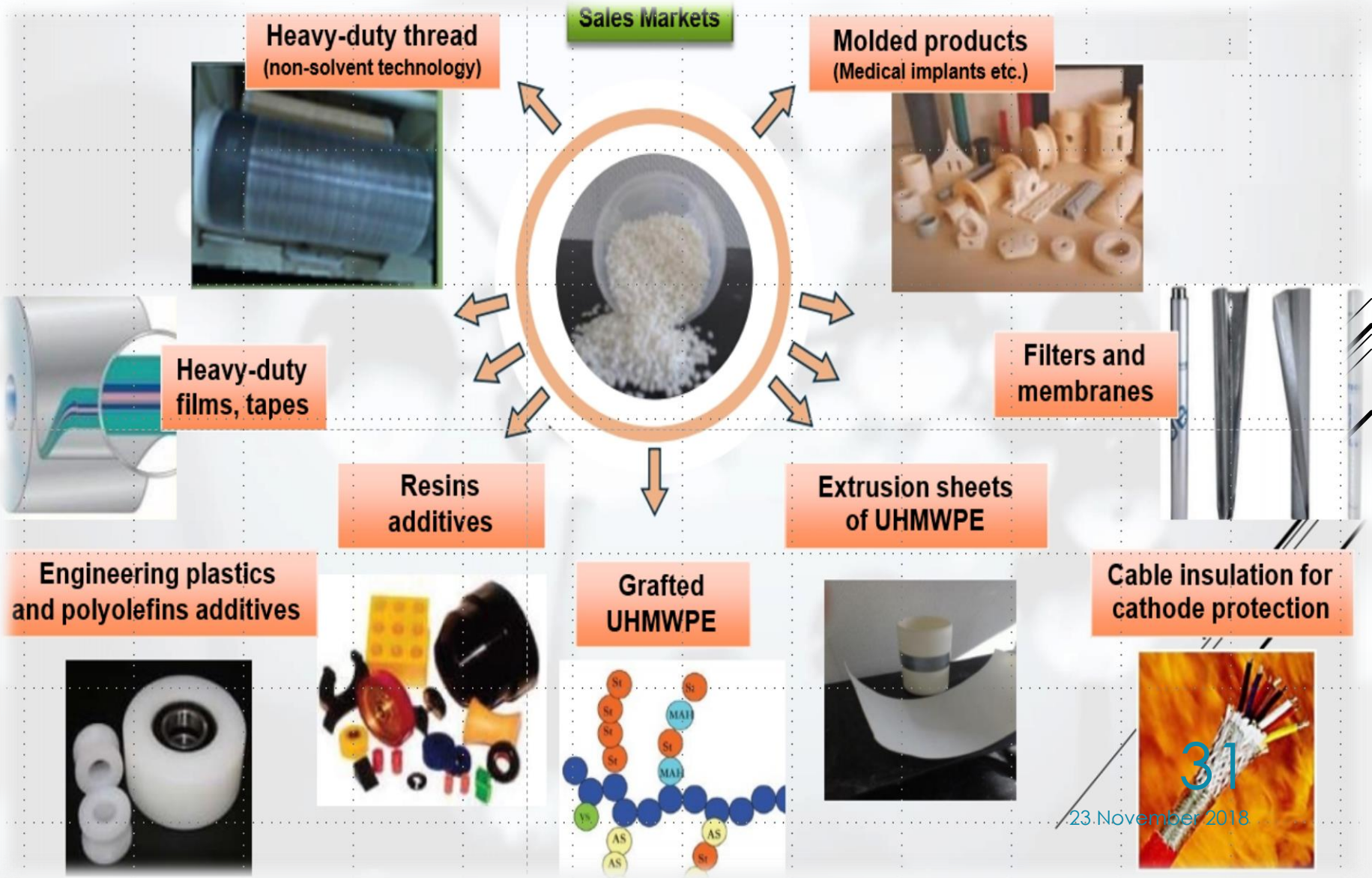
- Easily melt-processible for any type of products using standard polymer-processing equipment (extruder,injection machine, calander).
- Physical and mechanical properties are significantly higher than the standard UHMWPE.
- Tribological properties are the same as the standard UHMWPE.
- High crystallinity (94% for MP-UHMWPE vs 60-85% for standard UHMWPE).
- Excellent biocompatibility (for medical purposes).
- Easily welded (unlike a standard UHMWPE).
- Easily stretchable.
- Homogenized with different grades of HDPE .
- Efficiency of solid-phase grafting for MP-UHMWPE significantly higher than the standard **UHMWPE** (due to morphology).
- Adjustable porosity 0% default.
- Geometric stability, shrinkage is minimal .
- Technology of production is environmentally friendly , without the use of toxic solvents.
- Easily colored in any color

GRAFTALEN™ MP –UHMWPE (melt-processible)

GRAFT POLYMER
COMBINE INCOMPATIBLE

Examples of Alloys based on MP-UHMWPE

- PE125 next generation
- MP-UHMWPE/PET
- MP-UHMWPE/POM
- MP-UHMWPE/PDMS



GRAFTALEN™ MP –PVA(melt-processible poly vinyl alcohol)

GRAFT POLYMER
COMBINE INCOMPATIBLE

Market Needs

- To provide a polyvinyl alcohol **melt processable** material, not only reduces the temperature of the plasticized polyvinyl material, making it suitable for melt processing, processing and product quality obtained, no toxicity.
- To provide **a method** for preparing said melt-processable polyvinyl alcohol material.
- One of the properties to improve is the **Melt Flow Index.**
- PVA generally has moisture content up to 5% by weight. This has to be **reduced to below 1%** to avoid processing issues on standard thermoplastic equipment, such as the generation of volatiles which causes foaming. Conventionally, the polymer is dried in a standard polymer dryer for 4-8 hours at 90 ° C

Our Advantages:

- High Gas Barrier
- Oil & Solvent Resistance
- Melt Extrusion
- Transparency
- Water Solubility

GRAFTALEN™ MP –PVA(melt-processible poly vinyl alcohol)

GRAFT POLYMER
COMBINE INCOMPATIBLE

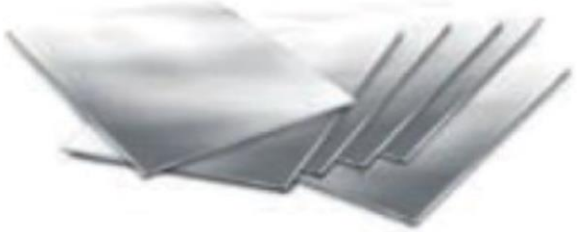
pplications in Building and Construction and
uel containment

Extended energy efficiency and service life

Underfloor heating pipe

VOC barrier construction membranes

Preinsulated pipe



Vacuum insulation panels

Durable and stain-resistant wallpaper

Fuel tanks, lines and filler pipes

GRAFTALEN™ MP –PVA(melt-processible poly vinyl alcohol)

GRAFT POLYMER
COMBINE INCOMPATIBLE

Applications in Food Packaging

Flexible (blown, cast, lamination)

Extended freshness and protected value

Fresh meat shrink wrap

Sliced ham

MAP with long-lasting gas mix

Al foil-free for safety and reduced environmental impact

Ultra efficient bag-in-box liner

Al foil-free aroma barrier

Transparent barrier lid film

GRAFTALEN™ MP –PVA(melt-processible poly vinyl alcohol)

GRAFT POLYMER
COMBINE INCOMPATIBLE

Applications in Medical and Pharmaceutical

Ensuring product integrity and protection from contamination

Sealable medicine sachet

Nutrition provided intact

Visibility and protection

Applications in Agriculture

Fewer chemical emissions, less waste of farm produce

TIF much films

Chemical and solvent resistant bottles

Barrier IBC

GRAFTAMID™

GRAFT POLYMER
COMBINE INCOMPATIBLE

GRAFTAMID™ grafted copolymers :

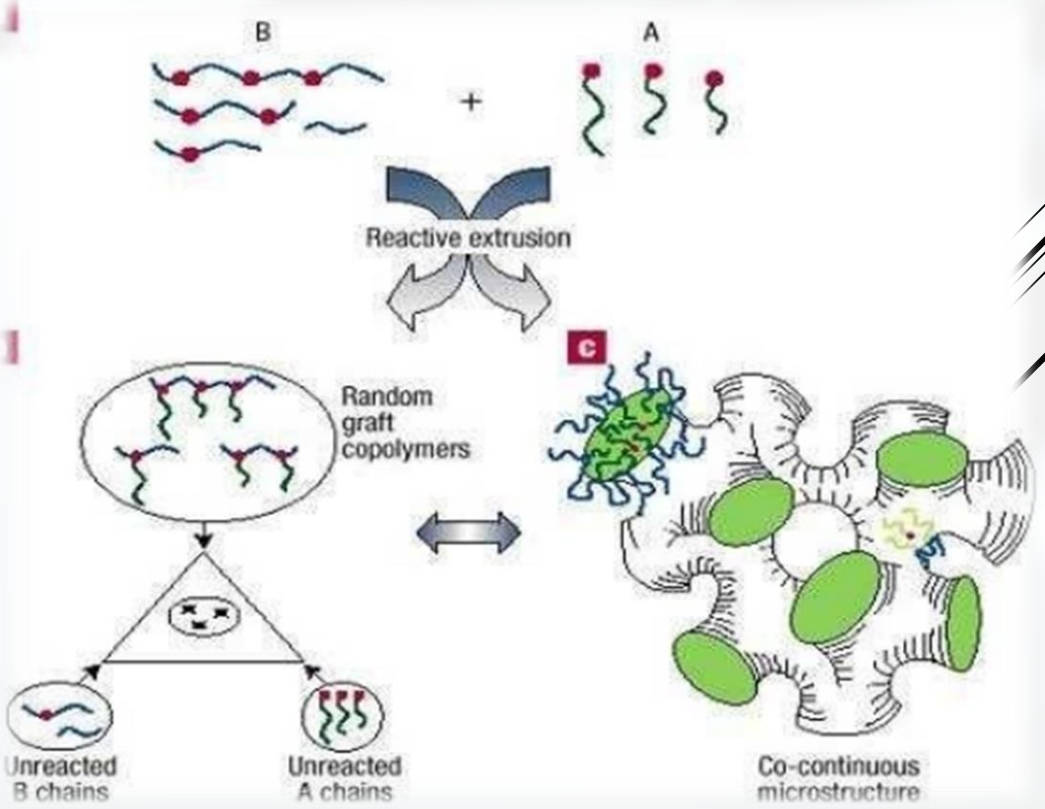
- Co-polyolefin main linear chain, with grafted linear lateral chain
- Co-continuous morphology

Market demands

- ❑ To remove macro Phase Separation
- ❑ To increase content of Grafted Polymers
- ❑ To remove Side Reactions during grafting

Functional ethylene copolymer or terpolymer

Functional co-polyamide or polyether



GRAFTAMID™

GRAFT POLYMER
COMBINE INCOMPATIBLE

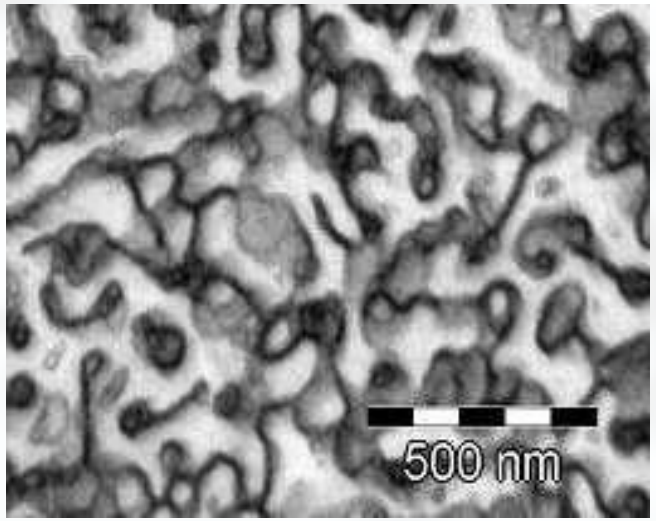
Our Advantages:

- ❑ Transparency
- ❑ Processability
- ❑ Thermo-mechanical and oxidation resistance
- ❑ Chemical resistance
- ❑ Compatibility with polyolefin (and polyamides)

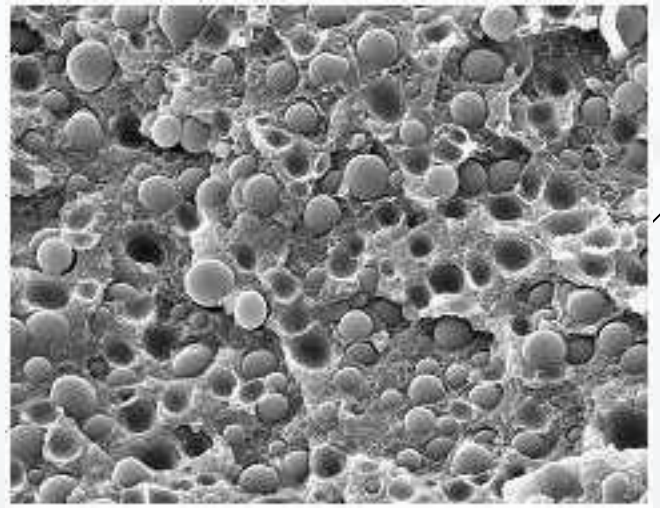
GRAFTAMID™ – Main Products Range

- ➢ PA11 grafted PO
- ➢ PA6 grafted PO
- ➢ Copolyamid grafted PO
- ➢ Special products
- ➢ Fire retarded grades

GRAFTAMID



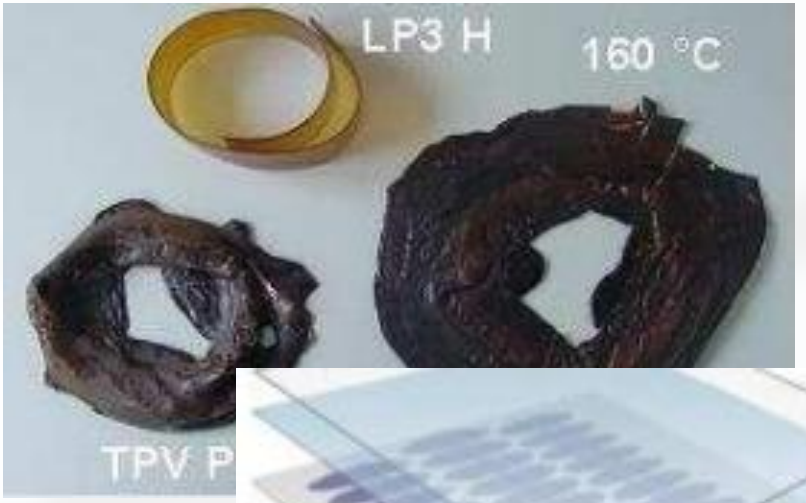
Classical TPV

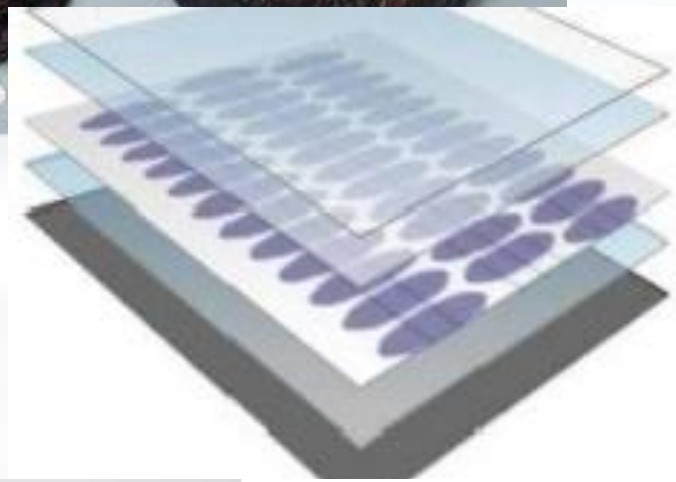


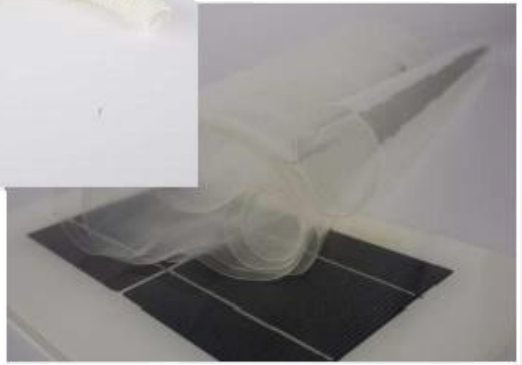
GRAFTAMID™

Applications

- **GRAFTAMID™ Automotive**
  - Thermal protection for cable, multilayers…
- **GRAFTAMID™ special films**
  - Transparency and adhesion in photovoltaic films,
  - Thermo-mechanical and adhesion in multilayers adhesive films
- **GRAFTAMID™ Fire** retarded grades
  - Cable, corrugated tubings for fire and thermal protection
- **GRAFTAMID™ additive**
  - Thermo-mechanical and adhesion in polyolefins or TPV's,
  - Impact strength in polyamids
  - Hot melt adhesives







GRAFTALEN™ AERO

GRAFT POLYMER
COMBINE INCOMPATIBLE

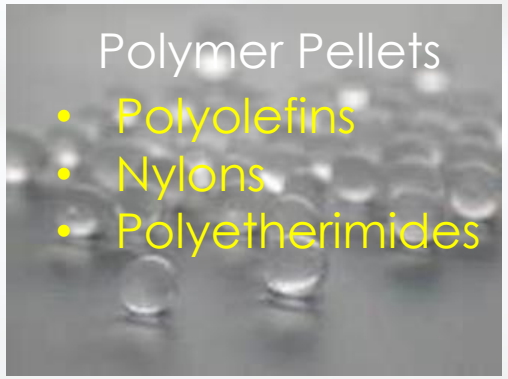
Aerogel infused thermoplastic polymers

- ✓ Thermally processing similar to base polymer; low overhead cost for technology development
- ✓ Composites exhibit a 20-50% decrease in thermal conductivity
- ✓ Commercially available nanoparticle additives provide adaptable infusion
- ✓ Extremely wide range of targeted applications

Aerogel Properties

- ✓ low thermal conductivity
- ✓ hardness
- ✓ heat resistance
- ✓ transparency
- ✓ elasticity
- ✓ insulation
- ✓ durability
- ✓ flexibility
- ✓ Aerogel is super strong for its weight
- ✓ NASA uses aerogel because it's really lightweight
- ✓ Has a density lower than any other known solid
- ✓ One of the highest surface area solids
- ✓ Hydrophobicity
- ✓ Lowest thermal Conductivity

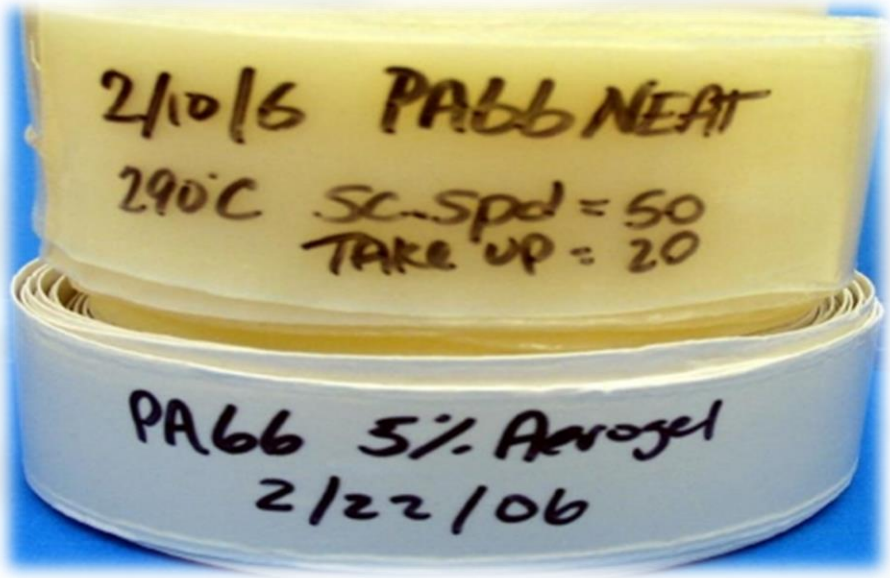
Aerogel meet

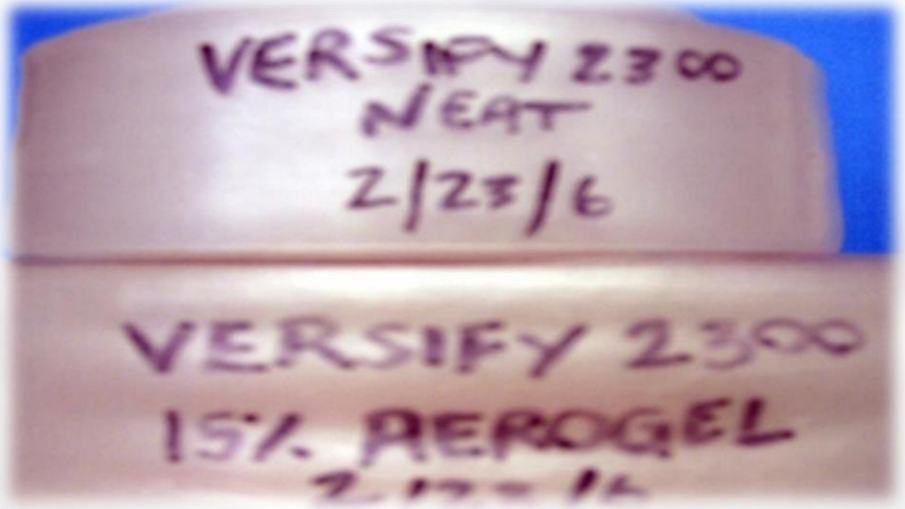


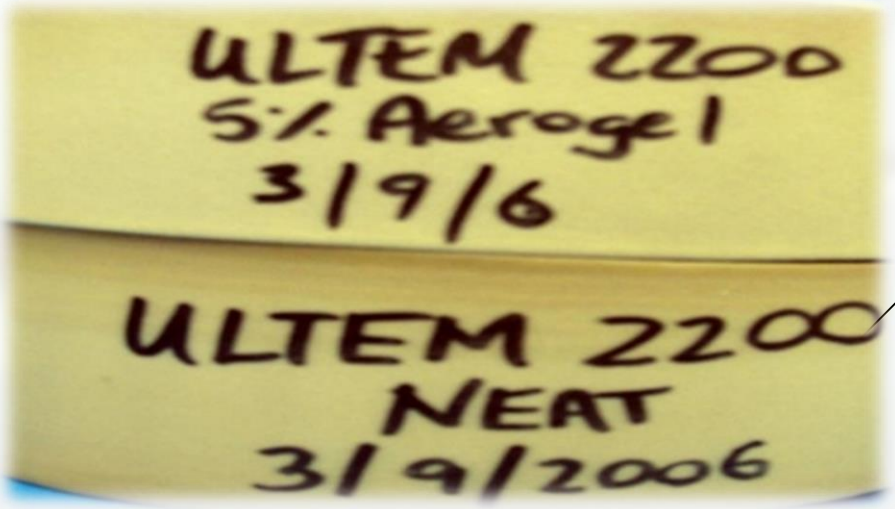
GRAFTALEN™ AERO

GRAFT POLYMER
COMBINE INCOMPATIBLE

Examples of Aeroplastic Tapes



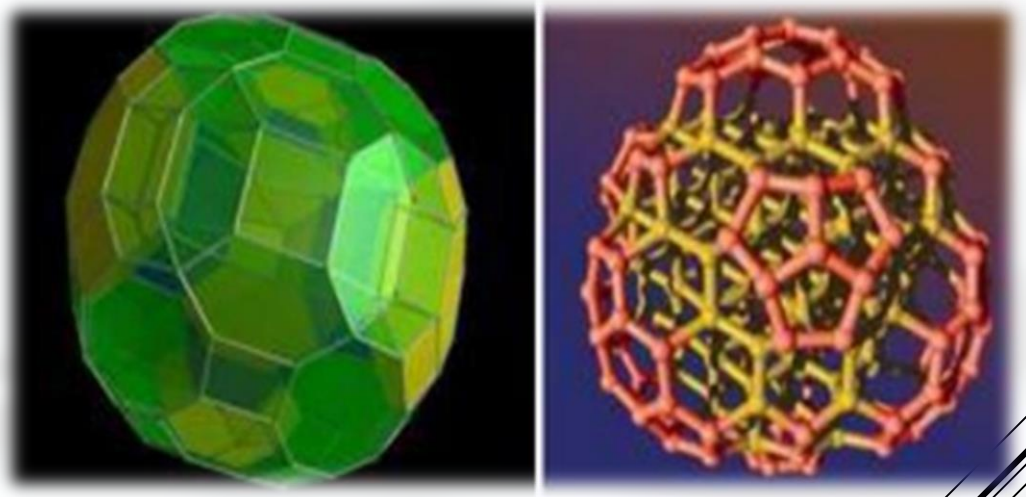


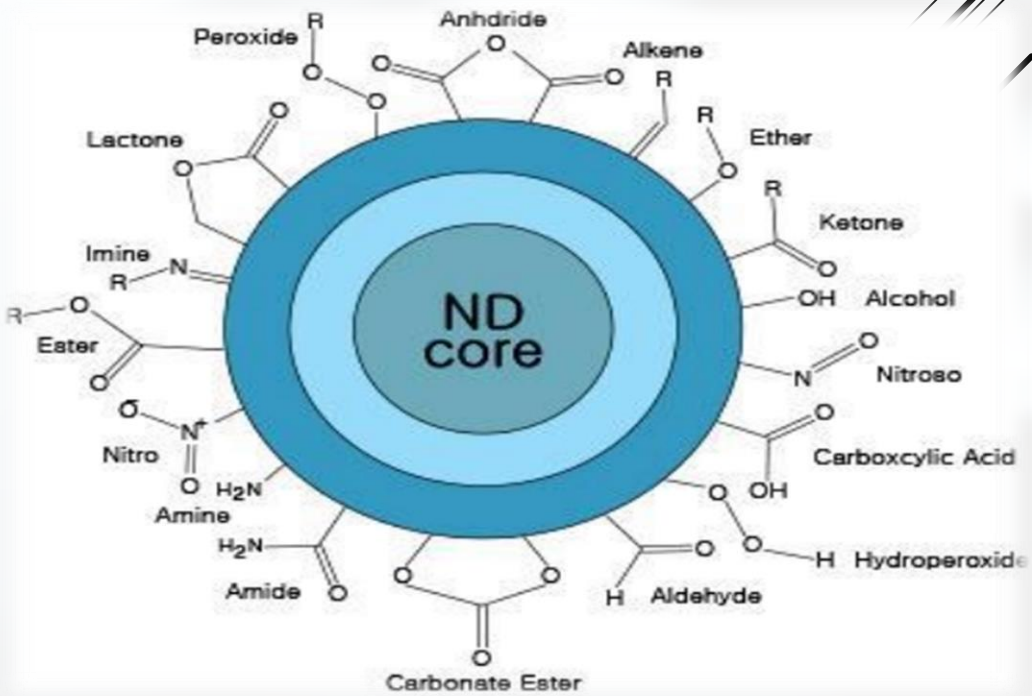


GRAFTALEN™ ND

GRAFT POLYMER
COMBINE INCOMPATIBLE

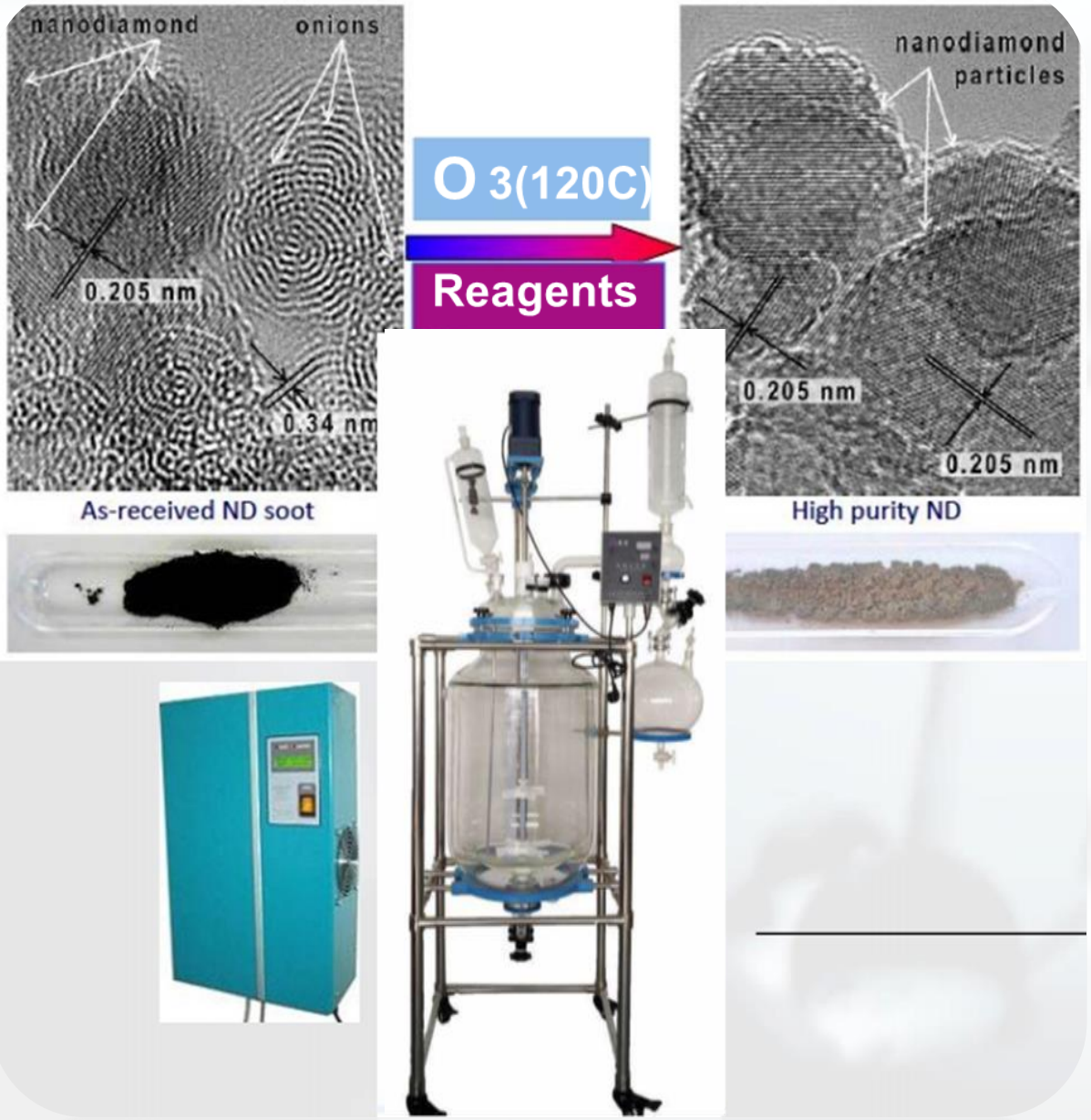
Carbon is unique in the number and the variety of its allotropes due to its valiancy.
ND is an allotrope of carbon. NDs are carbon-based materials approximately 2 to 8 nanometers in diameter.
Figure 1 shows the crystal structure of Nano diamonds.
The crystal structure of ND consists of two close packed interpenetrating face centered cubic lattices; one lattice is shifted with respect to the other along the elemental cube space diagonal by one-quarter of its length.
NDs are clustered carbon atoms with both graphitic (sp 2) and diamonded (sp 3) bonds.
The two types of bonds can be interchangeable.
This interchangeability allows ND particles to be flexible templates, particularly around the curved surface where electrons are unstable.
Figure 1: Crystal Structure of Nanodiamond



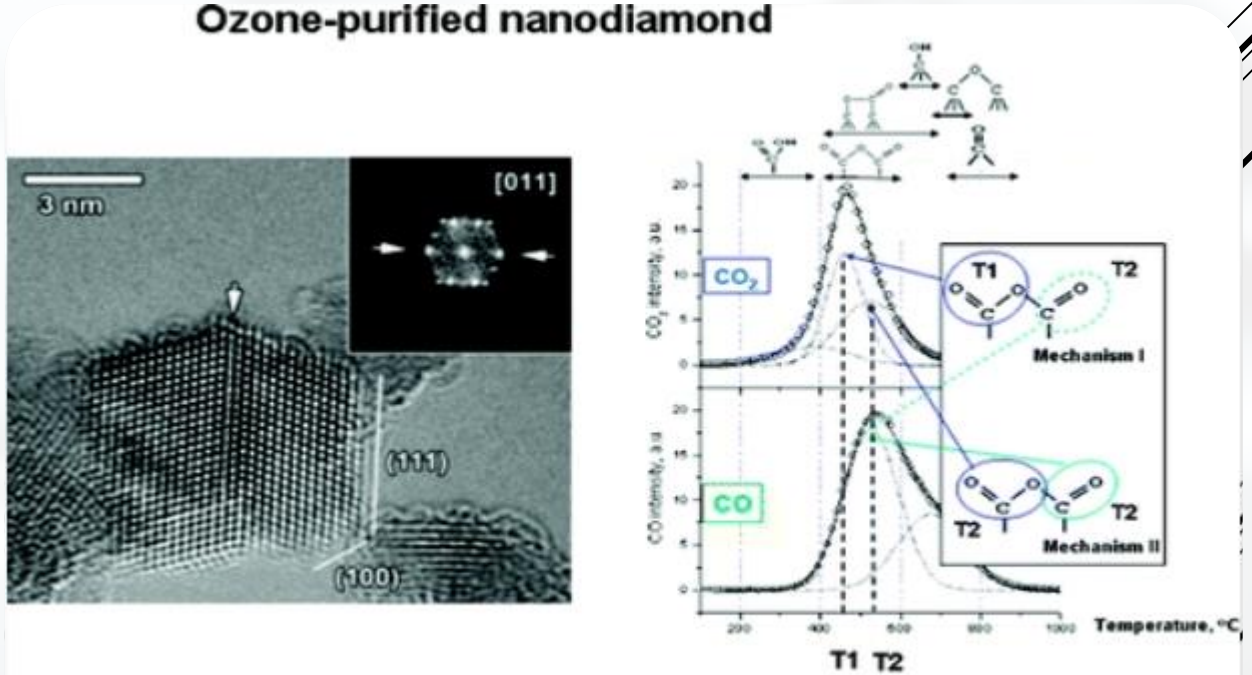


GRAFTALEN™ ND

GRAFT POLYMER
COMBINE INCOMPATIBLE



Nanodiamond from ozone purification (NDO) demonstrates very distinctive properties within the class of detonation nanodiamonds, namely very high acidity and high colloidal stability in a broad pH range. To understand the origin of these unusual properties of NDO, the nature of the surface functional groups formed during detonation soot oxidation by ozone needs to be revealed .



- minimal presence of non-sp^3 carbon enrichment with carboxylic acid anhydrides

Properties Improvements in GRAFTALEN™ ND composites

GRAFT POLYMER
COMBINE INCOMPATIBLE

Applications

- In lubricants & polishing materials
- fillers in electroplated films
- polymer coatings with enhanced mechanical properties and thermal resistance.
- UV and radiation-resistant materials and formulations are based on the exceptional bulk properties.
- in immobilization of biomolecules, drug delivery, and composites are based on the surface properties.

The combination of the unique bulk and surface properties of nanodiamonds make them extremely versatile materials with a number of applications.

Some of the important applications of NDs include their use in:

- drug delivery
- polymer strengthening
- high density nucleation and growth of CVD diamond films and as additives for oils, lubricants and fuels, catalysts support
- antibacterial and antifungal coating material.

The outstanding chemical and mechanical properties, along with their small size and approximate spherical shape, render NDs ideal candidates for the aforementioned applications

Polymer	ND content	Property	Quantitative increase
Polydimethylsiloxane	0.1 wt.%	Elastic strain	N/A
Polyurethane-2-hydroxyethylmethacrylate	0.25 wt.%	Young's modulus	N/A
		Glass transition temperature	N/A
Polyethylene	11 wt.%	Young's modulus	2.5 times
		Hardness	4.5 times
Polyamide-11	20 wt.%	Young's modulus	400%
		Hardness	200%
		UV absorbance	N/A
Polyamide-11 (Nylon-11)	7 wt.%	Adhesion	N/A
Polyvinyl alcohol	1 vol.% (detonation soot)	Tensile modulus	40%
		Fracture energy	70%
Polyvinyl alcohol (Gohsenol NH-18)	5 wt.%	Young's modulus	2.9 times
		Tensile strength	1.3 times
		Strain at break	0.2 times
		Toughness	0.2 times
		Thermal conductivity	1.3 times
		Crystallinity	8%
Polyvinyl alcohol	0.6 wt.%	Young's modulus	90%
		Hardness	78%
		Crystallinity	14%
Poly-(methyl methacrylate)	0.1 wt.%	Impact strength	N/A
		Fracture toughness	N/A
	0.8 wt.%	Young's modulus	80%
		Glass transition temperature	20 °C
Poly-(methyl methacrylate)	5 wt.%	Hardness	1.2 times
		Young's modulus	2.1 times
Polycarbonate	5 wt.%	Hardness	1.3 times
		Young's modulus	1.6 times
Poly-(lactic acid)	5 wt.%	Tensile modulus	19%
	3 wt.%	Storage modulus	75% (@130 °C)
	1 wt.%	Onset of thermal decomposition	10.1 °C higher
Poly-L-(lactic acid)	10 wt.%	Young's modulus	2 times
		Hardness	8 times
		Fracture energy	316%
Poly-L-(lactide-co-ε-caprolactone)	10 wt.%	Young's modulus	6 times
		Glass transition temperature	9 °C higher
	50 wt.%	Young's modulus	15 times
Polyimide	5 wt.%	Young's modulus	25%
		Hardness	15%
Epoxy (DER 332 + TETA)	0.1 wt.%	Tensile strength	6.4%
		Hardness	41%
		Glass transition temperature	37 °C higher
Epoxy (Epon828 + PACM20)	35 vol.%	Young's modulus	700%
		Hardness	300%
		Scratch resistance	N/A
Epoxy (Epon828 + PACM)	7.5 vol.%	Friction coefficient	0.25 times
		Wear resistance	N/A
		Abrasion	N/A
Epoxy (DGEBA + Jeffamine D2000)	0.5 wt.%	Young's modulus	25%
		Fracture toughness	N/A
Epoxy (Epon828 + PACM)	30 vol.%	Young's modulus	700%
	3.5 vol.%	Young's modulus	60%
	20 vol.%	Glass transition temperature	28 °C lower

GRAFTALEN™ POSS

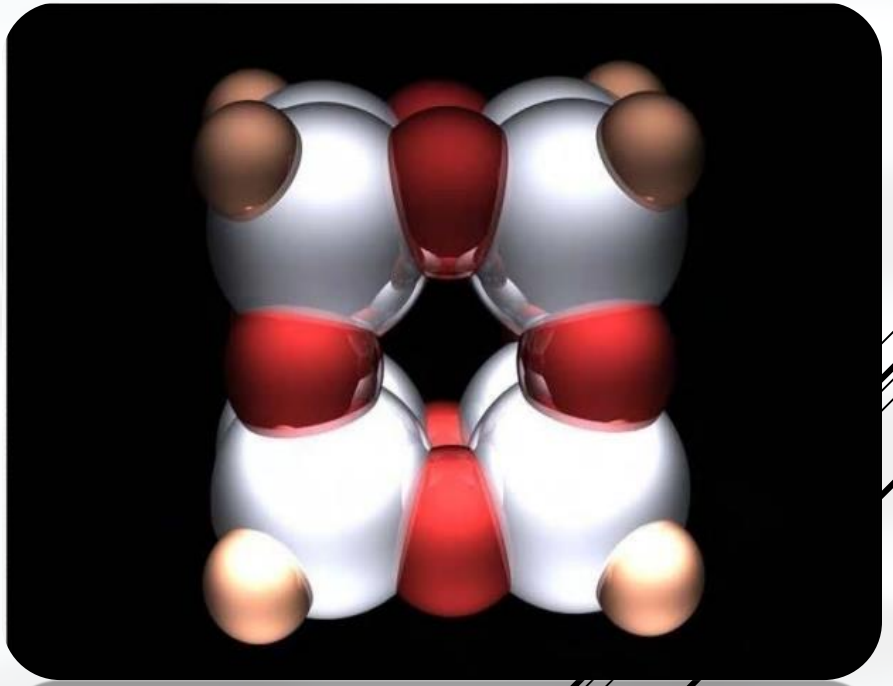
GRAFT POLYMER
COMBINE INCOMPATIBLE

Polyhedral Oligomeric Silsesquioxanes (POSS) are used to impart unique properties to thermoplastics, thermosets, elastomers and coatings.

The basic POSS structure can be thought of as a cage of molecular silica comprised of 8 silicon atoms linked together with oxygen atoms.

At each of the 8 corners is a substituent which can be just about any chemical group known in organic chemistry.

Therefore, there are potentially an unlimited number of POSS variants.



GRAFTALEN™ POSS

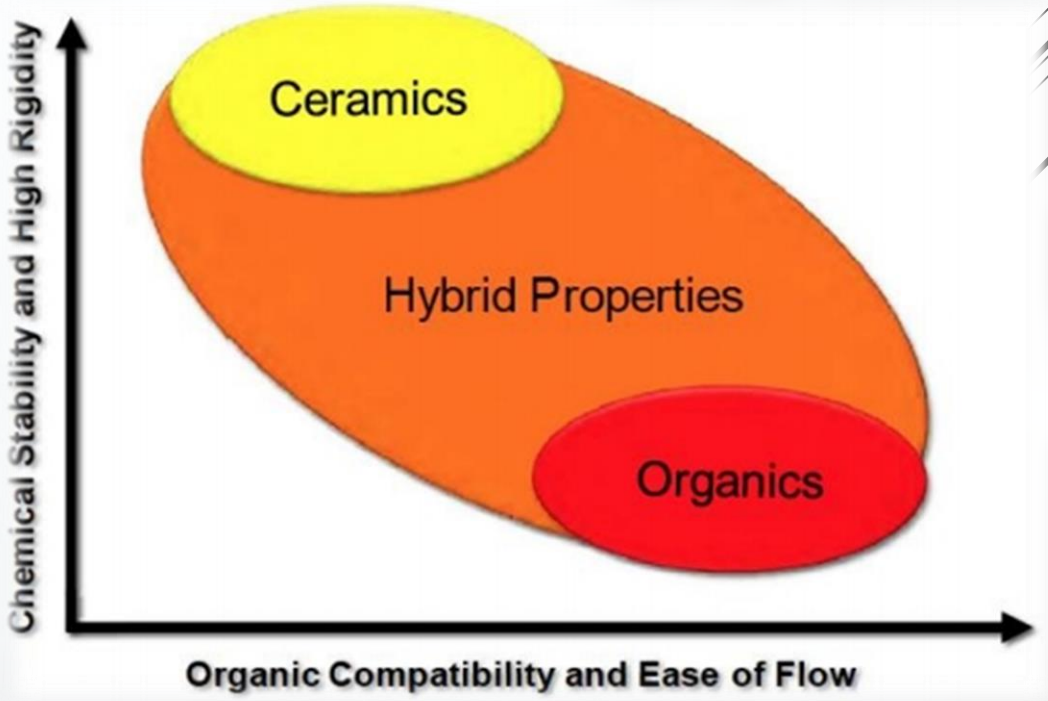
GRAFT POLYMER
COMBINE INCOMPATIBLE

POSS allows the creation of materials exhibiting hybrid properties .
The silica core of the POSS is inert and rigid whereas the surrounding organic groups provide compatibility with the matrix and processability.
Conceptually, POSS may be thought of as an organic-inorganic hybrid

POSS is sometimes considered to be a filler and sometimes a molecule.
For example, POSS is rigid and inert like inorganic fillers, but unlike those conventional fillers, POSS can molecularly dissolve in a polymer.

Normal fillers and especially Nano fillers suffer from agglomeration.
The agglomerates formed when using conventional fillers lead to weak points in the polymer (stress concentrations) and this gives poor impact resistance and elongation to break.
As a molecule, POSS dissolves in polymer as 1-3nm cages and this gives performance advantages not seen with fillers

POSS is a unique hybrid organic-inorganic composition



GRAFTALEN™ POSS

GRAFT POLYMER
COMBINE INCOMPATIBLE

Solution by Graft Polymer

Proprietary Synthesis of our own reactive functionalized POSS on the basis of common functional silane precursors

Masterbatches of various POSS on Polymers

Functional POSS

Polymer-POSS Masterbach

THANK YOU

GRAFT POLYMER
COMBINE INCOMPATIBLE

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