

Optimum use of Processing Additives in Rubber compounds

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Basic principles and applications

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Agenda

Basic principles dominating the function of Processing Additives

- Interactions of Compound components
- Physico-chemical principles
- Specific and combined effects

Applications

- Product classes
- Point of additive addition

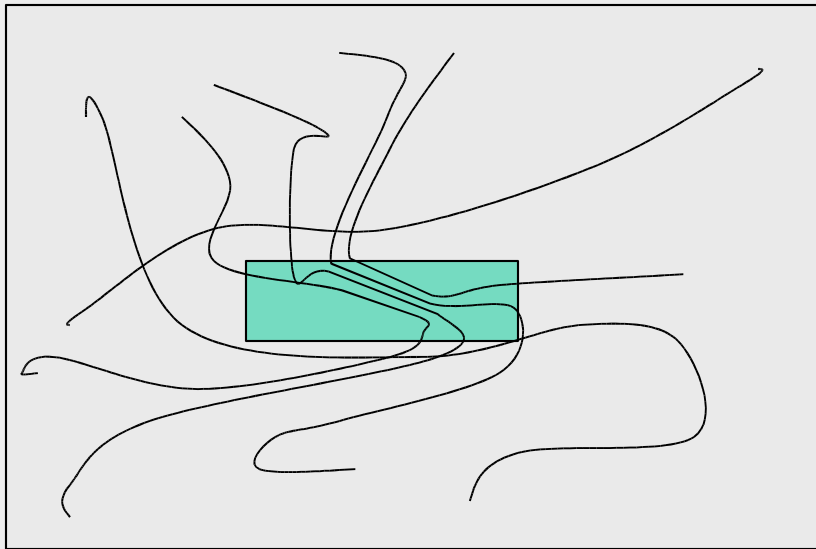
Conclusion



Optimum use of Processing Additives

Basic principles dominating the function of Processing Additives

Interaction of Compound components



Polymer – Polymer Interaction

Influenced by:

Strength of interaction (enthalpy driven):

Van-der-Waals forces

Hydrogen bonding

Polar forces

Ionic forces

Covalent bonding (-> network)

Steric hindrance

Possibilities to arrange (entropy driven):

Molecular mass

Number of permutations

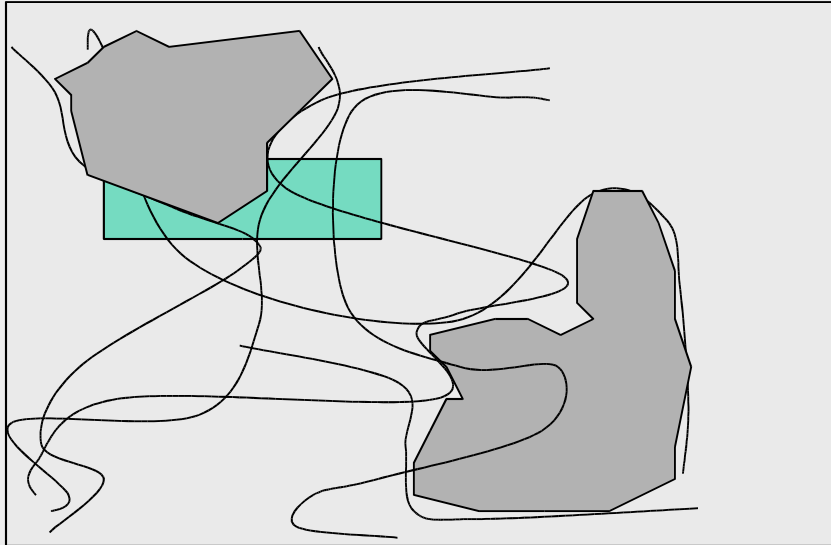
Affect: Glass transition, Modulus, Tear Strength, Elongation, Resilience, Abrasion, Viscosity, Processability, Polymer blending



Optimum use of Processing Additives

Basic principles dominating the function of Processing Additives

Interaction of Compound components



Polymer – Filler Interaction

Influenced by:

Strength of interaction (enthalpy driven):

Van-der-Waals forces

Polar forces

Ionic forces

Covalent bonding forces

Steric hindrance

Possibilities to arrange (entropy driven):

Molecular mass

Number of permutations

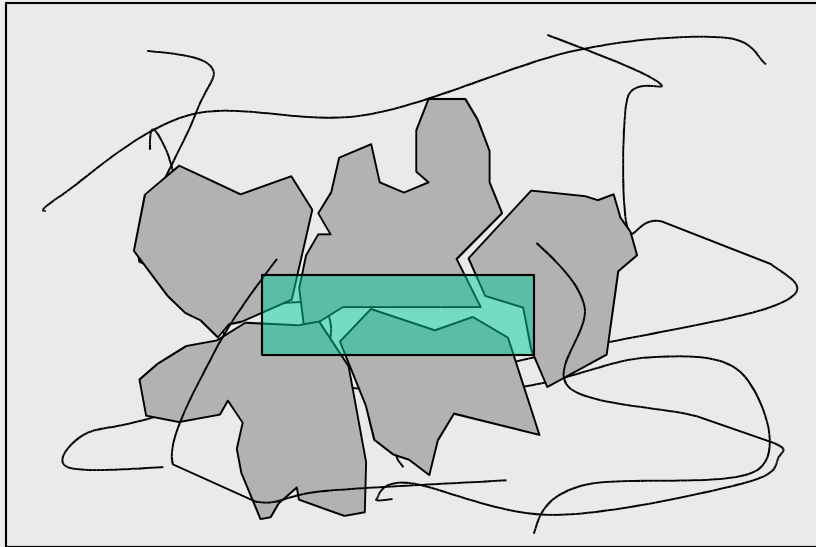
Affect: Reinforcement, Modulus, Tear Strength, Elongation, Hardness, Resilience
Abrasion, Viscosity, Heat built-up, Processability, Filler incorporation etc.



Optimum use of Processing Additives

Basic principles dominating the function of Processing Additives

Interaction of Compound components



Filler – Filler Interaction

Influenced by:

Strength of interaction (enthalpy driven):

Van-der-Waals forces

Hydrogen bonding

Polar forces

Surface structure

Possibilities to arrange (entropy driven):

Particle size

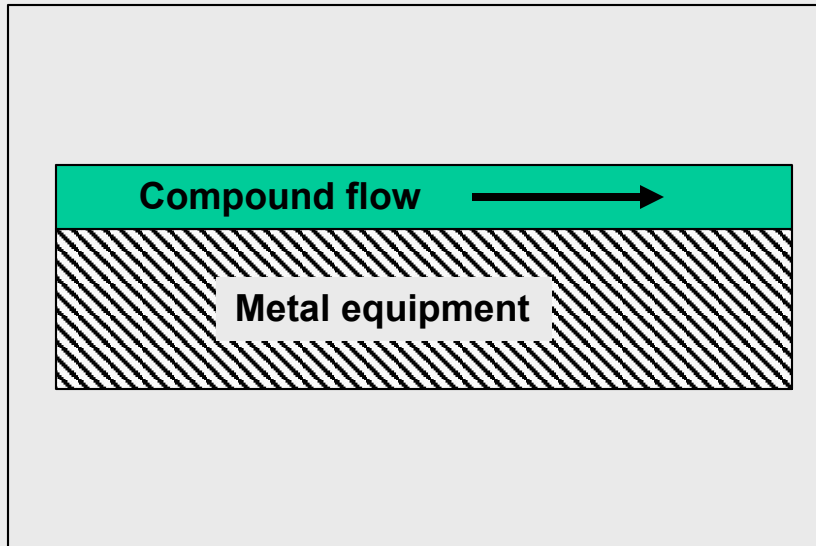
Affect: Modulus, Tear Strength, Elongation, Abrasion, Viscosity, Resilience, Hardness, Heat Built-up, Processability, Filler incorporation / dispersion etc.



Optimum use of Processing Additives

Basic principles dominating the function of Processing Additives

Interaction of Compound to Equipment



Influenced by:

Strength of interaction (enthalpy driven):

Van-der-Waals forces

Polar forces

Ionic forces

Covalent bonding forces

Compound – Metal Interaction

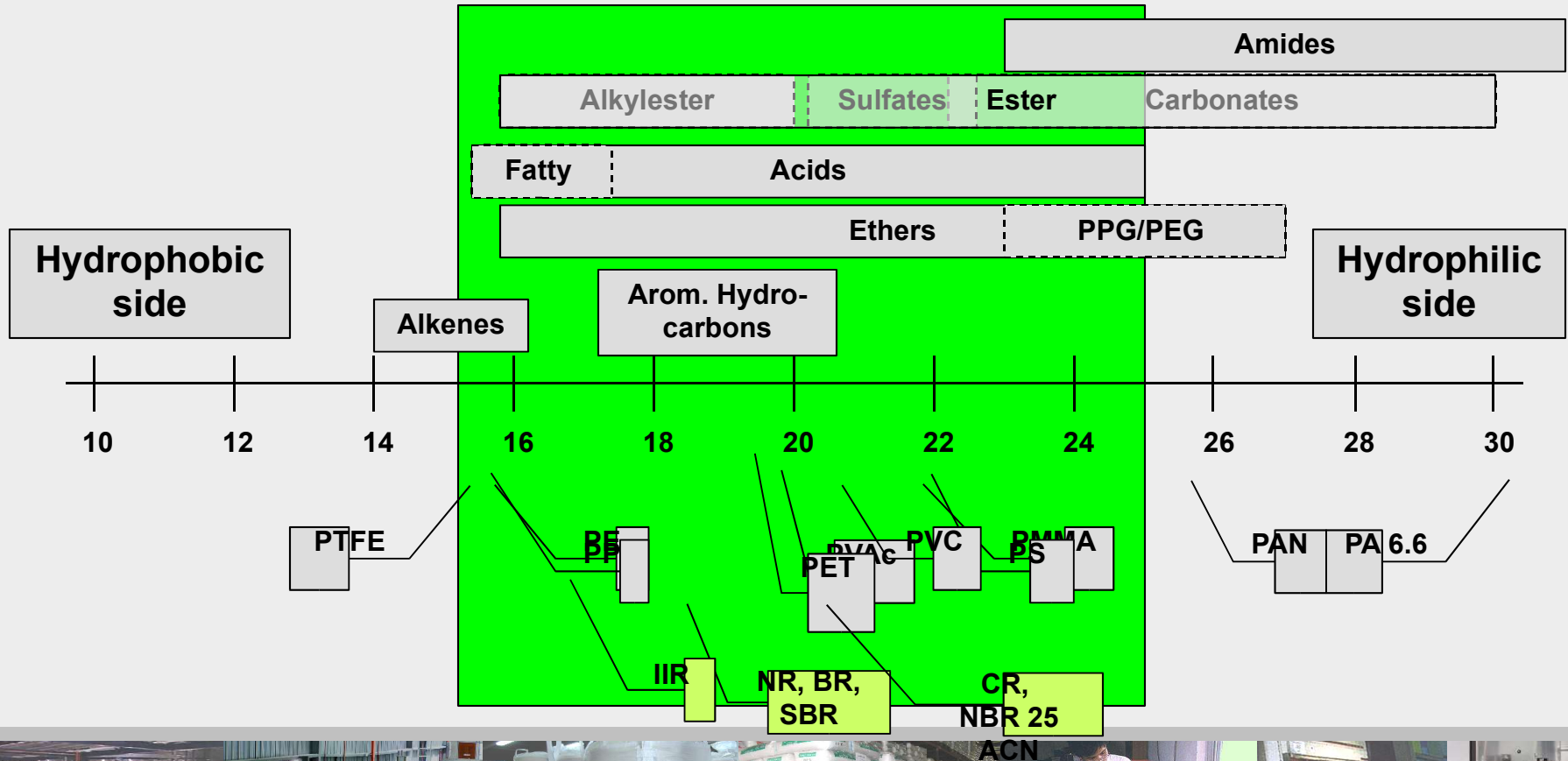
Affect: Mill / calander tack, Extrusion Flow Rates, Mould Release, Mould fouling, Building tack, Rubber-to-Metal adhesion



Optimum use of Processing Additives

Basic principles dominating the function of Processing Additives

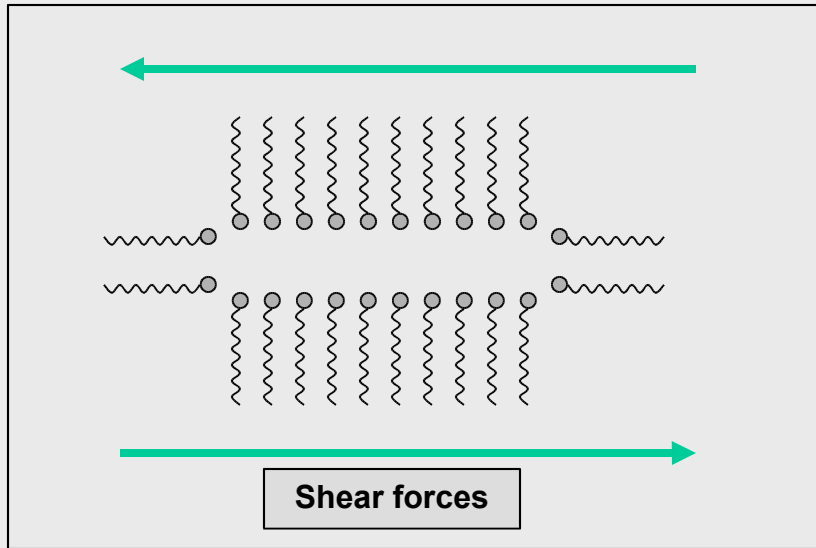
Solubility parameter concept: Hildebrand parameters (SI)



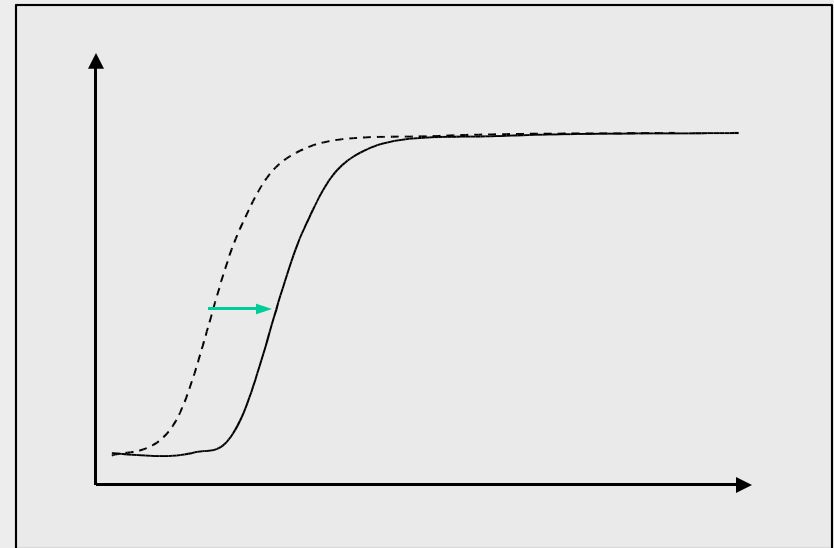
Optimum use of Processing Additives

Basic principles dominating the function of Processing Additives

Specific effects



Micell formation of Metal soaps, eg.:
Ultra-Flow 500
Ultra-Flow 800



Retarder ,eg.:
Ultra-Flow ZEH for PUR
Ultra-Gard IMR for ECO



Basic principles dominating the function of Processing Additives

Combined effects: Tackifier

A good tackifier:

- Needs a good to excellent solubility / compatibility to both adhesion partners
- Must have a minimum Molecular weight to built-up enough bonds to bridge the two partners (about 500 gr/mol)
- Must be dosed higher than the solubility threshold to migrate to the surface
- Works best 10K above its softening temperature, gets brittle below, at higher temperature the intermolecular forces get overruled by thermal movement
- Aromatic groups in tackifiers build forces to aromatics, filler surfaces and metal elements -> most widely used (C9, Phenolic resins, Xylene, Coumarone/Indene etc.)



Optimum use of Processing Additives

Basic principles dominating the function of Processing Additives

Basic need: Distribution of the additive

A good distribution of an additive can be achieved, if:

- it melts down at temperatures below the processing temperature
- at least one major component of the additive has to soften below the processing temperature (mill: max. 70°C, IM: max. 135°C)

Example:

- Sulfur or metal oxides do not melt during mixing, sulfur and metal oxide pre-dispersions in a low-melting matrix distribute the material excellently during mixing



Optimum use of Processing Additives

Application of Processing Additives

Peptizer / Mastication systems: Reduction of molecular weight of Natural Rubber

Chemical peptizer, eg.: Ultra-Pep 96, Ultra-Pep 148

- Viscosity reduction of NR in peptisation step
- Quick reduction of viscosity and nerve by cleavage of polymer main chain
- Improvement of blending and processing properties of NR by lower viscosity
- Booster component adheres to fillers, therefore incorporation into NR mandatory before filler addition



Optimum use of Processing Additives

Application of Processing Additives

Homogenizer: Increase of Friction, levelling the compatibility of polymers

eg.: Ultra-Blend 4000 (black), Ultra-Blend 6000 (light coloured),
Ultra-Blend 5500 (blend of homogenizer and lubricant)

- Enhanced polymer blending
- Higher mixing efficiency (lower energy consumption at equal homogeneity)
- Lower scrap rates
- Higher storage stability
- Better dimension stability of uncured products



Optimum use of Processing Additives

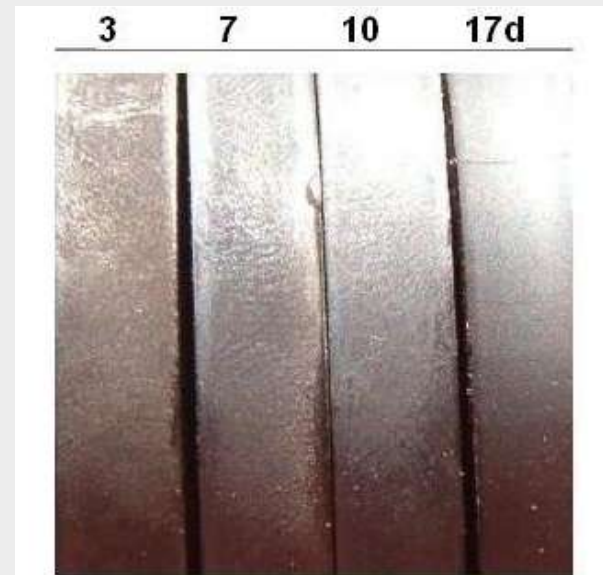
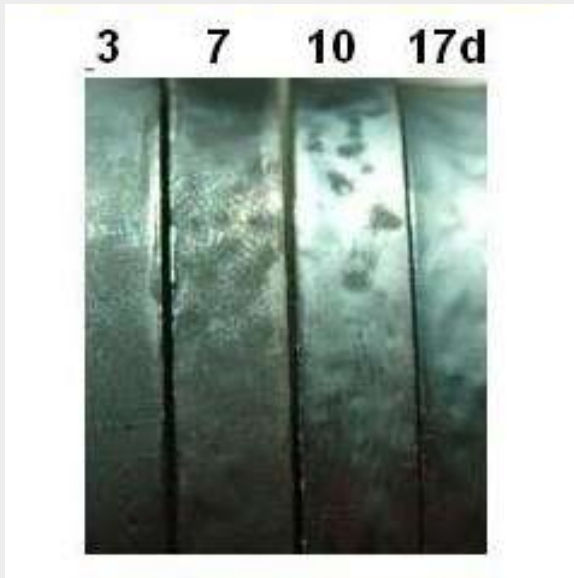
Application of Processing Additives

Homogenizer: Increase of Friction, levelling the compatibility of polymers

example: Ultra-Blend 5500 in NR/BR blend

NR/BR blend without additive:

NR/BR blend with 4 phr UB 5500:



Optimum use of Processing Additives

Application of Processing Additives

Internal Lubricants: Lowering polymer – polymer and polymer – filler interactions

eg.: Ultra-Flow 500, 600 -> NR, CB compounds
Ultra-Flow 440, 700S, 800 -> NR, CB and silica compounds
Ultra-Lube 200, 220 -> general filler dispersants and lubricants
Ultra-Lube 420: EPDM

- Lower compound viscosity
- Better filler incorporation
- Higher mixing efficiency (lower energy consumption at equal filler dispersion)
- Higher extrusion flow rates
- Lower viscosity rise upon storage
- Quicker compound relaxation behind extrusion die, better control over part dimensions



Application of Processing Additives

External Lubricants: Lowering compound – equipment interactions

eg.: Ultra-Lube 160	-> general purpose
Ultra-Lube IMX	-> highly effective, polar polymers (ECO, ACM, AEM, HNBR, NBR, CSM etc.)
Ultra-Lube 220, 420	-> SBR, EPDM
Ultra-Lube 790	-> FPM

- compound viscosity less affected
- Less adhesion to mill, calander or mixer
- Excellent extrusion flow rates
- Excellent mould release
- Reduced mould fouling



Application of Processing Additives

Plasticiser: Lowering polymer – polymer and polymer – filler interactions

eg.:

A) Ultra-Flex 750, 950 -> NBR, HNBR, ECO etc.

- Low temperature flexibility in high Tg polymers
- Low volatility at temperatures of use

B) Ultra-Blend 3000 / DL -> non-migrating plasticiser for NBR

- not oil-extractable
- non-volatile

C) Ultra-Flex AS -> brings antistatic properties

- Ultra-Flex AS: antistatic properties for rollers, flooring, cods etc.



Application of Processing Additives

Tackifier resins: migrating, surface active, increase adhesion forces

- eg.:
- Ultra-Blend 3000 -> Xylene resin blend, Sp.: 20 °C
 - Ultra-Blend 1000 -> Pelletized colophony, Sp.: 80 °C
 - Ultra-Blend 5000 -> Aromatic hydrocarbon resin blend, Sp.: 90-100 °C
 - Ultra-Blend 2000 -> Phenolic resin blend, Sp.: 135°C

- Migration velocity is steered by solubility and molecular weight
- The higher the MW, the slower the migration
- Low Softening point: high short term tack, low long term tack
- High Softening point: low short term tack, high long term tack



Optimum use of Processing Additives

Application of Processing Additives

Pre-Dispersions:

eg.: Ultra-Sulph 950, 1050, 1090, 1200, 1350 -> Sulfur pre-dispersions
Ultra-Mag 9000, 9020 -> Magnesium oxide pre-dispersions
Ultra-Zinc 7000 -> Zinc oxide pre-dispersions

- Low-melting matrix carries the non-melting product into the compound
- Matrix prevents reagglomeration of product
- Pre-dispersions ensure excellent dispersion in critical compounds, eg. soft roller compounds
- The full potential of more active Metal oxides is tapped



Optimum use of Processing Additives

Application of Processing Additives

Point of additive addition:

Mastication step: Conventional chemical peptizer

First masterbatch:

Together with Polymers: Modern peptizer, Homogenizer, Internal lubricants

Together with Fillers: Filler dispersants, Plastiziser

Last mixing step: External lubricants, Tackifier



Optimum use of Processing Additives

Application of Processing Additives

Conclusion:

- Processing Additives are no magic but work based on scientific knowledge
- Processing Additives allow to process critical compounds
- Processing Additives increase process efficiency
- Processing Additives help to manage the counteracting requirements of compound performance and compound processing
- Solve your compound requirements by the choice of rubber, filler, curing system; solve your processing requirements by processing additives !



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