Circular Economy –
keep it smart and close the loops
Talke Schaffrannek, Director Applied Sustainability, BASF
Circular Economy
Decouple growth from resource consumption

CLOSE THE LOOPS ➔ Turn waste into resources, use natural loops
KEEP IT SMART ➔ Increase efficiency of processes and enhance effectiveness of products and solutions
Our Purpose –
We create chemistry for a sustainable future
How can we steer our portfolio towards a more circular economy?

How can we measure progress?
We implement active sustainable portfolio steering

Accelerator: Substantial sustainability contribution in the value chain

Performer: Meets basic sustainability standards on the market

Transitioner: Specific sustainability issue which are being actively addressed

Challenged: Significant sustainability concern identified, action plan in development

We strive to increase the “Accelerators” and phase-out “Challenged” solutions.
With Sustainable Solution Steering, we can measure our contribution to circular economy.

In order to steer the portfolio of the future, we also screen R&D projects for their contribution.

*In our assessment, we focus on “hunger and poverty” – as many of the other UN SDGs are covered by our other sustainability criteria.
60,000 solutions in scope

~13,000 Accelerator solutions with > €15.5 billion sales in 2017

> 2,300 experts involved e.g.
R&D
Product Safety
Sales
Marketing
Sustainability

> 60% of R&D budget spent on Accelerator projects in 2017

> 800 actions defined
How are we “affected” by circular economy and how can we contribute to a more circular economy?
Circular economy transforms value chains
Decoupling growth and resource consumption

External factors driving the shift towards circularity

- **Technology shifts**: e.g. electric vehicles
- **Consumption changes**: e.g. car sharing
- **New regulations**: e.g. EU Circular Economy package, insulation standards

**Linear Model**
- Disposal of molecules at end-of-life

**Increasingly “bent” models**
- Partially renewable feedstock
- Some level of product recycling
- Start of partnering approaches

**Circular Model (total recovery)**
- Full re-use of molecules or carbon
- Design to re-use for end products
Our contribution to Circular Economy

**KEEP IT SMART**
Increase efficiency of processes and enhance effectiveness of products and solutions

**CLOSE THE LOOPS**
Turn waste into resources, use natural loops

Our contribution combines the idea of smart business models with circular resource use
ecovio® fruit & vegetable bags

Example for Loop

Certified home-compostable fruit & vegetable bags

- Dual use: fruit & vegetable bag and organic waste bag
- Less organic waste in landfill
- More compost

ecovio® bags help close the loop of the food value chain.
Green Sense® Concrete Technology
Example for Close the Loops

Green Sense® Concrete system consists of:
1. Innovative admixture products
2. Concrete mix services
3. Eco-efficiency analysis

BASF’s Green Sense®

- Replaces up to 78% of cement with recycled materials
- 45% less CO₂ emissions¹
- BASF material used at: Burj Khalifa, Al Attar Tower, Dubai Arch Tower, Infinity Tower, …

¹ Data based on 1 m³ compared to a reference mix
New business model: Biomass Balance
- allows us to use bio-based raw materials for the same product performance
Conclusion

- Circular Economy: much more than waste management
- With “Sustainable Solution Steering” we measure our contribution to circular economy
- Biomass Balance is a new business model that lowers the use of fossil resources
- It’s all about collaboration!
BASF Plastic Additive solutions as enabler for sustainable applications

Andreas Thürmer, Senior Technical Manager Polymer Additives
Plastic Additives as enabler for sustainable solutions

1  Background
   BASF Additives and Recycling

2  Polymers and Aging Phenomena

3  Additive Solutions
   Additive blends restore Polymer performance

4  Joncryl® Functional Additives
   Repairing and Enhancing PET and Polycondensates

5  Perspectives
BASF Additives and Recycling
Enabling Use and Re-Use

Fundamentally, BASF Plastic Additives provides solutions that enable the use of plastics in demanding applications:

- Plastic processing
- Prolonging the lifetime of plastics
- Functionalizing/Extending the performance of plastics including their coloration

Recycled Plastics will also require BASF Plastic Additives’ core competencies to broaden the use of recycled feedstock and enlarge the number of accessible higher value end applications:

- Repair polymer chain
- Re-coloration
- Markers to help plastics sorting
- Enable processability
BASF Additives and Recycling
Striving for Resource Efficiency

Inverted Pyramid and hierarchy for sustainable resources management

- Additives enable to use less, to use longer and to re-use
  - Prolonging lifetime
  - Enabling several cycles
  - Upgrading properties for up-cycling
Polymers and Aging Phenomena
Polymer Service Life

- Constraints during service life and waste post treatment

**Manufacturing**
- Polymerization
  - (T, Catalysts residues, water)
- Compounding
  - (Melting T, Other components)

**Converting**
- (Processing T)

**Service**
- (exposure to T/Energy, UV, Chemicals, pollutants, mechanical stress, etc)

**Waste to Regeneration**
- Re-processing
  - (T/Energy, Chemicals, water)

**Industrial/Consumer Use**
- Sorting, Cleaning
  - (Water, Chemicals)

Time Scale
- Minutes to Hours
- Weeks to Years
- Weeks to Months

Temperature Exposure
- Medium to High
- Low to medium
- Medium to High
Polymers and Aging Phenomena
Auto-Oxidation and Degradation Chemistry

- Radicals and hydroperoxides formation versus stabilization options

Irganox® Phenolic AOs and Tinuvin®, Chimassorb® hindered amines (HAS) react with free radicals to yield inactive products (ROH – H₂O)

Irgafos® Phosphites react with hydroperoxides to yield inactive products (ROH)

Irganox® Phenolic AOs and Tintuvin®, Chimassorb® hindered amines (HAS) react with free radicals to yield inactive products (ROH – H₂O)

Irgastab® Hydroxylamines or Irganox® E 201 or other radical scavengers capture carbon centered radicals

Degradation issues are complex and solutions are tailor-made
Aging of polymers leads to materials properties collapsing

- Change in Mw distribution
- Change in Mw
- Carbonyl build-up
- Rapid increase in ROOH
- Fast O₂ uptake
- Stabilizer consumption
- Small increase in ROOH
- Slow O₂ uptake

→ Induction Period
→ Degradation

Mechanical Failure
Discoloration or other visual changes

Restoring / enhancing polymer properties needs additives package
Challenges for Recyclates in waste stream

Virgin plastics
- Pure
- Clean
- Full stabilizer package

Recyclates
- Neat recyclates are low-value materials
  - Polymer mixtures
  - Impurities
  - pre-damage from 1st life
  - insufficient stabilizer residue

Monomer Manufacturing
Process Chemicals
- Lubricant Additives
- Polymerization Regulators
- Storage Stabilizers
- Antioxidants
- Processing Stabilizers

Synthesis
Granulation

Masterbatchers Converters
End Products
Polymer Recycling
Key Challenges in Plastic Recycling

- Mixtures of incompatible polymers
- Polymer degraded from previous heat history
- Unstable polymer – consumed stabilizers from previous life cycle
- Contamination with solid particles
- Out gasing and odor issues from volatile impurities

- Additive Blends provides solutions to address these challenges
Value Re-Creation of Plastics with Additive Blends

- Neat recyclates are limited to low-cost applications
- Stabilization packages for recycling allow to:
  - Re-enter the 1st market
  - Increase the content of recyclates in an application
  - Use recyclate for higher-end applications
  - Systems Ready to use or tailor-made

Picture Courtesy of BASF
Standard Blend System for PP Battery Cases

Addition of Recyclostab® 451*:

- Improves the long-term thermal stability of PP recyclates from battery cases.
- Minimizes negative effects of acidic residues

* Tradename of BYK

→ PP from battery cases can be used in high-end applications
Additive Blend Systems with Repair function for PO or TPO

Addition of Recycloblend® 660*:

- Neutralizes negative effects of solid impurities and retains mechanical properties
- Typical applications: bumpers, rotomolding, filled PP systems

* Tradename of BYK

System improves mech. properties of contaminated polyolefins
Mixed Polyolefins Consumer Waste PO Recycling

PolyAd* taylor made formulation improves at the same time:

- Mechanical properties of a PE / PP mixture
- Processability by adjusting the melt flow from a low MFI to high flow injection moldable material

Specific system to make the recyclate fit for the next applications
Taylor Made Systems
PE / PA or PE / PET Multilayer Film Reprocessing

- Incompatible PE / PET film mixture (85%:15%) or PE / PA film mixture (90% / 10%) not reprocessable as such
- Taylormade solution compatibilizes and restabilizes multilayer film scrap

Defective PE / PET and PE / PA Film without PolyAd* solution

PE / PET (1%) and PE / PA (2%) Film using PolyAd* solution

Smart system allows to recycle resins instead of landfilling them
Joncryl® ADR – Functional Additives
The Technology

Reactive modifier to upgrade PET and polycondensates

- Multifunctional reactive polymeric chain extender
- Reactive extrusion to upgrade R-PET
- Suitable for foams, films, sheets, straps and many other applications

→ Chain extenders to restore mechanical properties of Recyclates
Joncryl® ADR – Functional Additives
The Applications

Chain extension and chain branching enable second life for R-PET

- Enable R-PET in higher value applications beyond fibers
- Alternative to solid state polymerization
- Allow reactive compatibilization of alloys and blends
- New material properties based on long chain branching

→ Improve mechanical properties and enable new applications
Joncryl® ADR – Functional Additives

The Mechanism

Reactive Extrusion to restore mechanical properties of polymers

- Aging of polymers leads to materials properties collapsing
- Reactive extrusion with Joncryl® ADR build molecular weight and slight branching
- Different chain extender available optimized for different applications

→ Additive technology to modify and restore polymer properties
Joncryl® ADR – Functional Additives
Sheet and Thermoforming

Chain extension for PET – sheet and thermoforming applications

- Up to 100 % R-PET possible
- Significant improvement of impact properties
- Increased viscosity of polymer melt
- Faster and stable processing

⇒ Improve impact properties and line speed
BASF Additives and Recycling
Perspectives

- Recycled Plastics are now considered as an alternative (in volume also) feedstock for high end applications
- Additives will play a role in upgrading performance of recycled polymers and consequently increase their value
- Many elements still require developments:
  - Materials collection and efficient sorting of different polymers
  - Capacity for collection and transformation
  - Additives to repair and homogenized or enable tuning of recycled grades characteristics
  - Additives for virgin plastics that do not impair later recycling