Partikelschäume auf der Basis von thermoplastischem Polyurethan

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HIGHEST ENERGY RETURN IN THE RUNNING INDUSTRY

ENERGY RETURN MATERIAL TEST

standard EVA

BOOST
temperature resistance like never before

FROM 40°C TO -20°C

BOOST™ cushioning performs more consistently and doesn’t lose its cushioning properties like standard EVA.
Some Records with Boost + Infinergy™

New York City Marathon, Nov 2013

Geoffrey Mutai, Winner

All over 2-3% more energy return with Boost shoes

Berlin Marathon, 2014
Dennis Kimetto set world record,
Geoffrey Mutai second

Berlin Marathon, 2014
Tirfi Tsegaye
annual world record time
What’s Infinergy™?

- 1st particle foam of thermoplastic polyurethane (TPU)
- High elastic particle foam
  - soft
  - completely closed cells
  - integral foam structure
  - low density
  - like foam filled tennis balls
- High rebound
- Low compression set
- Excellent energy return
- Similar properties over wide range of temperature
Structure of Infinergy™

- Chemistry: nm scale
- Foam cell: μm scale
- Particle: mm scale
- Part welding: cm scale
What’s thermoplastic Polyurethane (TPU)?

TPU is a linear block copolymer based on:

1. Diisocyanates: mainly aromatic isocyanates (MDI, TDI), but also aliphatic isocyanates (HDI, H12-MDI) for transparent and light stable systems

2. High molecular weight polyols, functionality 2, Mw 600-3000, like Polyester- or Polyetherdiols

3. Chain extender (low molecular diol), like Butandiol

Segmented block copolymer:
Morphology on molecular level (schematic)

- Segmented **block copolymers** with an alternating sequence of hard and soft segments.
- Incompatibility of the hard and soft segments: **Two phase structure** of an **amorphous soft phase** with low glass temperature and a high melting, **crystalline hard phase**.
- Low temperature **flexibility** is fixed by the soft phase type and the **hardness** is adjusted by the hard phase amount.
Comparison of Hardness
Thermoplastics and Elastomers

Elastomers
- soft PVC
- Silicons
- EPDM

Thermoplastics
- rigid PVC
- PP
- TPEE
- ABS
- PC

Comparison of Hardness
- Shore D: 45, 55, 65, 75, 85
- Shore A: 50, 70, 90, 110, 120, 130, 140, 150
- Rockwell - R: 20, 30, 40, 50, 60, 70, 80, 90, 95
One Shot TPU Reaction

**Elastollan® (TPU)**

No foaming step and random hard segment length!
Infinergy™

Production of TPU Particle Foam

Autoclave Technology

1. Impregnation
2. Expansion
3. Work-Up & Sale

Thermoplastic Polyurethane, Raw Material
Density = 1110 g/l

Extruder Technology

Polymer
Blowing agent

Extruder
Density = 130 g/l

密度 = 1110 g/l

密度 = 100 g/l
DMA of Elastollan 11 Series
Foaming TPU in a Vessel

Area of critical Stiffness for Vessel Foaming
TPU Pellets – foamed E-TPU DMA

TPU – E-TPU Stiffness

TPU compact ~ 1100g/l
E-TPU ~ 150g/l same trend, but 30 x softer
Foamed TPU Particle
Comparison Vessel vs Extruder at Particle Center

*ESRF Synchrotron Data, Voxel Size = 300nm, Cube Size = 300µm*

Achim Besser

1- Vessel center  
2- Extruder center
2-Movie

Note: Thin Walls are not resolved in This Movie
**Infinergy™ - E-TPU Properties**

**Important Properties – Overview**

(*: detected on parts with $\phi = 220$ g/l)

- **Closed cell rate:** > 95 %
- **Cell gas:** air
- **Rebound**: > 60 %
- **Compression set**: < 5 %  
  (ISO 1856, 50 % compression, 22h, 23°C)
- **Compression strength**: > 300 kPa  
  (ISO 844, 50 % compression)
- **Tensile strength**: > 700 Pa  
  (DIN EN ISO 1798)
- **Elongation at break**: > 200 %  
  (DIN EN ISO 1798)

**Material Energy Return**

- Boost
- 74 %
- 85 %
- 78 %

Special EVA

**Image**: Adidas running shoe comparison between 0 Kilometers and 500 Kilometers.
Benchmark again System Foams

Hysteresis Profiles of Selected Materials (Thickness 10 mm)

Damping %

- Boost - 190g/L: 24
- PTHF System 350g/L: 44
- high rebound (PTHF) 380g/L: 33
- ULTRA PU - 300g/L: 48
Extraordinary Properties of Infinergy™
Torsion
Easy molding in a steam chest machine (like EPP)

- Moulded parts or sheet goods possible
- Existing technology - optimized by BASF
- Possible Automation
Processing – Bonding with Adhesives

…without pressure
Technology according to produce rubber crump plates (lab scale)

- One component PU-adhesive (binder)
  Very long tack free time
- Two component PU-adhesive (binder)
  Tack free time adjustable
- Molded part with high porosity
  ➔ permeable to water
  reduced mechanical stability

…under pressure

- One component or two component PU-adhesive (binder)
- Molded parts with closed surface and a low internal voids fraction
  ➔ almost impermeable to water
  improved mechanical properties
Processing - Foaming with PU Foam under Pressure

- Combination of particle foam and system foam
- Molded parts with closed surface
- Closed crotch, better mechanical properties
We create chemistry