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- Global Megatrends and Solutions for Industry & Society
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Bayer: Science For A Better Life

Our mission:

• We help patients around the world by preventing, alleviating and curing diseases as well as improving diagnosis.

• We ensure a sufficient supply of high-quality food, feed and fiber.

• We make significant contributions in the fields of energy and resource efficiency, mobility and home living – to name just a few.
Bayer MaterialScience provides high-tech polymer solutions:

- through its 14,800 employees worldwide
- in polyurethanes, polycarbonate and special applications,
- for customers in a wide range of industries, including: automotive, construction, electrical / electronics, medical, furniture and leisure,
- generating annual sales of € 11.503 billion (2012)
- with an R&D investment of more than € 200 million (2012)
Close to our customers

Strategically positioned world-scale manufacturing facilities, systems houses and innovation centers:

• Approximately 30 production sites around the world provide short delivery times and flexible service

• World-scale production plants meet the needs of our global customers

• More than 30 local systems houses throughout the world

• Global network of competence centers, technical and innovation centers
A permanent eye on the future
A forward-looking strategy

Listening to customers – coupled with strong market intelligence – creates new business opportunities:

• **New Technologies:** We develop technical innovations through close co-operation with our large network of external companies, institutions, colleges, universities and customers

• **Creative Center:** We co-operate with external experts to focus on the needs of the market over the next decade

• **Industry Innovation:** We develop market-driven products and technologies
Investing in the future:
More than € 200 million for R&D
A clear vision

Dr. Hermann Schnell:  
Invented industrial scale polycarbonate in 1953.

While even his colleagues doubted his experiments, Schnell succeeded in synthesizing Makrolon® at the first attempt.
Tough and smart

BMS is one of the world’s leading manufacturers of polycarbonate resins, compounds and sheets:

- Polycarbonate sales in 2012: ca. € 2.9 billion
- Technology leader in polycarbonate manufacturing, application development and injection molding technologies
- World-scale production sites in Germany, Belgium, United States, Thailand and China close to world markets
- A growing global network with focused application portfolio
Market needs in focus

BMS is well positioned in the polycarbonate industry value chain:

• Global network of forward integration for sheets and compounding close to central growth markets

• Technology cells for key industries established that ensure global knowledge transfer into growth markets (e.g. glazing)

• Close network of technical centers and development capabilities with easy access for our customers and joint collaboration projects
Toward zero emissions

EcoCommercial Building

- Rigid polyurethane foam for high- and low-temperature insulation
- **Lightweight, stable and transparent polycarbonate sheets**
- Components for durable, efficient photovoltaics
- Raw materials for low- and zero-VOC paints, coatings and adhesives
- Building a network of specialists
Global Megatrends and Solutions for Industry & Society
The networked computers of 2030 will be at least several million times more powerful than today's machines.

Global megatrends:
The world is changing

- Climate change and global warming
- Energy – shortage of fossil resources
- Growing population / Changing societal demographics
- Accelerating changes in technology / Dynamic market changes
- Globalization / Urbanization
- Healthcare revolution

Melting of the polar ice sheets would cause sea levels to rise by up to 70 m.

In 1960 there were 2 megacities – by 2015 there will be 26.

A baby born in 2030 may live until 2160.

The world's population increases by 1 billion every 14 years.
Megatrend: Climate change

- Extreme weather conditions in western Europe: arctic temperatures in winter, monsoon rains in summer.
- 38% of the Earth's land surface is at risk from desertification.*
- During the last 50 years the number of weather-related disasters has risen from 13 to 74 per year.**

Sources: (*) GTZ; (**) Munich RE

Recently in …?
Our solutions

Sustainability sits at the heart of our strategy:

• Building insulation
• Insulation throughout the cool chain
• Materials for solar modules and wind power plants
• Lightweight materials for automotive and transportation
• Waterborne coatings
• High solid coatings
• Renewable Polycarbonates
Polycarbonates Solution: Automotive Glazing

Weight savings up to 50 % vs. glass
- Lower center of gravity
- Reduction of CO$_2$-emission

Safety & security
- Passenger retention
- Anti “smash-n-grab”

Styling and design
- Design freedom
- Functional integration
Can different kinds of Eco-related requirements be classified into more systematic approach?

Category 1
Limiting the level or control of certain restricted substances

Blue Angel (Germany)
TCO’06 independent swedish company (global)

Eco Flower (EU)
Sony Green Partner
Green Book

REACH
Blends with Post-Consumer PC and PET Feedstock

- For polycarbonate blends an attractive way is the use of post-consumer recyclate as feedstock and offers alternatives to virgin polymers.
- Post consumer polycarbonate recyclate (PCR) from end-of-life water bottles and recycled PET represents the feedstock for sustainable Makrolon, Bayblend and Makroblend grades.
- Recycled PET is available in large quantities and prime quality.
- Price competitive FR recycling blends.
- Optically perfect "Class A" automotive exterior parts from recycled PC & PET.
Post-Consumer PC and PET
The most promising post-consumer materials
## Renewable Polycarbonates

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Makrolon</strong></td>
<td>Post-Consumer Recyclate (PCR) PC Blend</td>
</tr>
<tr>
<td>1837GR</td>
<td>Impact modified, medium viscosity</td>
</tr>
<tr>
<td>6485GR</td>
<td>Unreinforced; <a href="mailto:V-0@1.5mm">V-0@1.5mm</a>, <a href="mailto:5VA@3.0mm">5VA@3.0mm</a>, medium viscosity</td>
</tr>
<tr>
<td>FR3021GR</td>
<td>15% mineral filled; flame retardant, <a href="mailto:V-1@1.2mm">V-1@1.2mm</a>, <a href="mailto:V-0@1.5mm">V-0@1.5mm</a></td>
</tr>
<tr>
<td>FR630GR</td>
<td>Unreinforced; flame-retardant, <a href="mailto:V-0@1.5mm">V-0@1.5mm</a>, <a href="mailto:5VB@1.8mm">5VB@1.8mm</a>,</td>
</tr>
<tr>
<td>FR3050GR</td>
<td>Unreinforced; flame-retardant, <a href="mailto:V-1@1.0mm">V-1@1.0mm</a>, <a href="mailto:V0@1.5mm">V0@1.5mm</a></td>
</tr>
<tr>
<td>FR610GR</td>
<td>Unreinforced; flame-retardant, V-0 @1.5 mm, <a href="mailto:5VA@3.0mm">5VA@3.0mm</a></td>
</tr>
<tr>
<td><strong>Bayblend</strong></td>
<td>Post-Consumer Recyclate (PCR) PET Blend</td>
</tr>
<tr>
<td>EC305 GR</td>
<td>EU Eco flower compliant; ESC resistance and dimensional stability</td>
</tr>
<tr>
<td>EC405 GR</td>
<td>UL94V0 @ 1.5 mm; FR package different with EC305 GR</td>
</tr>
<tr>
<td>GR235 M</td>
<td>Mineral filled type</td>
</tr>
<tr>
<td><strong>Makroblend</strong></td>
<td>PC/PLA Blend</td>
</tr>
<tr>
<td>BC250</td>
<td>impact-modified polycarbonate blend</td>
</tr>
<tr>
<td>BC400</td>
<td>impact-modified polycarbonate blend</td>
</tr>
</tbody>
</table>
Post Consumer Recycle Grades of Makrolon, Bayblend and Makroblend

- Post consumer recyclate from end-of-life PC and PET bottles are viable feed stocks for sustainable Makrolon, Bayblend and Makroblend products

- **Makrolon 1837GR** (Impact modified non-FR PC)
  Impact modified, medium viscosity, mobile phone housing

- **Makrolon 6485GR** (FR PC)
  Flame retardant, UL 94V-0/1.5mm and 5VA/3.0mm, medium viscosity
  UL94 V-0, 5VA/3.0mm, adapter or general FR PC application
Bayblend PC/ABS FR-Grades Based on Post-Consumer Polycarbonates

- **Bayblend FR610 GR**: Post Consumer Recyclate PC. High impact strength and good balance of flow and mechanical performance. flame-retardant, V-0 @1.5 mm, 5VA@3.0mm

- **Bayblend FR630 GR**: post-consumer recycled polycarbonate. General purpose grade with improved heat distortion temperature, optimal balance of mechanical properties and melt flow. Vicat 110°C, UL 94 V0 at 1.5 mm, 5VB at 1.8 mm

- **Bayblend FR3021 GR**: Mineral filled grade with post-consumer recycled polycarbonate. Excellent chemical resistance and FR performance, well balanced stiffness and ductility. Vicat 98°C, UL94 V-0 at 1.5 mm.

- **Bayblend FR3050 GR**: High heat grade with post-consumer recycled polycarbonate. Excellent mechanical properties and FR performance, good balance of flow and chemical resistance. Vicat 135°C, UL94 V-0 at 1.5 mm.
Makroblend PC/PET-Grades Based on Post-Consumer Polycarbonates

- Makroblend EC305 GR: FR PC/PET grade with recycled PET; Chlorine- and bromine free FR-package; EU Eco flower (for TV) compliant; High flow and good ESC-behavior; Excellent quality for high gloss and mat surfaces; V-0 at 1.5mm

- Makroblend EC405 GR: FR PC/PET grade with recycled PET; Chlorine- and bromine free FR-package; FR package different with EC305 GR; V-0 at 1.5mm

- Makroblend GR235 M: Optically perfect Class A automotive exterior parts from recycled PC and PET; Mineral filled PC/PET; Premium-like PC/PET-blend based on post-industrial polycarbonate water bottles and post-consumer PET from bottles; Excellent stiffness and low CLTE
Makroblend® PC/PLA-Grades
Based on Blend Partners from Renewable Sources

- Biopolymers as blending partners for polycarbonate opens up the opportunity to develop sustainable new materials with unique property profiles
- Makroblend BC250 and BC400 contain a bio-based polymer (PLA)
- PLA resin is made from lactic acid by ring opening polycondensation
- Lactic acid is derived by fermentation of sugar or starch (carbohydrates)
- Good availability for L(+) lactic acid based PLA resins
- Both Makroblend grades have an outstanding well balanced profile of physical, thermal and mechanical properties as well as environmental stress-crack resistance
- Lower Total-Energy Consumption / Lower Total Greenhouse-Gas Emissions
Makroblend PC/PLA-Grades Based on blend partners from renewable sources

<table>
<thead>
<tr>
<th>Telephone Cover made of Makroblend BC250</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural color</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Telephone Cover made of Makroblend BC250</th>
</tr>
</thead>
<tbody>
<tr>
<td>White color</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Typical Values</th>
<th>[Unit]</th>
<th>BC250</th>
<th>BC400</th>
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<tbody>
<tr>
<td>PLA content</td>
<td>[%]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MVR 260° C/5 kg</td>
<td>[cm³/10 min]</td>
<td>16</td>
<td>27</td>
</tr>
<tr>
<td>Melt viscosity 260° C; 1000 s⁻¹</td>
<td>[Pas]</td>
<td>270</td>
<td>190</td>
</tr>
<tr>
<td>Tensile modulus</td>
<td>[MPa]</td>
<td>2400</td>
<td>2500</td>
</tr>
<tr>
<td>Izod notched ISO 180/A 23° C</td>
<td>[J/m]</td>
<td>65</td>
<td>60</td>
</tr>
<tr>
<td>Izod notched ISO 180/A -30° C</td>
<td>[J/m]</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>Vicat B/120</td>
<td>[° C]</td>
<td>135</td>
<td>100</td>
</tr>
<tr>
<td>HDT 0.45 MPa</td>
<td>[° C]</td>
<td>132</td>
<td>100</td>
</tr>
<tr>
<td>HDT 1.80 MPa</td>
<td>[° C]</td>
<td>106</td>
<td>60</td>
</tr>
</tbody>
</table>
The 21st Century will be marked by the rapid growth of cities.

By 2030, some 5 billion people will live in urban areas.*

The number of people living in cities in Asia and Africa is currently growing at a rate of 1 million a week.*

By 2030 the total built-up area of cities with more than 100,000 inhabitants will increase by 175 %.*

Source: (*) UNFPA 2007 (United Nations Human Settlements Programme)
Our solutions

Innovative building materials
• Coating materials and PCS sheets
• PC/Blends for light management solutions
• Polyurethane insulation materials
• Composite materials
• Anti-corrosion materials

Materials for greater mobility
• Materials for auto components
• Rail track construction solutions

Improved communications
• Smart films
• Data storage solutions
• IT hardware materials
Polycarbonates Solution:
Polycarbonates Sheet

Multiwall sheets:

• Wide range of thicknesses: 4 – 40mm

• Wide range of profiles ranging from 2 to 9 walls
Compared to standard opal white sheets, Makrolon multi IQ-Relax sheets allow more light into your building, and less heat, the best of both worlds.
Polycarbonates Solution: Polycarbonates Sheet
Polycarbonates Solution: Polycarbonates Sheet
Megatrend: Healthcare revolution

- Increased life expectancy requires continuous innovations in health care.
- 7.2 million people die from heart attacks every year. Many of them could be saved if their condition was carefully monitored.*
- In recent years the number of blood transfusions carried out worldwide has doubled.**
- Artificial blood will help to overcome the supply bottleneck.
- Robots help with 80% of prostate operations in the USA.***

Sources: (*) German Heart Institute Berlin; (**) German Red Cross; (*** University of Munich Hospital
Tomorrow application

From Megatrends to Business

Our Future Artificial Companions

Build Mobility upon Solidity, Material Matters

While the world is still struggling to advance the EV industry by building a wide-ranging, convenient, and affordable EV infrastructure, Bayer MaterialScience has found solutions for all the challenges mentioned.
Polycarbonates Solution

Material for Robot
Material For Robot

Robots:

Our Future Artificial Companions

The world is experiencing an escalation of aging populations and, according to a report by DESA, U.N., by 2050, the proportion of elderly people will be equal to that of young people for the first time in history. The elderly in countries like China, which practices a one-child policy, have traditionally been relying on their children to care for them in old age. Yet, this put great pressure on the younger generation which has to balance the need to earn sufficient household incomes with their parents’ need for care. Robots as artificial companions can be one of the solutions in the future, which may help society provide care and assistance to the aging population. Bayer MaterialScience is dedicated to bringing polycarbonate products and solutions to a variety of applications, driven by the global megatrends. Finding applications in a wide range of industries, Makrolon® and Bayblend® polycarbonate products are amorphous thermoplastic materials noted for their outstanding impact strength, superior dimensional stability, glass-like transparency, excellent thermal resistance, and low-temperature toughness, which makes it the optimal material for use in the outer shell of a robot. NAO®, a programmable, 57 cm tall humanoid robot shown at Ceatec 2012, is a breakthrough in robotics, responding to a modern population’s diversified needs and tailored to assist in the daily demands, such as artificial assistance in caring for the elderly. One of the major factors that make NAO® different is its outer shell which utilizes Makrolon® and Bayblend® polycarbonate from Bayer MaterialScience that display very high impact resistance, as well as flame retardant. More importantly, NAO’s outer shell can even withstand an extreme temperature range from -40°C to +120 °C, while also exhibiting good weathering resistance, good thermal stability and easy processing.

Polycarbonates can also respond to different individual needs in terms of their moldability and scalability, permitting design freedom for NAO®’s appearance and offer a wide selection of colors for personalized aesthetics. Additionally, while accompanying elderly people outside for walks and various activities, NAO® retains complete functionality regardless of weather or natural forces, making it excellent for outdoor performance. Moreover, the non-conductive material protects the outer shell against electricity, ensuring the safety of NAO®, particularly e.g., when it assists by switching on the domestic circuit breaker from the off position for an urgent cut-off. This provides great help to the elderly who are disabled or have difficulty in moving at home.

Bayer is dedicated to providing polycarbonate solutions for the outer shell of robots which have also attracted the interest of other robot manufacturers who consider Makrolon® and Bayblend® polycarbonates to be the preferred material for the outer shell of their robots. Myon® is another humanoid robot encapsulated by Bayer MaterialScience whose polycarbonates which provide an aesthetic appearance while protecting its internal electronic systems. HAL®, another well-known, battery-driven robot commonly found performing various chores, has also adopted Bayer MaterialScience’s polycarbonates as its exoskeleton which weighs as little as ten kilograms. HAL® provides health services for physically handicapped and frail people across Japan, assisting in their mobility needs. Bayer MaterialScience has reinforced its thought leadership through partnering with companies in their most cutting-edge technological needs for innovative and advanced polycarbonate solutions and products.

As a leading global high performance materials manufacturer, Bayer MaterialScience will continue to follow the global megatrends, and showcase its innovative and sustainable products and applications in order to improve people’s lives. Through collaborations with robot companies to fulfill the emerging needs of aging societies, Bayer materialScience wants to demonstrate its commitment to bringing the world “Science For A Better Life.”
VIDEO ROBOT
Polycarbonates Solution

Electrical Vehicle Charger
The number of cars worldwide will rise from 600 million today to 2.7 billion in 2050

Source: WIFO
Industry and society require

- Fuel-efficient automobiles
- Emission reductions
- Lightweight and durable materials
- Short design cycles
- Recyclable materials
Material For EV Charger

**Transparent cover: 透明盖 Makrolon 6557**
- Unbreakable even at very low temperature, -40 °C, tamper and vandalism proof
- Flame retardant UL V-0 and sVAA Rating, compliance to RoHS, REACH.
- Excellent outdoor performance in any weather condition
- Design freedom

**Upper body 主体上部 Makrolon 6687/ 9447**
- Unbreakable even at very low temperature, -40°C, tamper and vandalism proof
- Flame retardant UL V-0 and sVAA Rating, providing security against high currents, compliance to RoHS, REACH.
- Lightweight compared to metal and metal relatively lightweight
- Excellent outdoor performance in any weather condition
- Chemical resistance
- Design freedom

**Lower body 主体下部 Bayblend FR3010 BBS910**
- Unbreakable even at very low temperature, -40°C, tamper and vandalism proof
- Flame retardant UL V-0 and sVAA Rating, providing security against high currents, compliance to RoHS, REACH.
- Lightweight compared to metal and metal relatively lightweight
- Excellent outdoor performance in any weather condition
- Chemical resistance
- Design freedom

While the world is still struggling to advance the EV industry by building a more convenient, and affordable EV infrastructure, Bayer MaterialScience has found all the challenges mentioned.

With the contribution from Bayer MaterialScience, Bayer MaterialScience is perfectly positioned to meet the challenges offered by charging points and provide a wide range of benefits.
Our solutions

- Environmentally friendly materials for durable coatings
- Materials for metal-free dashboards
- Energy absorbing materials for bumpers
- Polyurethane foam for car seats
- Lightweight materials to replace e.g. glass in windows, panorama roofs, headlamp lenses and bezels
- Technologies enabling easy and cost-efficient integration of functionalities in body and glazing parts

Customers in the automotive industry account for 20% of the total sales of Bayer MaterialScience (2010).
Polycarbonates Solution

Auto Glazing
Polycarbonates Solution: Automotive Glazing

Weight savings up to 50% vs. glass
- Lower center of gravity
- Reduction of CO₂-emission

Safety & security
- Passenger retention
- Anti “smash-n-grab”

Styling and design
- Design freedom
- Functional integration
Advantages of polycarbonate automotive glazing

Weight saving potential

Comparison of density:
- Polycarbonate: $1.2 \text{ g/cm}^3$
- Glass: $2.5 \text{ g/cm}^3$

- Theoretical savings: ~ 50 %
- Achievable in reality: 30 – 50 %

Realized weight savings:
Smart Fortwo fixed panoramic roof
- Laminated glass: 13,1 kg
- Polycarbonate: 7,6 kg

- Weight savings: 5,5 kg
Resource efficiency

Life cycle analysis on automotive glazing
polycarbonate vs glass

Use - 150,000 km

production

→ 1 kg PC saves ~ 14 – 22 kg CO₂-emission along total life cycle, compared to glass.

Source: GUA GmbH, Corporation for Comprehensive Analyses, study commissioned by Bayer MaterialScience
Advantages of polycarbonate automotive glazing

Safety

Dart impact test

- room temperature
- Ø 20 mm dart, 13 kg
- velocity at impact: 5 m/s

Coated Polycarbonate  Laminated glass  PMMA
Polycarbonate glazing today
Polycarbonate fixed vertical windows

- **Main driver styling**
  - functional integration
  - weight savings (thermoformed windows for sports cars)


- Smart fortwo
- Smart Roadster Coupé
- Honda Civic
- Lamborghini Gallardo Superleggera
- Audi R8 GT
- Mercedes C-class Coupé
- Smart forfour
- Seat Leon
- Porsche GT3RS
- Citroen DS5
VIDEO AUTO GLAZING
Buildings are responsible for more than 40% of global energy use

Source: WIFO
Industry and society require

- Low-emission buildings
- Energy-efficient architecture
- Sustainable solutions
- Modular systems

Photo: Hearst Tower, New York (Green Building)
Our solutions

- Rigid polyurethane foam for high- and low-temperature insulation
- Lightweight, stable and transparent polycarbonate sheets
- Components for durable, efficient photovoltaics
- Flame retardant polycarbonate blends for smart energy metering and cabling
- Materials for low- and zero-VOC paints, coatings and adhesives
- Polycarbonate for energy-saving LED and other interior lighting solutions
- A concept for zero-emission buildings

Customers in the construction industry account for 19 % of the total sales of Bayer MaterialScience (2010).
Our solutions

Film technology based on polyurethane and polycarbonate technology, for innovation products, such as diffuser sheet from **diffuser material** to ensure uniform light distribution in LCD flat screens.
Polycarbonates Solution
GREEN LIGHT

About 20% of global electricity is used for lighting. If all lighting was converted to LEDs, about 1/4 of this energy consumption could be conserved. Over a year this is the equivalent of ...

- 2 billion barrels of oil
- More than 3 in electricity costs
- The output of more than 4 power plants
- More than 5 million tons of CO2 emissions

According to Philips Lightings, Source: International Energy Agency (IEA) and World Resource Institute (WRI)
Basics of a LED Luminaire
Several modules have to fit together to make the system work efficiently.

Philips LED System

Makrolon LED2245 & LED2643

Makrolon® TC8030
VIDEO LED LENSE

LENSES MADE OF MAKROOLON®
LED Lighting Applications
Facade Illumination

Before

After

• LED optics molded from Makrolon LED2643
LED Lighting Applications

Audi A8 Headlamp and Light Guides

Makrolon® LED2245 natural
Advanced LIGHT DIFFUSION technology from Bayer MaterialScience

Light diffusion technology developed by Bayer MaterialScience LLC can be used to disguise lighting hot spots — hiding an LED (light emitting diode) light source, yet allowing higher levels of light transmission with little reflectance.

The breakthrough achieved by the Bayer MaterialScience Color Competence and Design Center in Newark, Ohio, creates the effect of softened LED light with minimal reflection. Until now, light from translucent white colors could be diffused, but never at this light transmission level or with as little reflectance. Using this technology, designers have nearly limitless freedom for their light diffuser packages, with the bonus of a broad palette of colors to customize the application.
Light Diffusion Application

Light Diffusion products are appropriate for applications like backlighting to convert zero or one dimension light source into any two dimension shape e.g. for LCD displays, auto interior decoration, in-house lighting where soft light is more comfortable by reducing direct glare (see photos)
Polycarbonates Solution: Advantage of LED

- Low CO2
- Mercury free
- No UV
- Low IR
- Energy Saving
- Long life

LED 5W
- Electricity cost for 100 lamps for 1 year
- 10 Hours a day usage
- Electricity cost at $1/KWH.

Flourescent 40W

Electricity Cost

$1825
$1460

Polycarbonates Solution:
Polycarbonates Solution: Advantage of LED

- 100 Lamp CO2 emission per year
- 10 Hours per day usage.
- 0.39kg CO2/kWH
Bayer – An inventor company and a global enterprise
Forward-Looking Statements

This presentation may contain forward-looking statements based on current assumptions and forecasts made by Bayer Group or subgroup management.

Various known and unknown risks, uncertainties and other factors could lead to material differences between the actual future results, financial situation, development or performance of the company and the estimates given here. These factors include those discussed in Bayer’s public reports which are available on the Bayer website at www.bayer.com.

The company assumes no liability whatsoever to update these forward-looking statements or to conform them to future events or developments.
Thank you!