News Release

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Nanotechnology:
Small dimensions – great opportunities

- **Around €8 billion sales in 2013 with products on the market for less than five years**
- **Research in North America and Asia expanded**
- **Nanotechnology as innovation driver in numerous applications**

Speech by Dr. Andreas Kreimeyer,
Member of the Board of Executive Directors and
Research Executive Director, BASF SE, Ludwigshafen

The spoken word applies.

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BASF developed a Concept Bike following the principle “Rethinking Materials”. This futuristic e-bike contains 24 of the company’s innovative engineering materials and demonstrates how BASF delivers fresh impetus to inventions of the past – optimized with today’s modern know-how.

This also applies to nanotechnology. Nature has been utilizing the features and effects of nanostructures since the first living material appeared. One well-known example is the water-repellent effect of the lotus blossom. Some years ago science began to recognize the potential of the nanoscale. BASF combines these insights with modern technology to promote innovations in almost all areas.

BASF’s Concept Bike illustrates that innovations in the chemical industry are no longer achieved merely by developing additional chemicals, but increasingly also by using tailor-made materials with exceptional properties and system solutions. These types of innovations require interdisciplinary approaches and cross-sectional technologies like nanotechnology.

Today’s BASF Research Press Conference is being held under the motto “Nanotechnology: Small dimensions – great opportunities.” The topics BASF is working on to develop sustainable solutions for the future through nanotechnology are presented. How BASF accompanies the development of products with safety research and communication is also shown.

The topic of nanotechnology is as much of interest to politics as it is to science, business and the public. The guest speaker at today’s Research Press Conference is an expert on the application of nanotechnology in material science, Prof. Dr. Stephan Förster, who received the ERC Advanced Grant from the European Research Council for his outstanding, pioneering research on nanoparticles. The ERC Advanced Grant is the highest science distinction awarded by the EU.

Stephan Förster is professor for physical chemistry at the University of Bayreuth, editorial board member of different trade journals and consultant of notable research institutes like the German Research Foundation, the National Science Foundation and the Helmholtz Association.

In the afternoon, insights will be given into safety research at BASF, exemplifying how BASF promotes an open dialogue on nanotechnology. BASF’s experts will then present several research projects powered by nanotechnology. A new insulation material and an encapsulation technique for the targeted release of active substances will be presented.

Insights will also be given into the graphene activities of BASF for which *the* expert in material synthesis has agreed to give a presentation: Professor Dr. Klaus Müllen is Director at the Max Planck Institute of Polymer Research in Mainz and President of the German Association for the Advancement of Science and Medicine (GDNÄ). He has published around 1,500 specialized articles and has received numerous distinctions for his wide range of research activities, including an “Advanced ERC Grant” in 2010 for his work on nanographenes, and this year the Carl Friedrich Gauß Prize for outstanding scientific achievements. He also heads the Carbon Materials Innovation Center (CMIC), in which application-oriented research on carbon-based materials is conducted. One central topic is graphene. Finally, an insight will be given into color filters for LCD displays.

1. Overview (Slide 3)

Highlights of BASF Research and Development in 2013:

1. BASF has invested about €1.8 billion in research and development.
2. In 2013, the company launched more than 300 new products on the market. Sales of products which have been on the market for less than five years amounted to about €8 billion. From today’s perspective, BASF is on track to achieve its target for sales of new products and technologies within the “We create chemistry” strategy.
3. BASF again takes top place in the Patent Asset Index of the global chemical industry.
4. The company has received numerous distinctions for its innovations.
5. BASF came another step closer to its R&D globalization target 2020 of conducting 50% of its research and development in North America and Asia. Laboratories and research facilities in Asia and North America were expanded or inaugurated.
6. The company has reached important milestones in the growth and technology fields with which BASF is tackling many new research topics and wants to access future business fields.

2. Research expenditures 2013 (Slide 4)

In absolute terms, BASF leads the field in the chemical industry (excluding pharmaceuticals) with its R&D expenditures – no competitor spends more on research and development.

In 2013, the company increased its research budget to about €1.8 billion (from €1.7 billion) – a new record level. Of this, 21% was spent on corporate research, in

other words multi-focus, long-term oriented topics aiming at new areas of activity. For 2014, BASF is planning a similar increase in its research and development expenditures as in the previous year.

In the four research platforms and the corporate divisions, around 10,650 highly committed employees (150 more than in 2012) are working in international and interdisciplinary teams on around 3,000 projects to find answers to the challenges of the future and secure sustainable profitable growth for BASF.

The decisive element of BASF's knowledge Verbund are the interdisciplinary and international cooperations: BASF collaborates in a global network with more than 600 top-ranked universities, research institutes and companies in a wide range of disciplines and numerous individual projects to achieve its highly ambitious, innovation-driven growth targets.

What counts is naturally not only the input, but above all the output. In past years, the company has established a series of tools and systems to increase and measure the performance of the innovation process. Strategic and operative controlling, including an entire range of performance parameters, also belong to innovation management and support efficient and effective research.

3. Sales with new products (Slide 5)

The output of BASF research and thus its innovative strength are apparent firstly from its sales of new products launched on the market within the last five years: In 2013, sales reached about €8 billion. In 2013, the company launched more than 300 new products on the market. Including new formulations and optimized products, the figure even amounts to several thousands.

Slide 6 shows ten examples of the latest innovations from many different areas: marketable, affordable solutions attuned to today's and tomorrow's needs of customers and simultaneously an example of intelligent chemistry and sustainability:

- CathoGuard® 800 – the new eco-friendly and cost-effective cathodic electrocoat providing effective corrosion protection in automotive coating.
- Ultrasim®/Ultracom™ – an innovative simulation technique for lightweight components. It not only supports the product design but also enables the prediction of the material behavior of plastics under static and dynamic conditions.

- The new four-way conversion catalyst for gasoline engines – the innovative technology removes particulate matter as well as carbon monoxide, hydrocarbons and nitrogen oxides from gasoline-engine exhaust.
- Zetag® Ultra – the new cationic powder flocculant range for water treatment.
- Slentite™ – a high-performance insulation panel for more efficient climate management.
- Luviset® One – the all-in-one solution for hair styling gels, creams and waxes.
- Lumina® Royal – a pigment family enabling automotive coatings with special effects.
- Ecovio® coffee capsules – the compostable plastic ecovio is used for the series production of plastic capsules with aroma-tight barrier packaging.
- Genuity® DroughtGuard® – the groundbreaking plant biotechnology solution for drought tolerant corn developed in collaboration with Monsanto.
- Biobased succinic acid – the fermentative production of succinic acid in commercial quantities for the world market has been achieved.

4. Patent portfolio (Slide 6)

Another parameter used by BASF to measure its research output is the patent portfolio. In 2013, the company filed 1,300 patents. The patent portfolio now holds about 151,000 registrations and intellectual property rights worldwide. Again BASF is clearly at the top of the Patent Asset Index this year – for the fifth year in succession.

The Patent Asset Index was developed at the WHU – Otto Beisheim School of Management and is published every year for the chemical industry. Based on the patent portfolio, this index compares the competitive impact of patents and the innovative strength of companies, and compares these data globally in more detail and more precisely than previously and makes them transparent.

5. Innovation awards (Slide 7)

The success of innovation management at BASF is also apparent from the awards received by the company from industry and government organizations in 2013.

Three of them are:

- The innovative center console made of Neopolen® used in vehicles of the BMW Group was distinguished with the SPE European Division Automotive Award. This is the best known award granted by the automotive industry for innovative, creative performance in the plastics industry.

- The hardening accelerator Master X-Seed was honored by the Ulm trade fair with the innovation award in the category concrete technology. The product improves concrete quality and reduces carbon emissions during concrete hardening because no heat has to be supplied. This functionality, by the way, is made possible by nanotechnology.
- BASF received the Animal Protection Research Prize from the Federal Ministry of Food, Agriculture and Consumer Protection for developing alternative methods to animal testing.

BASF's purpose is: "We create chemistry for a sustainable future". The examples mentioned show that long-term commitment to innovation, research and development is recognized and valued in this respect.

6. Globalization of R&D activities (Slide 9)

In future, BASF is expecting strong impulses and contributions for its innovation pipeline from the regions: In 2020, the company therefore plans to conduct 50% of its research activities outside Europe, to gain greater access to customers, talents and innovation centers in the various regions.

In 2013 important milestones of the globalization strategy were again achieved. Since the last Research Press Conference, BASF has increased the proportion of research and development conducted outside Europe (from 27% in 2012) to currently 28%. At first, this figure would seem to indicate only minor progress. But more important than a rapid boost in workforce numbers is establishing the necessary platforms in the right locations, thereby strengthening the competence network. In 2013, the company opened six new laboratories in highly innovative locations in Asia and the United States and extended existing, strategically important research facilities.

Highlights in North America:

- At Research Triangle Park near Raleigh in North Carolina, research in the field of Agricultural Solutions has been greatly strengthened. The expanded facilities comprise a climate-controlled greenhouse and laboratories for research into plant biotechnology and insecticides.
- On the west coast of America, the "California Research Alliance by BASF" (CARA) has been established with the highly innovative universities – the University of California, Berkeley, Stanford University and University of California, Los Angeles. At this multidisciplinary postdoc center, BASF is pursuing joint research in the fields

of biosciences and new inorganic materials for the areas energy, electronics and renewable resources. The company is thereby continuing along the successful path it started on the east coast in the research cooperation NORA (with Harvard University, MIT and the University of Massachusetts Amherst).

Highlights in Asia:

- In Mumbai, BASF has created a new research platform in which organic syntheses and optimized lead structures for plant protection are being developed together with numerous highly qualified scientists from the region.
- Together with top-ranking universities, the research initiative “Network for Advanced Materials Open Research” (NAO) was established. Seven universities in China, Japan and Korea are involved in this project, cooperatively researching into new materials for a wide range of applications, including products for the automotive, construction and water industries and for the wind energy sector.

With these activities, BASF is contributing to implementing the “We create chemistry” strategy:

- The company is further expanding its local presence in the regions and can rapidly develop targeted solutions for the local markets.
- The postdoc centers enhance awareness of BASF, providing the company with early and better access to talents in the region. This helps to further expand research activities outside Europe.
- The academic partnership program “UNIQUE” was also developed last year to promote long-term and successful research cooperations with the top universities in a climate of mutual trust.
- In the UNIQUE program, BASF is currently collaborating with 13 universities worldwide. The UNIQUE team of selected BASF researchers is intended to create an even closer association between the universities and BASF’s global research units at the partner institutions.

7. Growth and technology fields (Slide 11)

Growth and technology fields are a further important element of the “We create chemistry” strategy. With them, BASF is addressing long-term topics. Resulting from global needs in the fields of resources, environment and climate, food and nutrition as well as quality of life driven mainly by the growing world population, primarily seven customer industries are addressed which promise major innovation and growth

potential: transport, construction, consumer goods, health and nutrition, agriculture, energy and resources, electronics.

From these, ten new growth fields for BASF have been identified. The following applies for all growth fields:

- They need chemistry as an enabler: Products and know-how of the chemical industry are the key to success.
- They show a business potential relevant for BASF.
- They have high barriers to entry: Tapping into this potential calls for intensive financial and human resource commitment.

A review of the growth fields with regard to technological feasibility and whether they remain relevant to the markets as well as the identification of new growth fields is of course a continual process. This means that over time several growth fields that do not fulfill expectations are not continued as growth fields. However, new ones are added instead.

Important milestones were reached in 2013 and the first quarter of 2014:

- **Batteries for mobility:** BASF wants to position itself as a leading supplier of battery materials and components and offers innovative solutions for the mobility of the future. In 2013, nickel-cobalt-manganese oxides with an improved safety profile were developed, lithium iron phosphate (LFP) from a novel production process, and new additives from electrolyte research were successfully launched on the market, and a research laboratory and center for application technology for battery materials was constructed in Amagasaki, Japan.
- **Enzymes:** BASF wants to position itself as an enzyme supplier in strategically important markets (animal nutrition, detergents and cleaners, food and baking industry) and tap into new markets, such as water treatment and oilfield chemicals. In 2013, the company strengthened its enzyme platform by acquiring the U.S. start-up Verenium and the detergent enzyme technology of Henkel.
- **E-power management:** In this growth field BASF is developing innovative solutions to increase the energy and carbon efficiency in the electric power value chain. This includes superconductors, magnetocaloric materials, photovoltaic elements and stationary energy stores. In 2013, the technology company Deutsche Nanoschicht GmbH was acquired, which has developed an innovative nanotechnology coating method to speed up the market launch of superconductors.

- **Thermal management for building applications:** BASF wants to position itself as a leading supplier of innovative thermal insulation materials and is developing, among other things, inorganic and organic high performance foams and solutions for the management of light and heat radiation. In 2013, mineral, non-flammable foams were added to the portfolio.
- **Lightweight materials:** In this growth field BASF wants to position itself as one of the leading suppliers of composite material systems and utilizes synergies between different material systems. In March this year, the prototype of a B-pillar reinforcement, manufactured completely from a fiber composite material, was presented together with Volkswagen at JEC Europe, the world's largest composites show. The prototype is 36% lighter than the steel version from the current series production.
- **Organic electronics:** BASF wants to position itself as a supplier of material solutions for next generation displays and illuminants. In 2013, the cooperation with Sungkyunkwan University in South Korea was expanded, and a new R&D center for electronic materials was established here. The inauguration is scheduled for 2014.
- **Plant biotechnology:** BASF is positioning itself as "The Trait Technology Partner" in cooperation with market leaders to improve the yield and quality of major crops like corn, soybeans and rice. In 2013, together with Monsanto, the world's first drought tolerant corn Genuity® DroughtGard® was launched on the American agricultural market.
- **Functional Crop Care:** BASF wants to establish itself as a provider of integrated solutions for farmers and offers sustainable solutions for soil management and seed treatment. In 2013, the company completed the integration of Becker Underwood and is now intensively researching into solutions to improve the water and nutrient management of plants in the soil, and aims to market the first products in a few years.
- **Water treatment:** In this growth field, BASF wants to establish itself as one of the world's leading suppliers of innovative chemical solutions in the water industry. In 2013, with Zetag® ULTRA a new range of cationic flocculants was introduced worldwide. These provide improved solid-liquid separation in industrial and municipal waste water treatment.
- **Wind energy:** BASF wants to further expand its position in the wind energy industry and is developing intelligent, customer-specific solutions that make the construction and operation of wind generators more efficient. In 2013, a facility was constructed

to independently manufacture component prototypes for wind turbine installations using new materials and tests were established to evaluate the mechanical properties of the prototypes.

As already described, the advances in the growth fields are closely linked to cross-sectional technologies, known as technology fields.

Technology fields raise potentials for the growth fields (Slide 12)

In its “We create chemistry” strategy, BASF is concentrating on three technology fields:

- Raw material change,
- White biotechnology and
- Materials, systems and nanotechnology.

In the technology field **“Raw material change”**, the company is searching for alternatives and supplements to crude oil as a raw material for the chemical industry. With natural gas, carbon dioxide and renewable resources, BASF is seeking to broaden the raw material base of its value chains in the long term. For example, research is ongoing into processes for the production of olefins and aromatics – which are at the beginning of the value chains – from the low-priced raw material methane as an alternative to crude oil.

In the technology field **“White biotechnology”** BASF is developing methods and processes for the efficient and resource-saving production of chemical and biochemical products by utilizing the forces of nature for intelligent chemistry. This year an important milestone was achieved in the manufacture of bio-based succinic acid: Succinity GmbH, a joint venture between Corbion Purac and BASF, has commissioned its first production plant. The facility has an annual capacity of 10,000 metric tons and produces bio-based succinic acid on the commercial scale for the world market.

The challenges of the future call for intelligent solutions based on new systems and functional materials, which means that formulation and application expertise are increasingly gaining significance. BASF has concentrated this expertise in the third technology field **“Materials, systems and nanotechnology”**.

In this technology field, for example, new and more resistant membrane materials for water treatment, biodegradable and bio-based polymers for the packaging industry and

innovative processes with new reactor concepts are being developed to competitively produce functional special polymers.

One innovation example from this technology field: Last year, BASF researchers developed a high-performance insulation panel based on polyurethane that requires only half as much space to do the same job as conventional materials. Thanks to its tiny, only 50 to 100 nanometer sized pores, Slentite™ provides especially efficient insulation.

Many of the innovations described are only possible on the basis of nanotechnology.

8. Nanotechnology enables a sustainable future (Slide 13)

Nanotechnology is concerned with the development, manufacture and applications of nanoscale materials and structures, i.e. with dimensions of one millionth of a millimeter, the nanometer. Although the dimensions are no longer visible to the unaided eye, the potential offered by nanotechnology is immense. It can be used to manufacture products and materials with new, unusual properties which could not previously be obtained. Many innovations in areas such as climate protection, automotive technology, energy, electronics, construction or medicine are not achievable without nanotechnology. Without this technology, it will not be possible to develop the next – much higher-performing – generation of photovoltaic elements, OLEDs, lithium-ion batteries or membranes for fuel cells. In medicine, it enables applications such as new surface structures for medical technology, or nanoparticles for cancer therapy. Nanotechnology will also make a major contribution to resource efficiency because the central concept of nanotechnology is to achieve more effect with less material.

The focal point of BASF's research interest is the user, the person: consumers expect researchers and industry to provide reliable, affordable solutions that maintain and even improve the living standard of the growing world population with limited resources, while simultaneously conserving the environment and climate and being safe to use. These challenges cannot be mastered using yesterday's approaches.

The following aspects will be presented and discussed at today's Research Press Conference:

- How to constructively manage the inherent, ancient field of unresolved tension between the opportunities and risks of a new technology,
- How potential risks are to be assessed, and

- How the potentials of nanotechnology can be utilized safely and in a manner viable for the future.

8.1 BASF is convinced of the potential of nanotechnology (Slide 14)

As cross-sectional technology extending across all industries, nanotechnology makes an important contribution within the “We create chemistry” strategy. BASF’s Know-How Verbund has all the competences needed to develop nanotechnology responsibly. The technology platforms operate cross-sectorally and globally with outstanding partners from science and industry. Examples of successful cooperative initiatives for nanotechnology are the postdoc centers NORA, JONAS or NAO already mentioned. Partners in industry also play an important role in integrating the “nano” solutions into systems. In this unique Know-How Verbund, BASF is researching into formulations, layers, materials and their characterization.

The fields of application of the examples of nanotechnology-based developments from the current research pipeline and for products with new or markedly improved properties on the market extend from

- new highly photostable dyes of high brilliance, through
- the additive X-Seed® for accelerated concrete hardening for the construction industry and
- the polishing paste Planapur for the manufacture of microchips
- to products that help supply people with clean water, satisfy the growing energy demand and sustainably establish individual mobility.

Innovative solutions from chemistry are delivered less and less by new molecules and increasingly by chemical effects, systems, components and functional materials. This requires technologies that transcend existing concepts and enable completely new approaches. Nanotechnology with its diversity of effects and applications has exactly this potential.

However, technological progress alone is often not enough. It must be accompanied by the responsible handling of potential risks as well as institutional and social change. Only when safe use is combined with appropriate regulatory interventions and public acceptance is successful marketing possible.