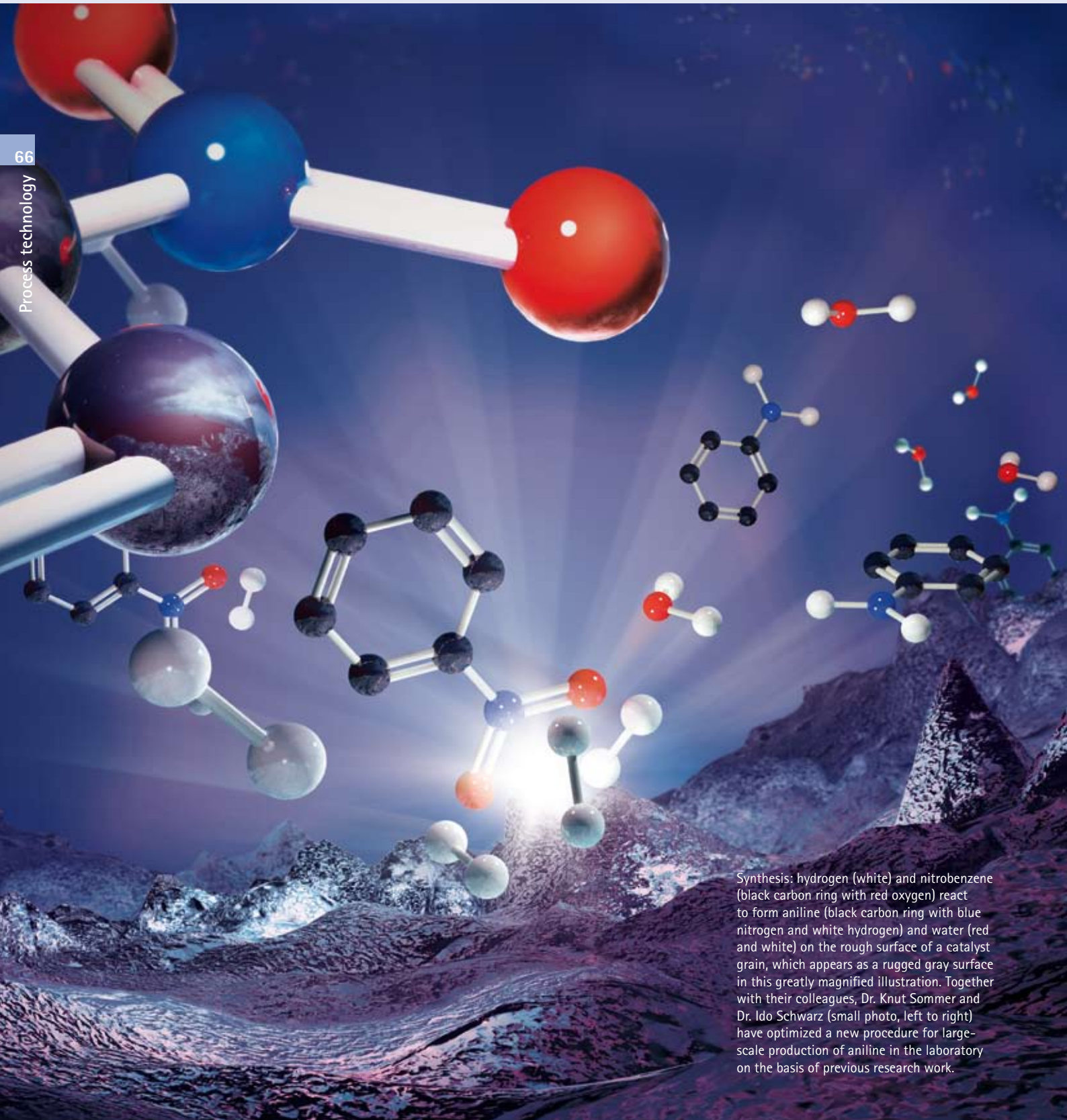
New process optimizes aniline production

# Away from the **tube**



Synthesis: hydrogen (white) and nitrobenzene (black carbon ring with red oxygen) react to form aniline (black carbon ring with blue nitrogen and white hydrogen) and water (red and white) on the rough surface of a catalyst grain, which appears as a rugged gray surface in this greatly magnified illustration. Together with their colleagues, Dr. Knut Sommer and Dr. Ido Schwarz (small photo, left to right) have optimized a new procedure for large-scale production of aniline in the laboratory on the basis of previous research work.

*Polyurethane has a particularly wide range of applications, ranging from heat insulation to car bumpers. A new process has now been developed to improve the production of one of polyurethane's most important raw materials – aniline. Instead of being carried out in a giant bundle of tubes, synthesis is now simply performed on a grate. The new technology not only results in higher purity levels, it can also be readily upgraded from laboratory to industrial scale.*

The plant in building R79 at Bayer MaterialScience in Uerdingen is fondly known as Mini 9. But although it may sound tiny, it is just about the biggest thing that can be built in a laboratory. This set of steel reactors has been designed to pilot a new process for the manufacture of aniline, and is actually the forerunner for a giant plant that is currently being installed at Bayer's site in Shanghai.

Aniline is an important raw material for the production of a certain class of polyurethanes – those plastics that are used in the form of foam, for example, for heat insulation in refrigerators and houses, and as bumpers in the car industry. Through chemical conversion, isocyanate methylenediphenyldiisocyanate (MDI) is produced from aniline in a multi-step process. When the MDI is mixed with polyols – compounds with alcohol end-groups – polyurethane foam is formed which cures after a brief period. Experts are working on the assumption that the demand for MDI – particularly through the economic growth in Asia – will rise continuously in the coming years. The decision was therefore taken to build a world-scale plant at the Shanghai site. Bayer has been producing aniline for decades for captive use, but the old technology would have been too expensive for the giant new plant: the classic isothermal process in which the temperature is kept constant and the substantial reaction heat is removed with a heat transfer oil, is no longer efficient enough. In addition, the aniline subsequently has to undergo a rather complex process to strip it of various by-products. This would have increased the price of the raw material to an excessive level, so a new. alternative process had to be found instead.

Plans for an alternative were already lying in a drawer when Dr. Ido Schwarz took up the adventurous challenge in 2003 to build a new laboratory facility in record time that could be readily upgraded to world-scale. Mini 9 was successfully developed within an amazingly short time. It works by the "adiabatic" process (adiabatic = without heat exchange), which means that no heat is discharged to the environment during the reaction so that oil cooling can be dispensed with. Mini 9 produces 100 kg of aniline a day.

## Steel tank replaces complex tube system

The concept proved so successful that Bayer MaterialScience immediately set about building a larger 50,000-ton pilot plant in Antwerp in Belgium, which went on stream at the beginning of 2006. "A big advantage of the adiabatic process is the fact that it can be upscaled almost without restriction," says Schwarz.

The reason is that the adiabatic reactor design is very much simpler than the traditional, isothermal process. With the isothermal method, the reaction of hydrogen gas and nitrobenzene takes place in a reactor block welded together from several thousand tubes. Each of these three-meter long tubes is filled with catalyst beads. Since heat is released during the reaction between the hydrogen and the nitrobenzene, the tube system must be surrounded by oil to dissipate the heat. "The pipe bundles are massive constructions, which have to be welded together by specialists," says Schwarz. "Pipe bundles on a world scale would be far too complicated, too large and too expensive."

The adiabatic reactor is completely different: Here, the reaction takes place in a giant steel tank. The catalyst rests on a grate, through which nitrobenzene and hydrogen gas are passed. Heat exchange with the ambient air is unnecessary because the reaction heat escapes with the flow of gas. The oil is then unnecessary.

The challenge with the design of Mini 9 was above all the fine tuning of the parameters – the flow rate of the gas, the temperatures, and the concentration of the co-reactants. The right catalyst also had to be found to achieve a good aniline yield. The purity of the aniline has improved with the adiabatic process, and the amount of work involved in cleaning has been significantly reduced. In the meantime, Dr. Knut Sommer has taken over the work in Uerdingen from Schwarz. And while the giant plant is reaching for the sky in China, Mini 9 continues to work its heart out. "The lab is the best place to optimize the process," says Sommer. The aim is clear: 100 percent pure aniline.

**www.pu.bayer.de**
*Under "Products", this Bayer website provides information about aniline, an important raw material in the manufacture of rigid foam.*