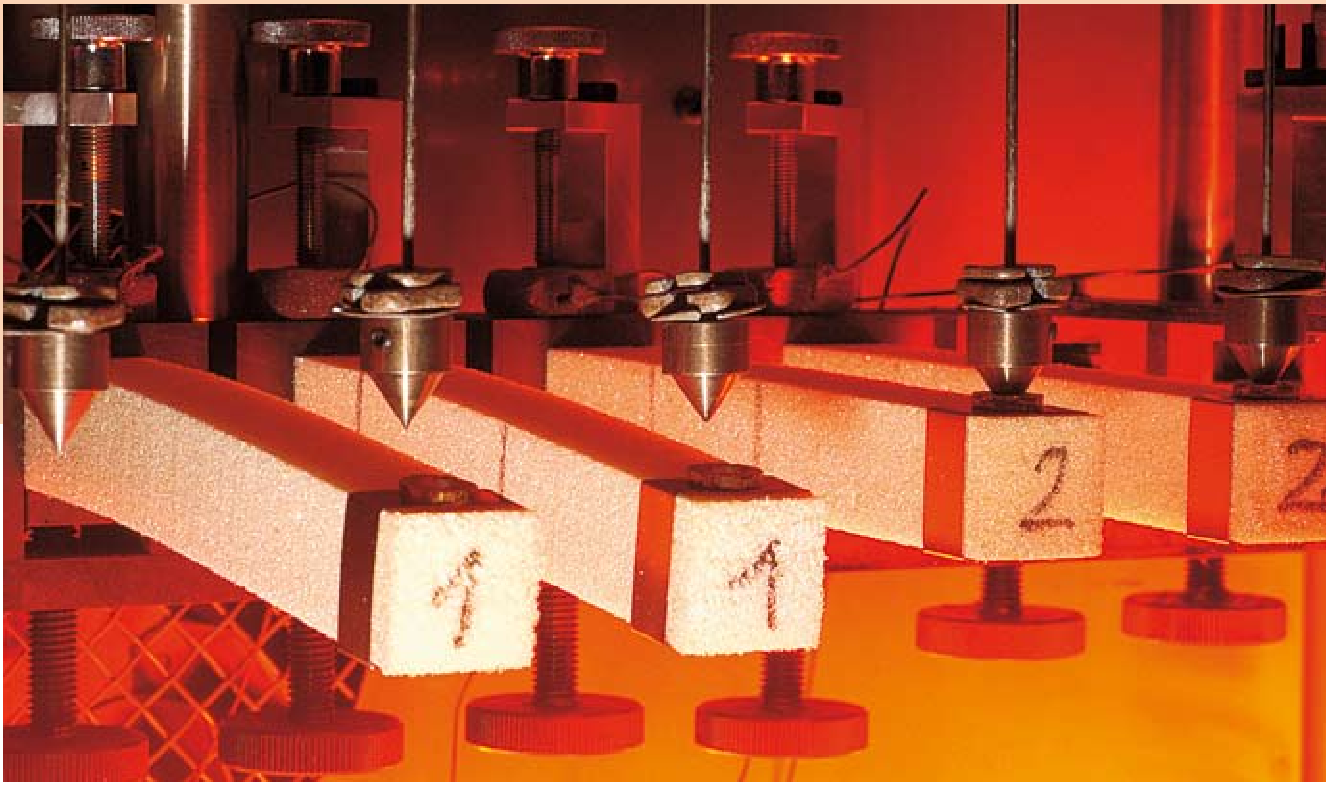
New insulating material for high temperatures

Holds up in the **heat**



Polyurethane foams are excellent insulating materials, but using them in extreme temperatures above 150 degrees Celsius used to be unthinkable. Now, chemists from Bayer MaterialScience have developed an innovative polyurethane rigid foam that remains dimensionally stable at 200 degrees Celsius and can withstand, for example, steam-conveying pipes and other extremely hot objects.

Polyurethane rigid foams possess a characteristic that makes them very useful: they insulate better than polystyrene or mineral wool and help, for example, to keep homes cozy and warm on the inside. Because they are both rigid and lightweight, polyurethane foams are used in residential construction and technical equipment, and even under load-bearing parking decks or roof gardens. In the past, high temperatures were the only condition they couldn't handle, being forced to give up the job to thick and heavy insulating materials made of mineral wool or foam glass. But a new generation of polyurethane foams is now set to change all that.

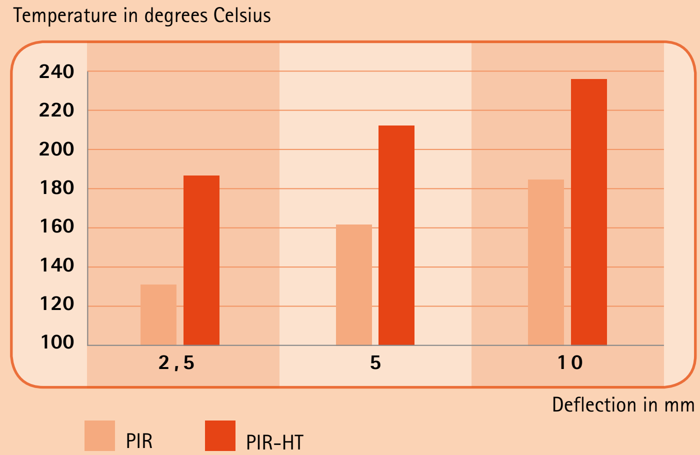
Thanks to its unique molecular structure, the new polyurethane foam is becoming a special representative of its class. As an insulating material, it's just as good as classical polyurethane foams, but in terms of heat resistance, it's far superior. Polyurethane rigid foams are almost always first choice when it comes to thermal insulation, e.g. residential and industrial construction, industrial vehicle and pipe insulation, refrigeration applications. But only almost. "Conventional polyurethane foams can't resist temperatures higher than 150 degrees Celsius for very long. They get brittle and lose their shape. That's when thermal bridges form and the insulating effect deteriorates," explains Bayer chemist Dr. Jacqueline Kušan-Bindels.

Together with Dr. Wolfgang Friederichs and other polyurethane experts at Bayer MaterialScience, she developed a rigid foam that maintains its dimensional stability even at extreme temperatures. The scientists arrived at their results by finding new ways to combine known chemical reactions in polyurethane chemistry.

All polyurethanes are made up of two components: isocyanates and polyols. "We know that excess isocyanate increases heat resistance," explains Friederichs, who initiated the new

Dimensionally stable even at high temperatures

The new PIR HT foam resists even greater heat. In the bending test with horizontally mounted strips, in which deflection is observed with increasing temperature, the PIR-HT remains stable up to 200 degrees Celsius. In contrast, classical PIR foams show signs of deformation at lower temperatures.



Proven resistance: In a bending test (left), the new foam (2) withstands extreme temperatures better than the previous one (1). Safety: In a flammability test, Mahi Hakiki checks the flame-retardant properties of the new polyurethane (top). Dr. Jacqueline Kušan-Bindels and Dr. Wolfgang Friederichs inspect pipe insulation after a heat exposure test (above).

development. "The surplus isocyanate molecules react with one another to form highly crosslinked structures. The result is what we call polyisocyanurate (PIR) rigid foams," adds the chemist. The polyisocyanurate structures reinforce the rigid foam, making it not only dimensionally stable, but also resistant to heat and flame. But the higher the polyisocyanurate content, the more brittle the material. For this reason, the idea of high-temperature applications initially landed in the desk drawer.

The experts from Bayer MaterialScience managed to revive it, however, by concentrating on the second basic component, the polyols. These chain molecules essentially determine the properties of polyurethane foams and thus their ultimate application. "Put simply, long-chain polyols make flexible foams, short polyol chains rigid foams," the two chemists explain.

Consequently, the project team started searching for polyols that would make the PIR rigid foam less brittle. In an extensive screening process, the experts examined over 20 representatives of this substance class. Individually and in various mixtures, they reacted the polyols with the isocyanates. In addition, they varied the ratios of the two components relative to one another. The resulting PIR rigid foams were then subjected to complex material testing.

Fields of application: road tankers and solar collectors

A variety of trials were performed to study the suitability of the samples for practical application. Is the foam too brittle? Does it maintain its shape at high and low temperatures? Does its fire behavior meet all regulations? The scientists gathered answers to these and other questions in fire, heat deformation and bending tests.

Suitability for use as a high-temperature insulating material hinges on what is known as the "torsion pendulum test". A specimen must prove its dimensional stability under both mechanical and thermal load, up to a temperature of 200 degrees Celsius. "If the rigid foam maintains its shape up to this temperature, we can assume that it will function properly in practice over an extended period of time," Kušan-Bindels explains.

Her team was successful. After two years of intense engineering work, they arrived at the formulation for a high-temperature (HT) insulating material that passed all tests with flying colors. The result is a PIR HT rigid foam that maintains its dimensional stability at a temperature of 200 degrees Celsius and displays better insulating properties at the same thickness than its competitor, mineral wool. With that, the Bayer developers have no worries about practical application of the material. The foams are already in use in the industrial construction sector. Soon, they may just put their outstanding properties to the test in solar collectors, under poured asphalt or in road tankers conveying hot cargo.

www.pu.bayer.com
The website profiles diverse polyurethane applications.