## State-of-the-art Simulation Techniques That Make Visible an Invisible World

Yokohama Rubber's proprietary multi-scale simulation is a core technology of crucial importance to the development of environmentally sound tires. Using this technology, engineers can predict the properties of materials even when they do not have the desired materials to hand, thus expanding the breadth of material design that can be performed. It has also made it possible to forecast performance in tire construction (on the road) from the material compounding stage, resulting in a dramatically improved accuracy of development.

#### Analysis of running performance of different materials (in case of Nano-Power Compound)

The results of multi-scale simulation of conventional carbon black compound and a newly designed silica compound show that the silica compound offers both superior rolling resistance and grip. This technology was used to develop the Nano-Power Compound used in the latest DNA Earth-1 eco tire.

#### < Comparison of rolling resistance > Conventional compounds (carbon black compound) and silica compound were found to have different particle configurations, with the configuration of silica compound exhibiting less energy loss when deformed and lower rolling resistance.

#### Analysis by multi-scale simulation

< Comparison of grip > Silica compound was found to create a greater area of contact with the road surface, resulting in excellent grip.



Conventional compound (carbon black compound)



Silica compound



Conventional compound



Silica compound

< Verification of results by video > In order to verify simulation results, the area of contact between actual rubber and road surface was investigated using the SPring-8 third -generation synchrotron radiation facility. This confirmed that the contact area of silica compound was greater than that of conventional compounds.



Conventional compound



Silica compound

### Multi-scale simulation is essential to materials development



Naoya Amino of the Tire Materials Development Dept. (left) and Masataka Koishi of the Tire R&D Dept. The Tire Materials Development Department, which decides on materials, and the Tire R&D Department (CAE Laboratory), which performs multi-scale simulations, are presently working closely together to develop environmentally sound products. When selecting new materials, the Tire Materials Development Department works with the CAE Laboratory to confirm tire performance on the road through simulation. This provides valuable feedback for material development. Collaboration between the two will be strengthened and information actively shared in order to develop products offering even greater environmental performance.

# Environmental performance of ADVAN premium tire also attained

Wet performance and rolling resistance are essentially conflicting forms of performance, which makes it difficult to simultaneously improve both. Multi-scale simulation was put to work to solving this challenge, and the ADVAN dB premium comfort tire launched in July 2009 was the result: a product developed based on analysis of simulation of the microscopic strain of compound and belt cord, and simulation of rolling resistance using precisely modeled tread patterns that recreated even lugs as well as main grooves. The end result was an environmentally sound product that combines lower rolling resistance with an extremely quiet ride and the rigidity and wet performance befitting of a premium car.





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