Application News
SHIMADZU

THERMAL ANALYSIS T115

Thermal Analysis of Rubber

Taking advantage of its excellent elasticity, restorability, and flexibility, rubber is used in many products including tires, tubes, belts, wire covering materials and so on. Other properties, like abrasion resistivity, oil resistivity and heat resistivity are also required of rubber, depending on its application. NBR (nitrile-butadiene rubber), for example, is used for machine belts because of its resistance to oil, and IIR (isoprene-isobutylen rubber), which is an excellent electric insulator, is used for covering electric wires. Carbon black is added as the reinforcement agent to rubber for car tires that must have abrasion resistance.
Thermal analyzers offer a very easy solution for the evaluation of the thermal property of rubber, that is, for the information on how the rubber to be used behaves at different thermal conditions.
The following is a list of measurable items with each analyzer.

DSC (differential scanning calorimeter)

Glass transition temperature

TGA (Thermogravimetric analyzer)

(1) Reinforcement agents (carbon black, inorganic substance etc.)
(2) Thermal resistivity

TMA (thermo-mechanical analyzer)

(1) Expansion coefficient
(2) Softening temperature
(3) Young's modulus
(4) Dynamic viscoelasticity analysis (DMA)

The following is an introduction of measurements for thermal properties of various rubbers with DSC, TGA, and TMA.

Dynamic viscoelasticity (DMA by TMA)

Rubber having double bond is vulcanized with sulfur and rubber without it is vulcanized with a vulcanizing agent for enhancement of elasticity, strength, thermal resistivity, etc. Vulcanization makes elasticity and viscosity change accordingly. Change of such rubber properties can be measured by analyzing DMA with TMA.
The following DMA curves of SBR (stylen-butadiene rubber) indicate that both elasticity (E') and viscosity (E") are greater in SBR with sufficient vulcanization than those in SBR with insufficient vulcanization.

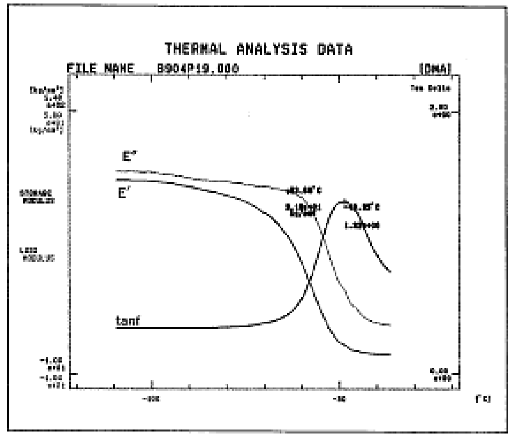

Fig.1 DMA of SBR with Insufficient Vulcanization

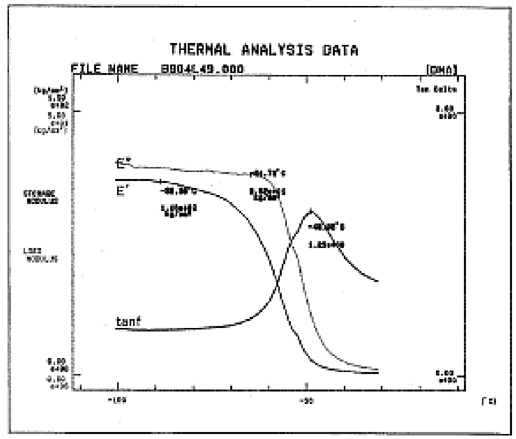

Fig.2 DMA of DBR with Sufficient Vulcanization

Thermal resistivity (TGA)

Thermal resistivity is evaluated by change of weight with TGA. SBR was decomposed in an environment of N_2 and air. TG curve in N_2 is simple, while the other in the air is complicated by the effect of oxidization decomposition. It is known from these curves in Fig.3 that the decomposition onset temperature differs by 35.2° C and also that thermal resistance deteriorates in the presence of oxygen.

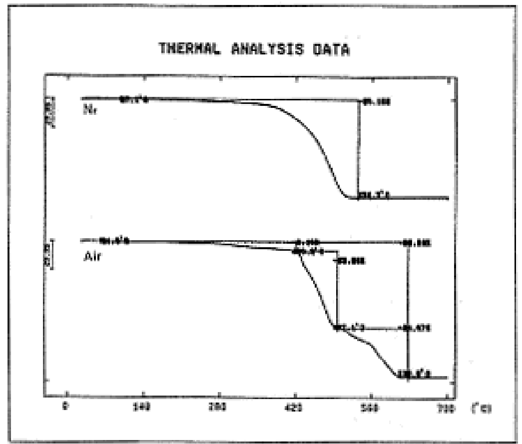

Fig.3
TG Curves of DBR in an Air and N_2 Environment

Glass transition (DSC)

Glass transition temperature, which is one of the important properties of rubber, can be measured by DSC. Here is an sample analysis of SBR and CR (chloroprene rubber) with DSC. Specimens cooled down to -150˚C with a cryogenic chamber were analyzed by DSC with the following result concerning their glass transition temperature.
SBR: -67.0˚C
CR : -54.5˚C

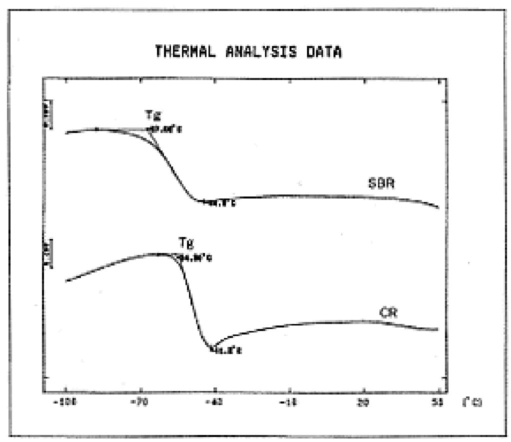

Fig.4 Tg Curves (DSC) of SBR and CR

Quantitative analysis of carbon black

A quantitative analysis of carbon black, a reinforcement agent of SBR, was conducted with TGA. The rubber was pyrolized in N_2 atmosphere and, then carbon black was burned with the environment switched to air for quantitative determination based on gravimetric change in each environment. The composition sharing ratio was 69.5% for rubber, 27.9% for carbon black, and the rest for inorganic substances.

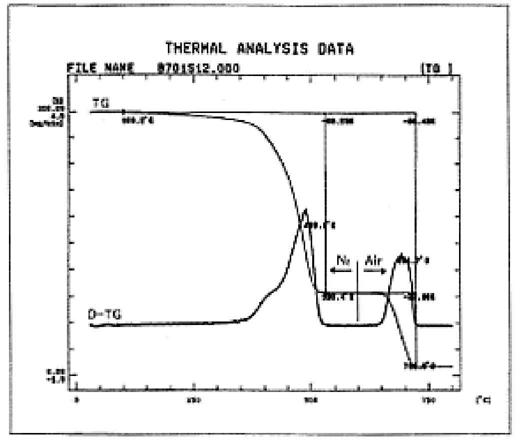

Fig.5 TG Curves of SBR in N_2 and Air

Penetration measurement (TMA)

The rubber is hardened if carbon black is added. A comparison measurement was conducted in penetration mode for rubber with and without carbon black. The results showed the penetration under a load of 50g as 99.5 μm for SBR with carbon black, and 297.7 μm for SBR without carbon black, which means a triple increase in hardness.

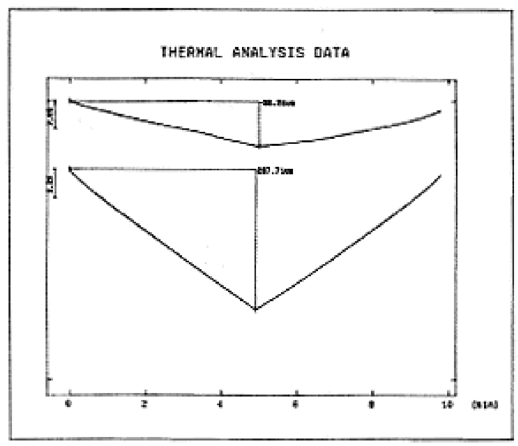

Fig.6 Penetration of SBR with/without Carbon Black

* Please be advised that data obtained before the implementation of the current Weights and Measures Law may be presented in terms of gravimetric unit.

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