Compressive properties of bitumen based composite materials

technische universiteit eindhoven

Compressive Properties of Bitumen Based Composite Materials

C.C. Puig†, L.H.G.J. Segeren‡, G.J. Vancso‡, M.A.J. Michels∗ and H.E.H. Meijer†
† Materials Technology, Faculty of Mechanical Engineering, Eindhoven University of Technology, P.O. Box 513, 5600 MB Eindhoven, the Netherlands.
∗ Department of Applied Physics, Eindhoven University of Technology, P.O. Box 513, 5600 MB Eindhoven, the Netherlands.
‡ Dutch Polymer Institute and Faculty of Chemical Technology, University of Twente, P.O. BOX 217, 7500 AE Enschede, the Netherlands.

Introduction

Recently, intermediate material properties (compressive strength) between those shown by traditional asphalts (9-11MPa) and those by cement concrete (30-60MPa or higher) were found by using some bitumens in the preparation of composites with a high content of minerals.

Experimental and discussion

Fig.1 shows the compressive mechanical behavior of two composites made up of a mineral filler (particle size $\sim 8\ \mu$m) and two bitumens (A and B) of different origin. Fig.1 also shows the compressive curves for the pure bitumens. The compressive stress at yield for the bitumen A based composite is about 50% higher than that shown by the traditional asphalt (bitumen B). If a mineral filler of larger particle size ($\sim 50\ \mu$m) is used then a lower compressive stress is obtained.

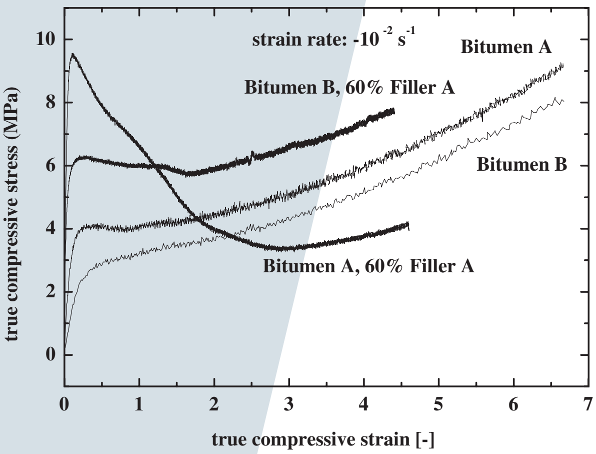

Figure 1 *Uniaxial compression curves for the composites and pure bitumens.*

We also investigated the nature of the surface energy properties of the bitumens by carrying out inverse gas chromatography at -30^oC, i.e. below their glass transition temperature. By plotting RTLn(V_N) versus a$(\gamma_L^D)^{1/2}$, where V_N is the retention volume given by the interaction of the probe (alkane molecules) with the bitumen, a and γ_L^D are the surface area and the dispersive surface energy of the probe molecules, respectively, the dispersive surface energy of the sample (γ_s^D) can be deduced from the slope. The corresponding values for bitumen A and bitumen B are 59.3 and 50.6 mJ/m^2, respectively, it is almost a 20% difference.
In order to gain some knowledge on the differences in composition between the two bitumens, thermal gravimetric analysis was carried out under an inert nitrogen atmosphere between room temperature and 700^oC. The amount of residue in bitumen A is 31% whereas in bitumen B is about 23%. The difference is attributed to the asphaltene content.

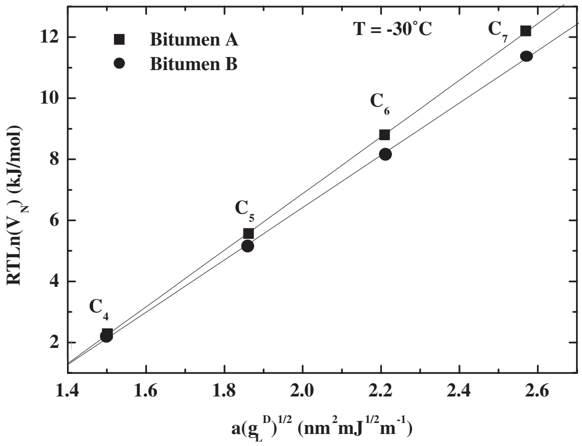

Figure 2 *Plot of RTLn(V_N) versus $a(\gamma_L^D)^{1/2}$.*

Anisotropic properties are expected from aggregates of asphaltene, which are highly planar polyaromatic molecules. The scattering of X-rays on the small angle region by doing in situ heating and cooling experiments using the synchrotron radiation shows the collapse of structures ($\sim$ 20 nm in size) in bitumen A (Fig. 3). We must bear in mind that in the presence of a constrained environment imposed by the presence of rigid mineral particles, the collapse of these anisotropic structures and their arrangement can be somehow modified.

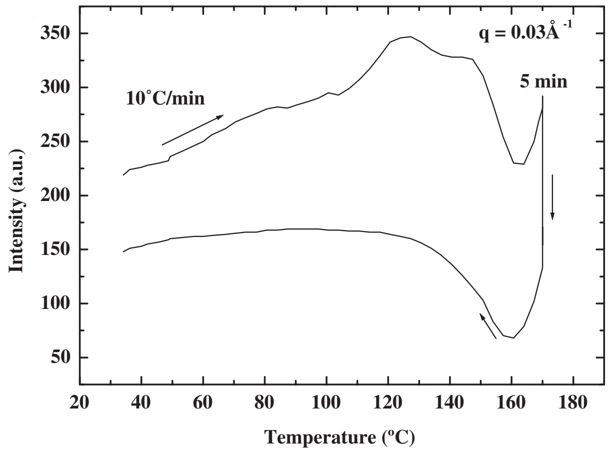

Figure 3 *X-ray intensity profile for a heating and cooling cycle at a given q value for bitumen A.*

Conclusions

The enhanced mechanical properties observed in some bitumen based composites may be explained by the higher asphaltene content and by the higher dispersive surface energy of the bitumen. The constrained imposed upon the aggregates of asphaltene molecules by the presence of filler particles may also be a contributing factor to the enhanced mechanical behavior.

PO Box 513, 5600 MB Eindhoven, the Netherlands