FRACTURE MECHANICS OF RUBBER NANOCOMPOSITES

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ABSTRACT

Usually, elastomers are highly filled, cross-linked and entangled polymeric blends. Due to their adjustable elastic and viscous properties, these systems are widely used in industry and technology, for example in tires, automotive systems, print rollers etc.. Dynamical operation conditions put extremely high demands on performance and stability of these materials. The required service life is usually decreased due to material damage as a result of wear processes such as abrasion and wear fatigue, mostly caused by crack formation and propagation.

New rubber materials concepts were developed in our group, recently, with respect to rubber nanocomposites. For example, a high degree of exfoliation of montmorillonite (MMT) was achieved in natural rubber (NR) utilizing the so called ‘Propping-open approach’ where stepwise expansion of interlayer spacing of MMT took place. Subsequently, the role of such type of highly exfoliated clay in the dispersion and synergy of MWCNT and clay in NR-MWCNT-clay composites was studied. Furthermore, solution-styrene butadiene rubbers (SSBR) with a graphene-nano-platelets/carbon black hybridfiller-system were developed, and the dynamic-mechanical properties and also the tear fatigue crack propagation characteristics were evaluated.

In the first part of the presentation we report about a multi-scale understanding of the fracture process in rubber materials by means of a novel combination of experimental methods of fracture mechanical characterisation and different modelling approaches which operate on the statistical-mechanical, mesoscopic and continuum mechanical levels.

The second part of the presentation is focussed on approaches for crack propagation in elastomeric materials based on an energetically characterisation like tearing energy. We demonstrate the power of new developed equipment for estimation of the crack propagation rate as function of tearing energy under dynamical loading conditions (Tear Fatigue Analyzer, TFA). A statistical analysis of the fracture surface topography by means of height-height correlation functions allows for the determination of relevant length scales of the fracture process and an estimation of the size of the fracture process zone exemplified with a particular fracture surface [Horst, Th.; Reincke, K.; Ilisch, S.; Heinrich, G.; Grellmann, W. Fracture surface statistics of filled elastomers, Physical Review / E **80** (2009) 046120(5)].

The third part shows examples how TFA testing predicts improved fatigue and fracture mechanical properties of the new designed rubber nanocomposites (see above) in comparison to state-of-art technologies in rubber compounding.