# Tribology of polymer composites

*Citation for published version (APA):*
Krop, S., Breemen, van, L. C. A., & Meijer, H. E. H. (2012). *Tribology of polymer composites*. Poster session presented at Mate Poster Award 2012 : 17th Annual Poster Contest.

*Document status and date:*
Published: 01/01/2012

*Document Version:*
Accepted manuscript including changes made at the peer-review stage

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# Tribology of polymer composites

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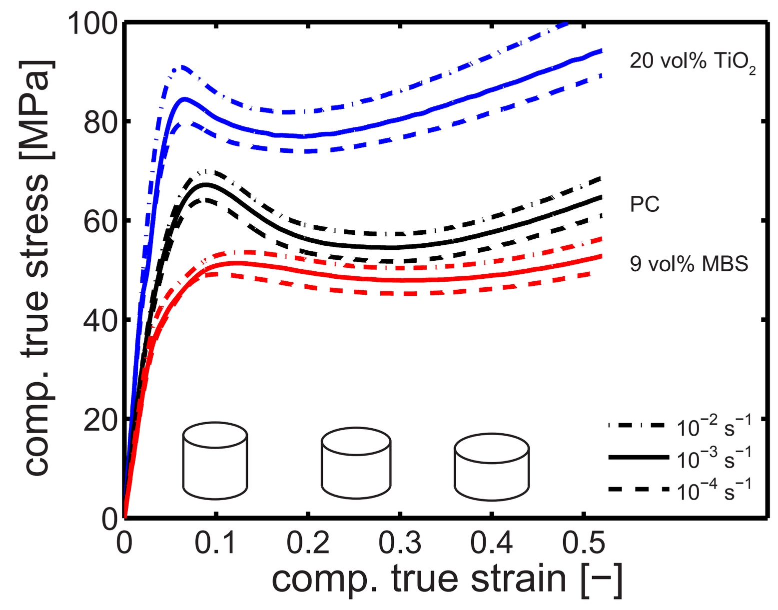
(a)




(b)

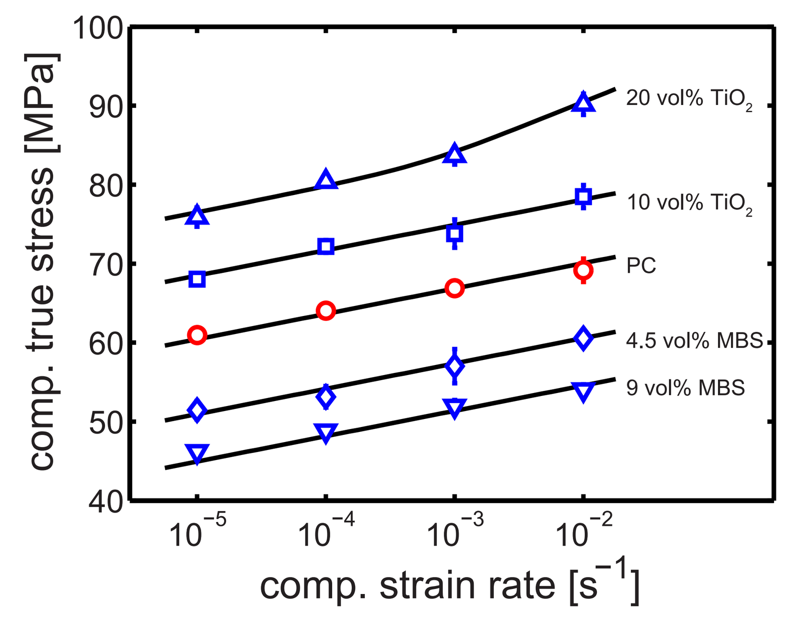
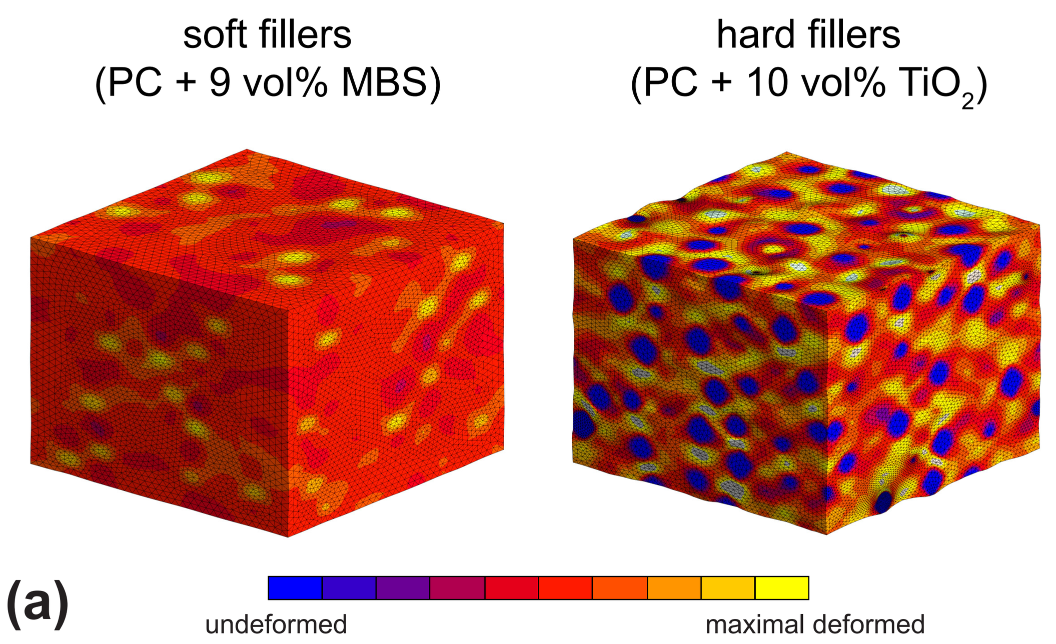



**Fig. 1: Effect of filler type on intrinsic mechanical response (a) and rate-dependent yield stress (b).**




(a)

(b)

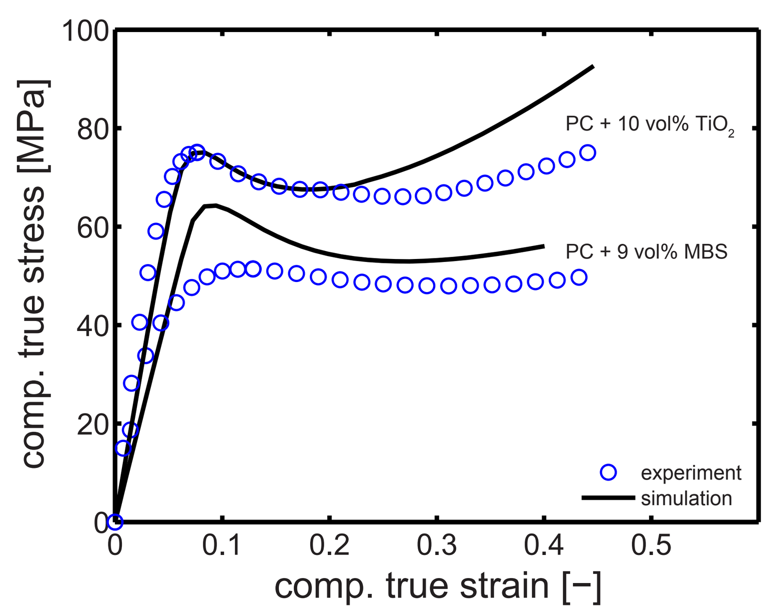



**Fig. 3: Deformed RVE showing local strain level (a) and the macroscopic mechanical response (b).**

## Introduction

Polymers play an increasingly important role in tribological applications. The application of a hybrid experimental-numerical approach in the single-asperity scratch test proved a powerful tool in understanding the polymers' frictional response [1]. In practice, however, these polymers are filled, e.g. with colorants and impact modifiers. Therefore, this strategy is extended to heterogeneous systems.

## Experiments

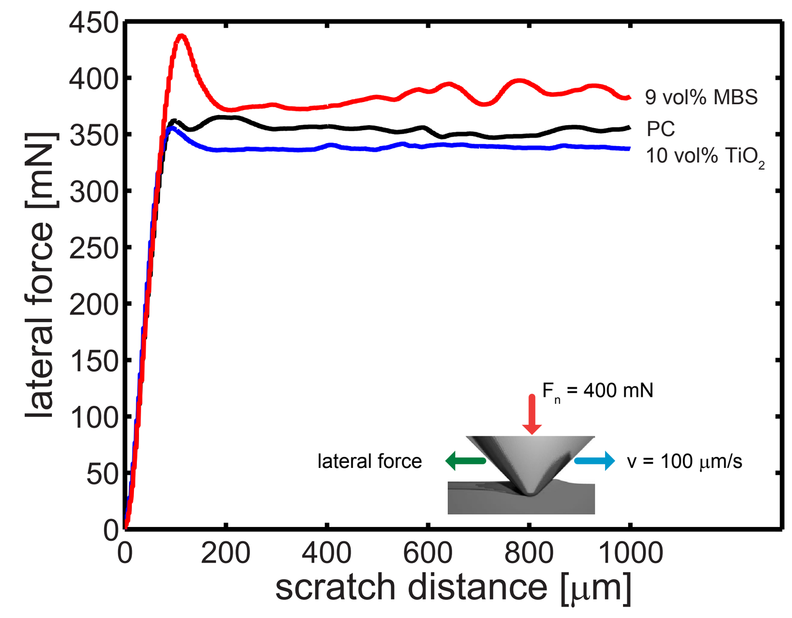
To characterize the effect of filler particles on the intrinsic mechanical response, model systems of PC filled with either hard ($TiO_2$) or soft (MBS) particles are tested in uniaxial compression, see Fig. 1a. Although the magnitude of stress changes dramatically, the rate dependence is solely determined by the matrix material, see Fig. 1b. This effect is also observed in the single-asperity scratch test; the addition of soft or hard fillers results in a change in the resistance against deformation (Fig. 2a), but the rate effect is still governed by the polymer matrix (Fig. 2b).

## Simulations

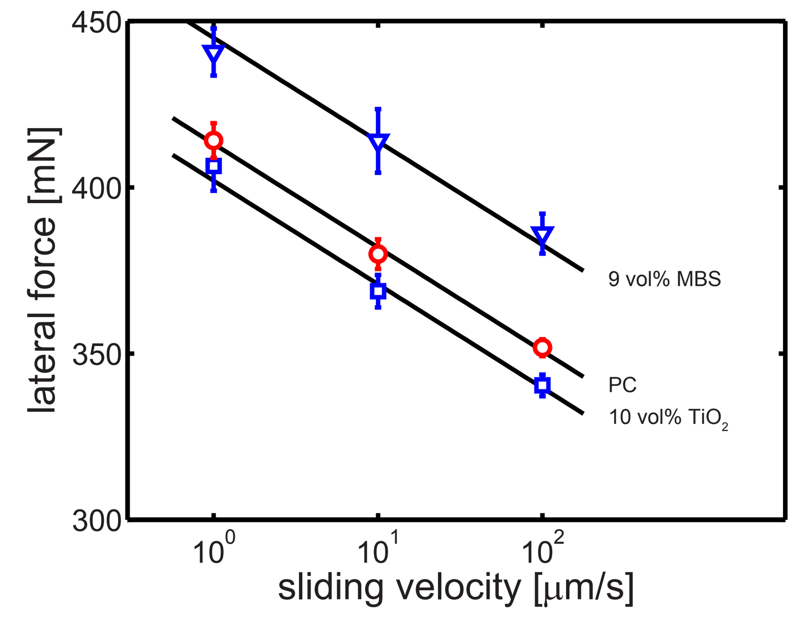
It is impossible to mesh these heterogeneous materials in a scratch simulation. Therefore, representative volume elements (RVEs) are constructed, see Fig. 3a, and subjected to a macroscopic deformation. Although effects like cavitation and particle-matrix adhesion are not taken into account, simulation results show that the mechanical response is captured rather well, see Fig. 3b.

## Discussion

A macroscopic material model of the heterogeneous system is constructed, which will be used in the simulation of the scratch test, see Fig. 4a. Apart from the stiffness and the yield stress, fillers also change the adhesive interaction with the indenter, which in turn changes the shape of the bow wave in front of the indenter-tip [1]. This adhesive component is the only unknown when relating the simulation to the experimentally measured total response. Imposing the local deformation from the scratch simulation on an RVE gives valuable information about the stress state in the filled system, see Fig. 4b. This enables the definition of a failure criterion that marks the onset of wear.

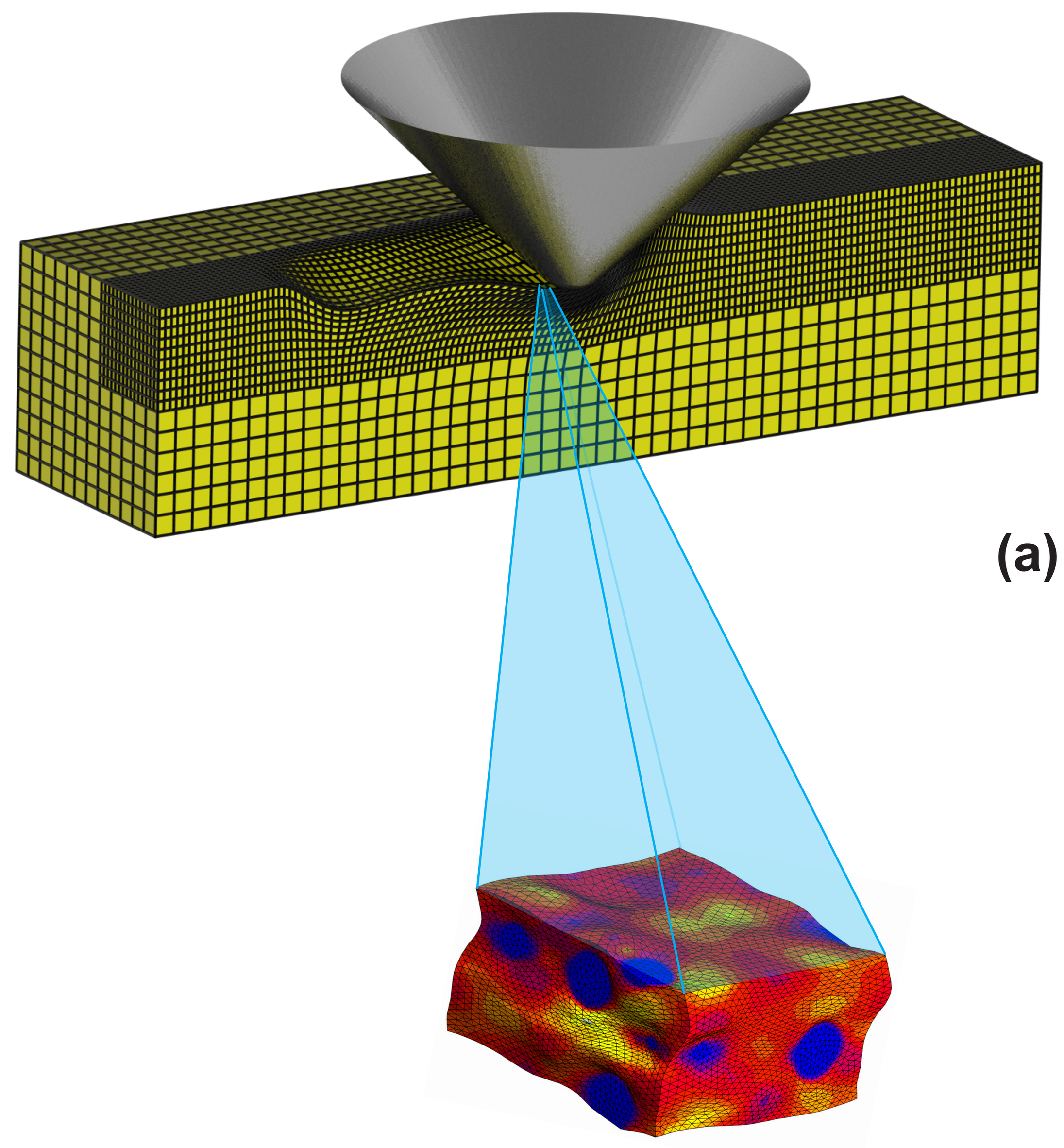



(a)




(b)

**Fig. 2: Effect of filler type (a) and sliding velocity (b) on the scratch response.**



(a)

(b)

**Fig. 4: Simulation of a scratch test using the macroscopic constitutive model (a) where the local deformation can be imposed on an RVE to reveal effects on smaller scale (b).**

[1] Van Breemen *et al.*, *Wear* **2012**, *274-275*, 238-247