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Rubber filled with carbon black from the nanoscopic structure to the macroscopic behaviour

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ABSTRACT

Many materials like rubber filled with carbon black, assumed homogeneous at macrosopic scale, are heterogenous at nanoscopic one. Homogenization approach consists in linking the rubber properties through these scales.

First, we propose to describe the morphology of the material at nanoscopic scale to model it with mathematical morphology approach [1], [2], [3], [4], [5]. The observation and the characterization of the microstructure is based on using of TEM (Transmission Electronic Microscope) (Fig.1a) and image analysis. A multiscale model was developped, to account for the inhomogeneous distribution of carbon black nanoparticles in the rubber matrix. The identification of the parameters of the model is made by means of the second and third order moments of the microstructure, combined to simulations. The validation of the model is based on comparison of percolation measures on microstructures computation with experimental data [4].

From 3D simulations of the filled rubber (Fig.1b), the purpose is to study the a RVE (Representative Volume Element) suitable in homogenization methods to predict the effective properties. A statistical approach is used to determine the RVE size [6] with a given precision of the estimation of the wanted overall property, for morphological properties like volume fraction, as well as for mechanical properties like Young's modulus in small deformations.

To conduct properly this study, numerical tools are needed like microstructure finite element meshing (Fig.2) and parallel computation methods.

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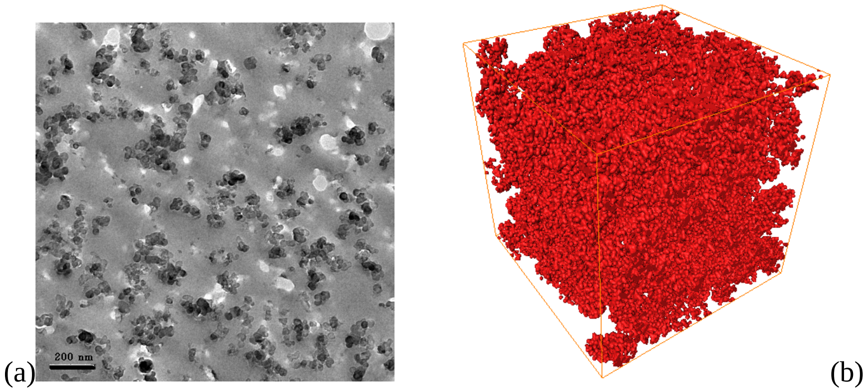

Figure 1: (a): TEM Image - (b): Simulation $1600^3 nm^3$, 20% of Carbon Black $\simeq 60000$ particles

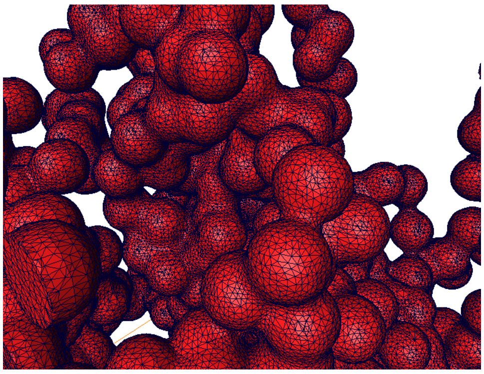

Figure 2: Finite Element Meshing

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