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Magnetorheological elastomers (MRE) are made from magnetic microparticles ,for instance nickel or iron ones, dispersed in an elastomeric matrix. The dispersion is realized in the presence of a magnetic field before curing, hence the apparition of several new properties due to the formation of aligned strands of particles inside the solid matrix. For instance, not only the viscoelastic properties of this material become controlable by the application of a magnetic field, but also its length or its electrical resistance.

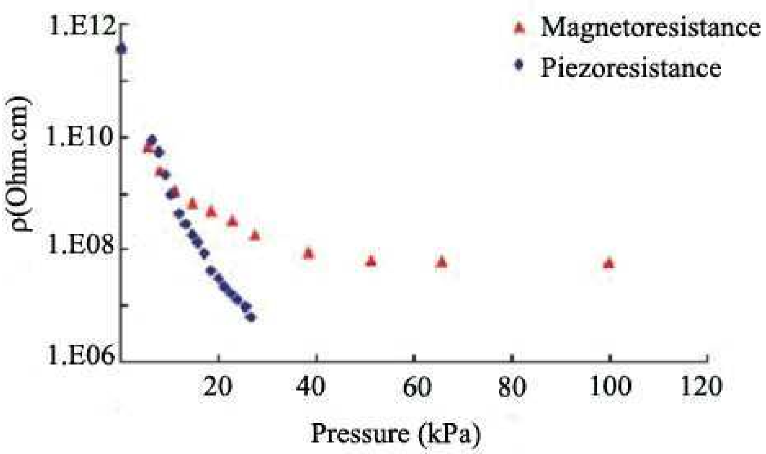

Fig.1 Piezo and magnetoresistivity versus pressure

An example is presented in fig.1 where the change of resistivity of a MRE is plotted versus the applied pressure (piezoresistance curve). In a similar way a decrease of the resistivity is obtained by the application of a magnetic field (magnetoresistance curve); here the magnetic pressure was calculated from the magnetic force betwwen two particles in the presence of the applied field . The beginning of the two curves is similar, reflecting the same origin, that is to say the decrease of the interparticle gap with the applied pressure. The change of resistivity can be modelled by taking into account the change of the thickness of the tunnel junction between asperities of the microparticles [1],[2]. The difference between the two curves at higher pressure - or magnetic field- is likely due to the oversimplification of the model that we used to convert the applied field in a magnetic pressure between the particles (in particular we do not take into account the the roughness of the particles which can induce a faster saturation of the magnetization in the contact areas) .

Besides the nanoscale related to the tunnel junctions between the particles , there is also a macroscopic scale which is the one of the sample: it is the percolation of the network of particles which will finally allow to form conductive pathways between the electrodes. The reduced time, t_p^* needed to form a given percentage of percolating chains was calculated versus the reduced size of the cell (N=h/d) by means of a generalized Smoluchowski equation which takes into account the specific interactions between magnetized chains of particles of different sizes[3] as well as the possibility of lateral aggregation between chains. This last point is important since, as observed experimentally, it is the main process by which percolation takes place. In Fig.2 it is seen that two regimes exist depending on the size of the cell, the first one is approximately linear in h/d whereas the second one is close to be quadratic. Numerical simulations of the aggregation of non Brownian particles wre found to be in good agreement with these predictions. Further experimental investigations are under progress to confirm the existence of these two regimes by the measurement of the change of conductivity during time for different thicknesses of the samples.

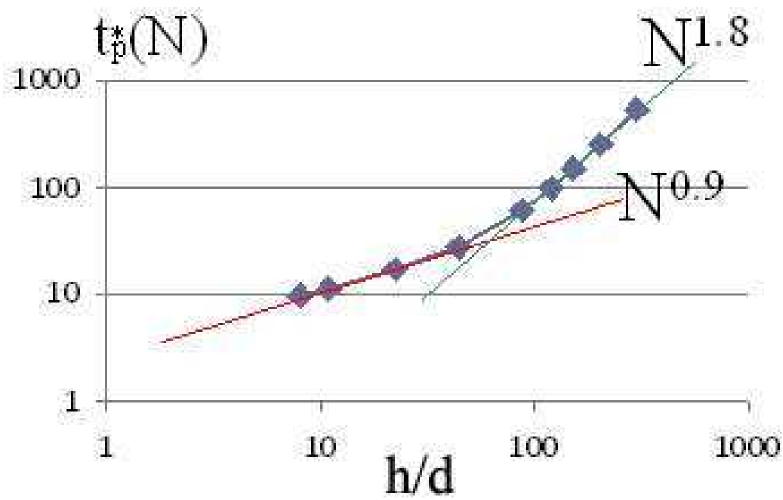

Fig.2 Percolation time in reduced units versus the thickness of the cell normalized by the diameter of the particles

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[3] Bossis G, Iskakova L., Kostenko V., Zubarev A. Physica A **390,** 2655 (2011)

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