Electrical conductivity of a monolayer of rod-like particles: A lattice approach

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The physical properties of inhomogeneous media attracts significant attention in the scientific community. The calculation of the electrical conductivity for a random mixture of insulating and conducting materials is one of the main problems in the theory of disordered systems. In particular, the singular behaviour of the electrical conductivity near a percolation threshold is of interest. Investigations of the physical properties of inhomogeneous media are significant for numerous applications such as the production and use of nanocomposites. Theoretical prediction of the effective properties for multiphase material systems is very important for the analyses of material performance and for the design of new materials.

In our study, the electrical conductivity of a monolayer produced by the random sequential adsorption (RSA) of linear k-mers, i.e., particles occupying k adjacent lattice sites, onto a square lattice was studied by means of computer simulation [1]. Both isotropic and anisotropic depositions were examined. To calculate the effective electrical conductivity, the monolayer was presented as a random resistor network. The Frank-Lobb algorithm was applied to calculate the electrical conductivity for different lengths ($k = 1 - 128$) and concentrations of the k-mers from $p = 0$ to the jamming limit, p_j. Two different models were examined, i.e., an insulating substrate and conducting k-mers and a conducting substrate and insulating k-mers. The "intrinsic electrical conductivity" and concentration dependence of the electrical conductivity were analysed.

The effect of impurities in the lattice and of defects in the k-mers on the behaviour of electrical conductivity has been studied [2]. The defects in the lattice are distributed randomly before deposition and these lattice sites are forbidden for the deposition of k-mers. The defects of the k-mers are distributed randomly on the deposited k-mers. The sites filled with k-mers have high electrical conductivity, whereas the empty sites, and the sites filled by either types of defect have a low electrical conductivity. The effects of vertical drying [3] and diffusion-driven [4] self-organizations on behaviour of electrical conductivity has also been investigated.

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