Inverse percolation by removing straight semirigid rods from bilayer square lattices

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Numerical simulations and finite-size scaling analysis have been carried out to study the problem of inverse percolation by removing semirigid rods from a $L \times L$ square lattice that contains two layers (and $M = L \times L \times 2$ sites). The process starts with an initial configuration where all lattice sites are occupied by single monomers (each monomer occupies one lattice site) and, consequently, the opposite sides of the lattice are connected by nearest-neighbor occupied sites. Then the system is diluted by removing groups of k consecutive monomers according to a generalized random sequential adsorption (RSA) mechanism. The study is conducted by following the behavior of two critical concentrations with size k: (1) jamming coverage $\theta_{j,k}$, which represents the concentration of occupied sites at which the jamming state is reached; and (2) inverse percolation threshold $\theta_{c,k}$, which corresponds to the maximum concentration of occupied sites for which connectivity disappears. The obtained results indicate that (1) the jamming coverage exhibits an increasing dependence on the size k. It rapidly increases for small values of k and asymptotically converges towards a definite value for infinitely large k-sizes $\theta_{j,k\to\infty} \approx 0.2701$; and (2) the inverse percolation threshold is a decreasing function of k in the range $1 \leq k \leq 17$. For $k \geq 18$, all jammed configurations are percolating states (the lattice remains connected even when the highest allowed concentration of removed sites is reached), and consequently, there is no nonpercolating phase. This finding contrasts with the results obtained in literature for a complementary problem, where straight rigid k-mers are randomly and irreversibly deposited on a square lattice forming two layers. In this case, percolating and nonpercolating phases extend to infinity in the space of the parameter k and the model presents percolation transition for the whole range of k. The results obtained in the present study were also compared with those reported for the case of inverse percolation by removing of rigid linear k-mers from a square monolayer. The differences observed between monolayer and bilayer problems were discussed in terms of vulnerability and network robustness. Finally, the accurate determination of the critical exponents ν, β, and γ reveals that the percolation phase transition involved in the system has the same universality class as the standard percolation problem.