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Kinetic roughening: how directionality changes the game

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The nonequilibrium evolution of growing interfaces has attracted many experimental and theoretical studies over decades. One of the most popular theoretical approaches considers kinetic discrete models to describe particle aggregation on substrates. Albeit simple, these models are expected to contain the relevant physics. Inspired by recent advances in the production of functionalized colloidal particles, with attractive patches on their surface, we have proposed a stochastic model to study the effect of directionality and selective pairwise interactions on the kinetics of aggregation. We find a nontrivial dependence of the bulk and surface properties on the strength and flexibility of the patch-patch interactions, and on the spatial-patch distribution. For three-patch particles, sustained growth is only observed for a finite-range of the distance between patches, yielding two absorbing phase transitions and a tricritical flexibility. For four-patch particles with two distinct patches, i.e. strong and weak bonds, and sufficiently different bonding probabilities, the scaling properties of the interface crossover from the universality class of Kardar-Parisi-Zhang to the critical class of Kardar-Parisi-Zhang with quenched disorder. The latter is observed for an extended range of the parameters revealing the presence of a self-organized critical mechanism. Implications of our findings beyond functionalized particles are also discussed.