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Frustration by Shape-Designed Local Polymorphism: A Near-Equilibrium Colloidal Glass of Hard Kites

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We study glass formation in uniform Brownian dispersions of hard colloidal polygonal platelets having the shape of 72-degree achiral kites, fabricated using optical stepper lithography. These kites are confined to a plane through roughness-controlled depletion attractions, and they diffuse in two-dimensions as we very slowly raise the particle density in the system. Although the densest packing of these kites is a crystalline lattice that fully tiles the plane, remarkably, we observe that the kites do not crystallize even for such quasi-static osmotic compression. By contrast, we have previously shown that such slow compression does cause crystallization of Brownian systems of other convex 2D lithographic shapes, such as squares and rhombs. Instead, the system of kites forms a disordered glass that undergoes an ergodic to non-ergodic transition, both in a rotational and a translational sense, while remaining near-equilibrium, as we measure by video particle tracking. We show that the high diversity of few-particle local polymorphic configurations (LPCs) of kites, related to our choice of angles and lengths in the designed shape, is responsible for suppressing long range spatial order and consequently favors glass formation instead. The prevalence and diversity of 5-particle LPCs, such as the pentagonal star, frustrate crystallization because these pentagonal LPCs are topologically different than the one 4-particle LPC that corresponds to the space-filling crystal. We anticipate that this mechanism of glass formation through shape-dependent frustration by diverse and incommensurate LPCs will also be relevant for molecular systems in three dimensions.