Kinetic energy of aggregates and universal power-law behavior of self-assembling in a thermal bath

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I draw readers' attention to the importance of the kinetic energy contribution which has been systematically ignored in the partition functions of worm-like objects in a thermal bath. The kinetic energy of linear aggregates is shown to play a unique role when they are reversibly formed from solute molecules in an isotropic solvent. The kinetic energy contribution to the partition function of an n-mer is modeled by the term n^q, where q is determined by the persistence lengths of different translation-rotation modes (e.g., $q = 5$ for a rigid rod and $q \approx 0$ for a very flexible chain). The n-mer concentration is found to depend on the solute concentration c via its powers which are fully determined by the parameter q. The model gives rise to two different aggregation regimes: A low n regime for lower c, and a high n regime for higher c. The total aggregate concentration is found to be a sum of universal power laws of c with the exponents that are different in different regimes, but in both cases are determined solely by the parameter q. The analytical formulas for the two regimes and the crossover point are in a quantitative agreement with the numerical solution of the model. The model is pertinent to self-assemblies of plank-like dye molecules dissolved in an isotropic solvent (related to lyotropic chromonic liquid crystals).